

INVENTORY OF INTERBASIN WATER TRANSFERS IN MINNESOTA

by L. C. Trotta

---

U.S. GEOLOGICAL SURVEY

Open-File Report 88-466

Prepared in cooperation with the  
MINNESOTA DEPARTMENT OF NATURAL RESOURCES

St. Paul, Minnesota  
1988



DEPARTMENT OF THE INTERIOR  
DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

---

For additional information  
write to:

District Chief  
U.S. Geological Survey  
Water Resources Division  
702 Post Office Building  
St. Paul, Minnesota 55101

Copies of this report can  
be purchased from:

U.S. Geological Survey  
Books and Open-File Reports Section  
Federal Center, Building 810  
Box 25425  
Denver, Colorado 80225

## CONTENTS

|   |    |
|---|----|
| Abstract.....   | 1  |
| Introduction.....   | 1  |
| Categories of interbasin water transfer in Minnesota..... | 2  |
| Organization of inventory data.....                       | 7  |
| Analysis.....   | 7  |
| Summary.....  | 14 |
| Literature cited.....                                     | 15 |

## ILLUSTRATIONS

|  |    |
|--|----|
| Figure 1. Water export data questionnaire.....   | 3  |
| 2. Conveyance information form for interbasin transfer of water<br>between water-resources subregions..... | 4  |
| 3. Rapid River, Upper Red Lake Area.....   | 6  |
| 4. 1985 net gains or losses due to interbasin transfer.....  | 13 |

## TABLES

|  |    |
|--|----|
| Table 1. Conveyance reference number, permit number, category, county,<br>and owner..... | 8  |
| 2. Exports of water from hydrologic units, 1985 calendar year...                         | 10 |

## CONVERSION FACTORS AND ABBREVIATIONS

Readers who prefer to use metric (International System) units rather than inch-pound units can make conversions using the following factors:

| <u>Multiply Inch-Pound Unit</u>    | <u>By</u> | <u>To obtain Metric Unit</u>                  |
|------------------------------------|-----------|---|
| mile (mi)                          | 1.609     | kilometer (km)                                |
| acre                               | 0.4047    | square hectometer<br>(hm <sup>2</sup> )       |
| acre-foot (acre-ft)                | .001233   | cubic hectometer<br>(hm <sup>3</sup> )        |
| gallon (gal)                       | .003785   | cubic meter (m <sup>3</sup> )                 |
| million gallon per day<br>(Mgal/d) | .04381    | cubic meter per second<br>(m <sup>3</sup> /s) |

# INVENTORY OF INTERBASIN WATER TRANSFERS IN MINNESOTA

L.C. Trotta

## ABSTRACT

Water-transfer data were collected by the U.S. Geological Survey, in cooperation with the Minnesota Department of Natural Resources, from the 13 hydrologic subregions in Minnesota. About 30,000 acre-feet of water is exported annually from eight of these subregions. Interbasin transfer of water is classified according to type of water conveyance in Minnesota. This information is needed by water-system managers and planners to develop water budgets for major river basins, to examine the extent of existing interbasin transfers, and to evaluate the feasibility of transferring water to meet regional water demands.

**KEY TERMS:** Interbasin transfers; Minnesota; water conveyance; sewer; ground-water infiltration

## INTRODUCTION

The Great Lakes Council of Governors has begun studies leading to regulation of diversions from the Great Lakes Basin (Snively, 1986, p. 75). Water-transfer information also is needed by water-system managers and planners to develop water budgets for major river basins and to evaluate the feasibility of interbasin transfers in meeting regional water demands. A preliminary inventory of the extent of existing interbasin water transfers is needed as a first step in determining the hydrologic effects of such diversions before they become commonplace in Minnesota.

This report focuses only on areas where water is transferred across subregion boundaries. There are 13 subregions, drained by major rivers, that are wholly or partly in Minnesota (U.S. Geological Survey, 1976). drainage divides were assumed to coincide with ground-water divides for the purpose of this preliminary inventory, in order to be compatible with concurrent national-scale studies. Ground-water divides for the shallow aquifer (whether drift or bedrock) do match the drainage divides fairly well; they have been delineated for many aquifers in Minnesota in hydrologic atlases and regional-aquifer reports published by the U.S. Geological Survey.

A questionnaire (fig. 1) was completed for every probable diversion point in the State within 1/4 mile of each subregion boundary. During this survey, the percentage of ground- or surface-water withdrawals diverted across drainage divides was estimated. This information was supplemented by interviews with water managers and by pumpage reports submitted to the Minnesota Department of Natural Resources (MDNR). When interbasin diversions were found, an information form (fig. 2) was completed and submitted for inclusion in a national-scale study of interbasin transfers (Mooty and Jeffcoat, 1986). On the form, the "point of origin" is defined as the point on the conveyance at which all or most of the water to be transferred is intercepted by the conveyance (for example, a well or stream intake). The "initial delivery point" is defined as the point in the receiving subregion where the exported water is either released to a natural channel, enters a reservoir from which the distribution of that water begins, or reaches a point along a canal or pipeline where the distribution of that water begins (Mooty and Jeffcoat, 1986).

#### CATEGORIES OF INTERBASIN WATER TRANSFER IN MINNESOTA

The name of conveyance allows Minnesota information forms (fig. 2) to be classified into five categories: public-water supplies, sewer systems, irrigation systems, drainage ditches, and mine dewatering.

Municipal public-water supplies compose a significant part of the interbasin diversions in Minnesota. A municipality's distribution system may pump from one side of the drainage divide and deliver to residential, commercial, and industrial users on the other side of the boundary. Some municipalities that use multiple-well fields pump water across a drainage divide in both directions, a situation that is accounted for by the transfer estimates. Intercity and rural supplies also present the possibility of interbasin transfers of water. A proposal for a rural-supply system to transfer water across Minnesota's northern border (League of Women Voters, 1984) awaits only financing.

Municipal sewer systems redirect water to a treatment plant or other disposal site, in some cases across a drainage divide. Water redirected through these sewers can amount to 20 percent of the water initially supplied (H. H. Jeffcoat, U.S. Geological Survey, oral commun., 1985). With ground-water infiltration and occasional storm runoff added to these amounts, Minnesota wastewater releases were estimated at 96 percent of municipal withdrawals in 1985. The locations of ground-water infiltration and storm sewers were unknown. Diversion amounts were based on the number of sewer connections on each side of the drainage divide. Offsets of sewer exports by public-supply imports also were accounted for in estimating net gain or loss.

Irrigation systems constitute another category of interbasin transfer in Minnesota. Irrigation wells pumping over 10,000 gallons per day that have been plotted by the MDNR (Diane Glinsman, Minnesota Department of Natural Resources, written commun., 1983) were used to locate potential interbasin transfers. After confirming an irrigation transfer by telephone, the percent of irrigated

**WATER EXPORT DATA QUESTIONNAIRE**

1) City name: \_\_\_\_\_

2) Information source (person's name): \_\_\_\_\_

3) Does \_\_\_\_\_ have a public supply?  
city/village/town

3b) Does the conveyance have a name?  
 \_\_\_\_\_

Note: some systems have names for channels, canals, pipelines, reservoirs, if this is not true in your case please leave blank.

4) Is the source from wells or surface water? \_\_\_\_\_

4b) If from well(s), how many \_\_\_\_\_ and where is/are the well(s) located? (Please mark the well location on a map.)

4c) If from surface water, how many \_\_\_\_\_ and where is/are the intakes located? (Please plot on a map.)

5) What year was the conveyance put into operation? \_\_\_\_\_

6) Do you have records of total pumpage for the/each conveyance on an annual basis for the last 10 years? (fill in as much information as you have readily available for this system).

| Year  | Pumpage |
|-------|---------|
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |

7) How is that amount measured? \_\_\_\_\_

8) Can you estimate the number of service connections on each side of the drainage divide? Please express the amounts as a percentage of the total service connections.

\_\_\_\_\_ amount  
 \_\_\_\_\_ direction relative to the divide  
 \_\_\_\_\_ amount  
 \_\_\_\_\_ direction relative to the divide

9) Can you further breakdown the amount of water pumped that is used specifically in relation to the drainage divide?

| Use           | Amount | Direction Relative to Divide |
|---------------|--------|------------------------------|
| Industrial    | _____  | _____                        |
| Commercial    | _____  | _____                        |
| Power Plant   | _____  | _____                        |
| Institutional | _____  | _____                        |
| Residential   | _____  | _____                        |

10) Is this breakdown based on metering or estimation? \_\_\_\_\_

Note: Estimated figures may be given as the number of service connections for each specific use. If amounts are given from metering, the units should be consistent with pumpage units.

11) Are there any other major delivery points, (water towers, reservoirs, open release, etc.) to which water is conveyed? Please locate delivery points on a map.

11b) Can you determine or estimate (please circle one) the quality delivered to this/these points? \_\_\_\_\_

12) Where is the sewage disposal located? Please locate on a map.

13) Do you use lift pumps to deliver to the disposal site? \_\_\_\_\_

13b) If yes: Can you determine or estimate the quantity delivered through the pumping station(s)?

| Year  | Pumpage |
|-------|---------|
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |
| _____ | _____   |

14) Could you determine or estimate the total amount delivered to the disposal site?

| Year  | Amount | Year  | Amount |
|-------|--------|-------|--------|
| _____ | _____  | _____ | _____  |
| _____ | _____  | _____ | _____  |
| _____ | _____  | _____ | _____  |
| _____ | _____  | _____ | _____  |

15) Do you know of any water that is used twice in your area?

For example: Is water at the sewage treatment plant reclaimed?

Does the sewage treatment plant use treated effluent for irrigation?

Does the sewage treatment plant backwash filters with treated effluent?

Might any industries in town use wastewater (either municipal or private) for irrigation? Air conditioning? Fire protection? Etc?

15b) Could you determine or estimate (please circle one) the amounts for any of the above?

| Year  | Amount |
|-------|--------|
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |
| _____ | _____  |

Figure 1.--Water Export Data Questionnaire

CONVEYANCE-INFORMATION FORM

For interbasin transfer of water between water resources subregions

Name of conveyance \_\_\_\_\_

Owner (or owners) of conveyance \_\_\_\_\_

Year placed in operation \_\_\_\_\_

Location Information

Point of Origin

Initial Delivery Point

Water body name \_\_\_\_\_

State code \_\_\_\_\_

County code \_\_\_\_\_

8-digit hydrologic unit code \_\_\_\_\_

Annual Diversion in Acre-Feet for Water Year

1973 \_\_\_\_\_ 1974 \_\_\_\_\_ 1975 \_\_\_\_\_

1976 \_\_\_\_\_ 1977 \_\_\_\_\_ 1978 \_\_\_\_\_

1979 \_\_\_\_\_ 1980 \_\_\_\_\_ 1981 \_\_\_\_\_

1982 \_\_\_\_\_

Location of measurement point(s) (gage numbers, well numbers, or latitude and longitude of gages or wells) \_\_\_\_\_

Data sources \_\_\_\_\_

Remarks on accuracy of estimates \_\_\_\_\_

Other remarks \_\_\_\_\_

Figure 2.--Conveyance information form for interbasin transfer of water between water-resources subregions

fields outside of the source drainage basin was applied to determine amounts transferred. This method assumes that the flow rate is constant throughout a particular irrigation system.

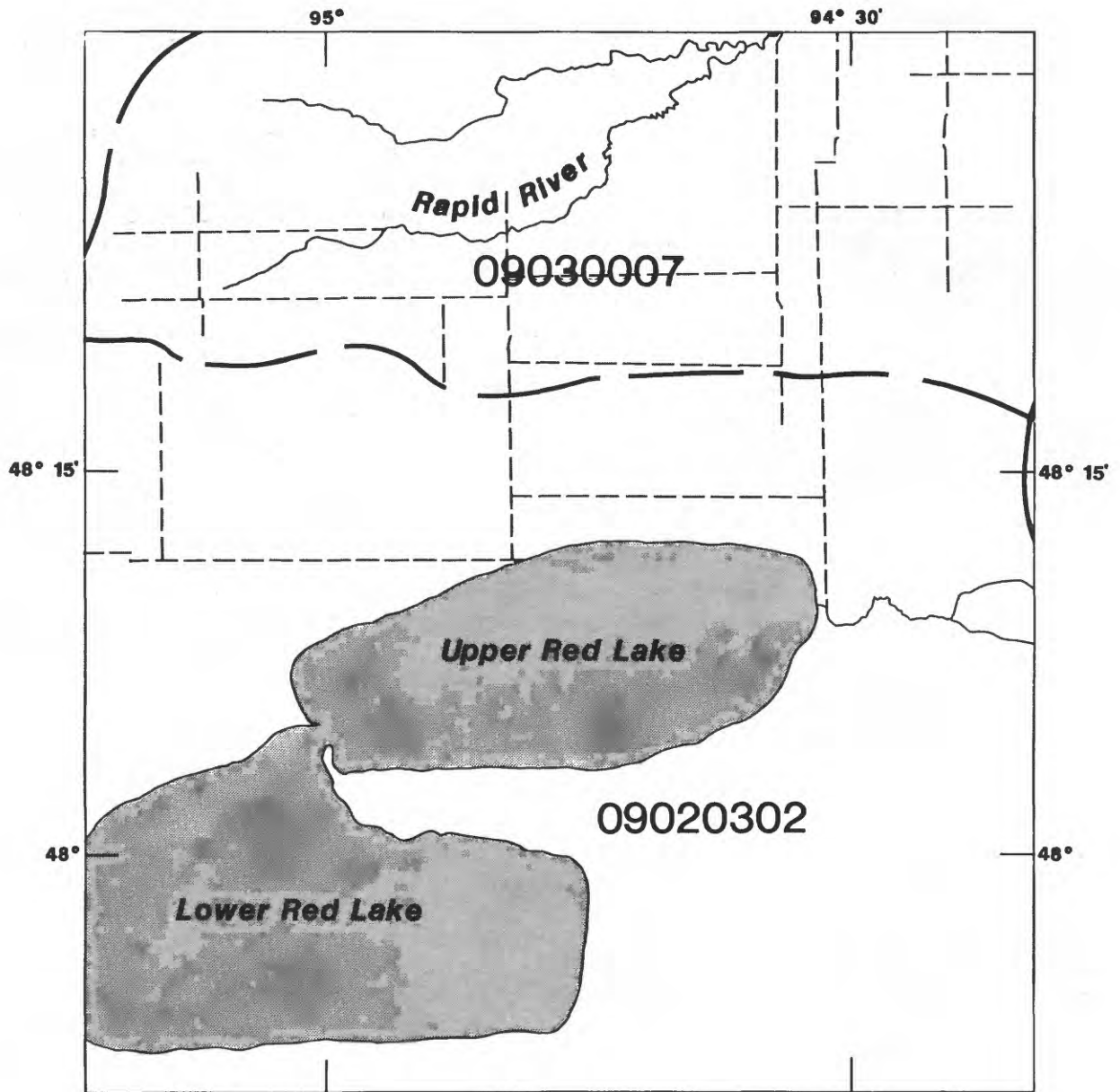
Drainage ditches constitute another category of interbasin transfer. As much as 19 percent of Minnesota was covered by wetlands in the 1830's (Palmer, 1915). Even before the inception of the first drainage act in 1858, these wetlands were looked at as a "common enemy" and were ditched and drained to expand agricultural land. Though drainage slowed after 1920, it was not until the ecological awakening of the 1960's that drainage law reflected a management desire to protect the waters of the State (King, 1980, p. 2-13). Owing to increased costs of draining and reduced crop prices, it is no longer profitable to drain the marshes for cropland (Larry Swanson, Nebraska Agricultural Extension, written commun., 1987). Although drainage-ditch inventories (for example, Minnesota Department of Natural Resources, 1974; Quade and others, 1980) and county ditch maps exist, flow measurements are scarce, making it difficult to quantify the historical effects of interbasin transfers via drainage ditches. A topographic high or surface-water divide (however minor) commonly was crossed to drain relatively flat regions. The drained water then would be transferred across this divide and usually routed into a stream or lake, essentially expanding the basin. Only about 2 percent of the State is now covered by wetlands (Sandy Fecht, Minnesota Department of Natural Resources, oral commun., 1987). Though not all comprised "subregion transfer," about 16 percent of the State (8,600,000 acres) was drained from 1830 to the present.

A current analysis suggests that interbasin transfer by drainage ditches is small. A general area of surface-water transfer exists in the wetlands between Rapid River and Upper Red Lake in northern Minnesota (fig. 3) that may be concentrated in the drainage ditches. Direction of movement here is unknown and may change with the wind. Elsewhere, leakage through a drainage ditch may affect the ground-water flow system (Faustini and Bradbury, 1985).

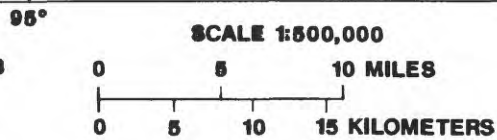
Mine dewatering presents the final category of subregion transfer in Minnesota. Like drainage ditches, the goal of mine dewatering is to remove water to present a dry working environment. Although this category may have been more significant in the past, only dewatering at one site currently satisfies inventory criteria.

There may be other categories of interbasin diversions in Minnesota, but no evidence has been found at the subregion boundaries. Privately owned wastewater pipelines, which are difficult to locate, may cross drainage divides. None were found in the detailed facility file records searched for this report (Gianessi, 1981).





Base from U.S. Geological Survey State base map, 1973



Area location

EXPLANATION

- Ditch
- Subregional boundary

Hydrologic Unit Code

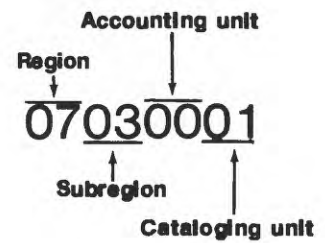


Figure 3.--Rapid River, Upper Red Lake area

## ORGANIZATION OF INVENTORY DATA

The conveyance information in this report is presented in tables 1 and 2 in the back of this report.

Table 1--Lists a conveyance reference number, the permit number, the transfer category, the county in which the conveyance originates, and the conveyance owner.

Reference number--An assigned number used to identify each conveyance in tables 1 and 2, and in figure 4.

Permit number--The water appropriation permit number assigned by the Minnesota Department of Natural Resources, Division of Waters, to the well or intake withdrawing the water supplied to the conveyance. Or, in the case of sewer systems, the National Pollution Discharge Elimination System (NPDES) number assigned by the Minnesota Pollution Control Agency to the outflow or discharge point of the conveyance.

Category--The transfer category as described in the previous section of this report.

County--The County name at the conveyance point of origin.

Owner--The entity that owns the conveyance. The listed entity for some conveyances may be the entity currently responsible for the operation of the conveyance.

Table 2--For each conveyance, table 2 lists the year the conveyance was placed in operation, the percentage of withdrawal exported from the source basin by the conveyance, the hydrologic unit code (see U.S. Geological Survey, 1976) for the point of origin (From) and the initial delivery point (To), the average export of water in Mgal/d (million gallons per day) for 1985, subtotals of 1985 exports for one water-resources subregion to another, total 1985 exports from each subregion, and a grand total of 1985 exports from all subregions. The net gain or loss due to interbasin transfer is portrayed graphically for each subregion on figure 4.

## ANALYSIS

A study focusing on the boundaries between all 81 tributary streams defined as major drainage basins by the State (Minnesota Department of Natural Resources, 1979) would doubtless uncover more transfers. In some cases, the choice of subregion boundaries as the base unit for definition of water transfer may limit the application of results. For instance, where the source of the water transferred is ground water, the ground-water divide then would be the more appropriate boundary of transfer. Water transported from the Mount Simon-Hinckley aquifer may cross a subregion boundary without crossing the potentiometric divide for that aquifer. Flow calculations listed in table 2 are, therefore, of little use to models of deeper aquifers.

**Table 1.--Conveyance Reference Number, Permit Number, Category,  
County and Owner**  
(Dashes indicate that number is not determined)

| Reference number | Permit number | Category            | County     | Owner                    |
|------------------|---------------|---------------------|------------|--------------------------|
| 1                | MN0003069     | Sewer system        | Otter Tail | City of New York Mills   |
| 2                | 754228        | Public water supply | Kandiyohi  | City of Willmar          |
| 3                | -----         | Sewer system        | Hennepin   | City of Deephaven        |
| 4                | 731119        | Public water supply | Hennepin   | City of Edina            |
| 5                | -----         | Sewer system        | Hennepin   | City of Excelsior        |
| 6                | -----         | Sewer system        | Hennepin   | City of Greenwood        |
| 7                | 756245        | Public water supply | Hennepin   | City of Hopkins          |
| 8                | MN0029874     | Sewer system        | Hennepin   | City of Long Lake        |
| 9                | 731429        | Public water supply | Hennepin   | City of Minneapolis      |
| 10               | -----         | Sewer system        | Hennepin   | City of Minnetonka       |
| 11               | -----         | Sewer system        | Hennepin   | City of Minnetonka Beach |
| 12               | -----         | Sewer system        | Hennepin   | City of Minnetrista      |
| 13               | -----         | Sewer system        | Hennepin   | City of Mound            |
| 14               | MN0024414     | Sewer system        | Hennepin   | City of Orono            |
| 15               | 620691        | Public water supply | Hennepin   | City of Richfield        |
| 16               | -----         | Sewer system        | Hennepin   | City of Shorewood        |
| 17               | -----         | Sewer system        | Hennepin   | City of Spring Park      |
| 18               | -----         | Sewer system        | Hennepin   | City of St Bonifacius    |
| 19               | 756227        | Public water supply | Ramsey     | City of St Paul          |
| 20               | -----         | Sewer system        | Hennepin   | City of Tonka Bay        |
| 21               | -----         | Sewer system        | Carver     | City of Victoria         |
| 22               | -----         | Sewer system        | Hennepin   | City of Wayzata          |
| 23               | none          | Irrigation          | Washington | Steve Houle              |
| 24               | 753209        | Public water supply | Isanti     | City of Braham           |
| 25               | 754228        | Public water supply | Kandiyohi  | City of Willmar          |
| 26               | MN0025259     | Sewer system        | Kandiyohi  | City of Willmar          |
| 27               | 811164        | Irrigation          | Pope       | Dwayne Lent              |
| 28               | 761431        | Irrigation          | Pope       | Larry Freeman            |

Table 1.--Conveyance Reference Number, Permit Number, Category,  
County and Owner --Continued

| Reference number | Permit number | Category            | County     | Owner                    |
|------------------|---------------|---------------------|------------|--------------------------|
| 29               | 796309        | Public water supply | Carver     | City of Norwood          |
| 30               | 665841        | Public water supply | McLeod     | City of Steware          |
| 31               | MN0025003     | Sewer system        | McLeod     | City of Steward          |
| 32               | 776448        | Public water supply | Carver     | City of Young America    |
| 33               | MN0046159     | Sewer system        | Hennepin   | City of Edina            |
| 34               | 756245        | Public water supply | Hennepin   | City of Hopkins          |
| 35               | -----         | Sewer system        | Hennepin   | City of Hopkins          |
| 36               | 796207        | Public water supply | Hennepin   | City of Minnetonka       |
| 37               | -----         | Sewer system        | Hennepin   | City of Richfield        |
| 38               | -----         | Sewer system        | Le Sueur   | City of Elysian          |
| 39               | 804148        | Public water supply | Waseca     | City of Waseca           |
| 40               | 650815        | Public water supply | Washington | City of Forest Lake      |
| 41               | MN0029815     | Sewer system        | Washington | City of Forest Lake      |
| 42               | 776294        | Irrigation          | Washington | Keith J. McCallum        |
| 43               | 784220        | Public water supply | Le Sueur   | City of Elysian          |
| 44               | 804148        | Public water supply | Waseca     | City of Waseca           |
| 45               | 795170        | Public water supply | Fillmore   | City of Harmony          |
| 46               | MN0022322     | Sewer system        | Fillmore   | City of Harmony          |
| 47               | 600885        | Public water supply | Stevens    | City of Donnelly         |
| 48               | 710507        | Irrigation          | Otter Tail | Arvin & Delvin Menze     |
| 49               | 801164        | Public water supply | Otter Tail | City of Henning          |
| 50               | -----         | Sewer system        | Otter Tail | City of Henning          |
| 51               | 751153        | Public water supply | Otter Tail | City of New York Mills   |
| 52               | 580353        | Mine dewatering     | St. Louis  | City of Virginia         |
| 53               | MN0030163     | Sewer system        | St. Louis  | City of Virginia         |
| 54               | 794114        | Public water supply | Lincoln    | Lincoln & Pipestone Cnty |
| 55               | 794114        | Public water supply | Lincoln    | Lincoln & Pipestone Cnty |
| 56               | 794114        | Public water supply | Lincoln    | Lincoln & Pipestone Cnty |
| 57               | 631128        | Public water supply | Nobles     | City of Worthington      |

Table 2.--Exports of Water from Hydrologic Units, 1985 Calendar Year

| Conveyance       |                          |                          |                      |          |  |
|------------------|--------------------------|--------------------------|----------------------|----------|--|
| Reference number | Year placed in operation | Percent pumpage exported | Hydrologic Unit Code |          | 1985 exports (million gallons per day) |
|                  |                          |                          | -----<br>From        | To       |  |
| 1                | 1935                     | 15                       | 07010107             | 09020103 | 0.02                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0701                 | 0902     | Subtotal 0.02                          |
| 2                | 1890                     | 500                      | 07010205             | 07020004 | 0.43                                   |
| 3                | 1973                     | ---- <u>1</u> /          | 07010206             | 07020012 | 0.26                                   |
| 4                | 1937                     | 50                       | 07010206             | 07020012 | 0.31                                   |
| 5                | 1972                     | 327                      | 07010206             | 07020012 | 0.35                                   |
| 6                | 1972                     | 144                      | 07010206             | 07020012 | 0.06                                   |
| 7                | 1954                     | 23                       | 07010206             | 07020012 | 0.04                                   |
| 8                | 1981                     | 200                      | 07010206             | 07020012 | 0.30                                   |
| 9                | 1961                     | 245                      | 07010206             | 07020012 | 2.70                                   |
| 10               | 1973                     | 43                       | 07010206             | 07020012 | 2.75                                   |
| 11               | 1981                     | 150                      | 07010206             | 07020012 | 0.07                                   |
| 12               | 1974                     | 445                      | 07010206             | 07020012 | 0.19                                   |
| 13               | 1974                     | 1171                     | 07010206             | 07020012 | 1.28                                   |
| 14               | 1981                     | 324                      | 07010206             | 07020012 | 0.58                                   |
| 15               | 1963                     | 34                       | 07010206             | 07020012 | 0.06                                   |
| 16               | 1973                     | 1919                     | 07010206             | 07020012 | 0.71                                   |
| 17               | 1974                     | 317                      | 07010206             | 07020012 | 0.30                                   |
| 18               | 1973                     | 229                      | 07010206             | 07020012 | 0.09                                   |
| 19               | 1962                     | 0                        | 07010206             | 07020012 | 0.02                                   |
| 20               | 1972                     | 311                      | 07010206             | 07020012 | 0.20                                   |
| 21               | 1973                     | 1319                     | 07010206             | 07020012 | 0.16                                   |
| 22               | 1971                     | 1406                     | 07010206             | 07020012 | 0.69                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0701                 | 0702     | Subtotal 11.55                         |
| 23               | 1978                     | 62                       | 07010206             | 07030005 | <0.01                                  |
| 24               | 1936                     | 30                       | 07010207             | 07030004 | 0.04                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0701                 | 0703     | Subtotal 0.04                          |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0701                 |          | Total 11.61                            |

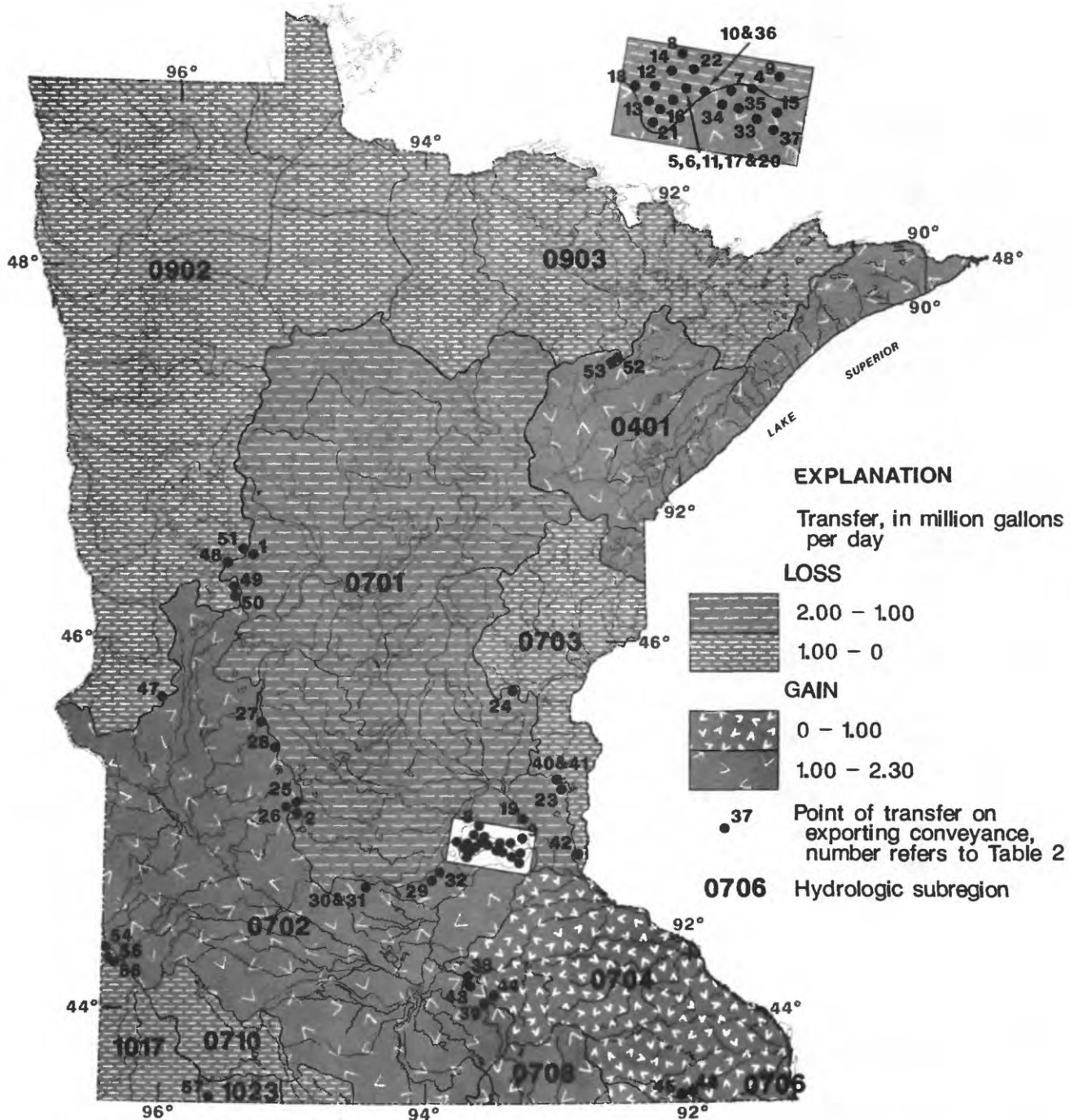
Table 2.--Exports of Water from Hydrologic Units, 1985 Calendar Year--Continued

| Conveyance       |                          |                          |                      |          |  |
|------------------|--------------------------|--------------------------|----------------------|----------|--|
| Reference number | Year placed in operation | Percent pumpage exported | Hydrologic Unit Code |          | 1985 exports (million gallons per day) |
|                  |                          |                          | From                 | To       |  |
| 25               | 1890                     | 60                       | 07020004             | 07010205 | 0.05                                   |
| 26               | 1912                     | 1320                     | 07020004             | 07010205 | 1.15                                   |
| 27               | 1981                     | 40                       | 07020005             | 07010204 | 0.04                                   |
| 28               | 1977                     | 51                       | 07020005             | 07010204 | 0.02                                   |
| 29               | 1926                     | 5                        | 07020012             | 07010205 | <0.01                                  |
| 30               | 1907                     | 25                       | 07020012             | 07010205 | 0.02                                   |
| 31               | 1957                     | 91                       | 07020012             | 07010205 | 0.06                                   |
| 32               | 1946                     | 40                       | 07020012             | 07010205 | 0.03                                   |
| 33               | 1923                     | 557                      | 07020012             | 07010206 | 3.45                                   |
| 34               | 1880                     | 27                       | 07020012             | 07010206 | 0.04                                   |
| 35               | 1971                     | 19                       | 07020012             | 07010206 | 1.30                                   |
| 36               | 1962                     | 34                       | 07020012             | 07010206 | 2.17                                   |
| 37               | 1952                     | 579                      | 07020012             | 07010206 | 0.97                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0702                 | 0701     | Subtotal 9.30                          |
| 38               | 1973                     | 660                      | 07020011             | 07040002 | <0.01                                  |
| 39               | 1923                     | 180                      | 07020011             | 07040002 | 1.09                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0702                 | 0704     | Subtotal 1.09                          |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0702                 |          | Total 10.39                            |
| 40               | 1931                     | 113                      | 07030005             | 07010206 | 0.22                                   |
| 41               | 1919                     | 88                       | 07030005             | 07010206 | 0.56                                   |
| 42               | 1977                     | 25                       | 07030005             | 07010206 | <0.01                                  |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0703                 | 0701     | Subtotal 0.78                          |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0703                 |          | Total 0.78                             |
| 43               | 1938                     | 3320                     | 07040002             | 07020011 | 0.02                                   |
| 44               | 1980                     | 13                       | 07040002             | 07020011 | 0.08                                   |
|                  |                          |                          |                      |          | ---                                    |
|                  |                          |                          | 0704                 | 0702     | Subtotal 0.10                          |

Table 2.--Exports of Water from Hydrologic Units, 1985 Calendar Year--Continued

| Conveyance       |                          |                          |                      |          |  |       |
|------------------|--------------------------|--------------------------|----------------------|----------|--|-------|
| Reference number | Year placed in operation | Percent pumpage exported | Hydrologic Unit Code |          | 1985 exports (million gallons per day) |       |
|                  |                          |                          | From                 | To       |  |       |
| 45               | 1950                     | 48                       | 07040008             | 07060002 | 0.02                                   |       |
| 46               | 1923                     | 146                      | 07040008             | 07060002 | 0.07                                   |       |
|                  |                          |                          | 0704                 | 0706     | Subtotal                               | 0.09  |
|                  |                          |                          | 0704                 |          | Total                                  | 0.19  |
| 47               | 1960                     | 51                       | 09020102             | 07020002 | 0.01                                   |       |
|                  |                          |                          | 0902                 | 0702     | Subtotal                               | 0.01  |
| 48               | 1971                     | 30                       | 09020103             | 07010106 | 0.03                                   |       |
| 49               | 1936                     | 27                       | 09020103             | 07010107 | 0.02                                   |       |
| 50               | 1938                     | 177                      | 09020103             | 07010107 | 0.12                                   |       |
| 51               | 1936                     | 15                       | 09020103             | 07010107 | 0.01                                   |       |
|                  |                          |                          | 0902                 | 0701     | Subtotal                               | 0.18  |
|                  |                          |                          | 0902                 |          | Total                                  | 0.19  |
| 52               | 1942                     | 60                       | 09030002             | 04010201 | 1.12                                   |       |
| 53               | 1907                     | 58                       | 09030002             | 04010201 | 1.08                                   |       |
|                  |                          |                          | 0903                 | 0401     | Subtotal                               | 2.20  |
|                  |                          |                          | 0903                 |          | Total                                  | 2.20  |
| 54               | 1979                     | 32                       | 10170203             | 07020003 | 0.07                                   |       |
| 55               | 1979                     | 32                       | 10170203             | 07020004 | 0.07                                   |       |
| 56               | 1979                     | 53                       | 10170203             | 07020006 | 0.11                                   |       |
|                  |                          |                          | 1017                 | 0702     | Subtotal                               | 0.25  |
|                  |                          |                          | 1017                 |          | Total                                  | 0.25  |
| 57               | 1900                     | 60                       | 10230003             | 07100001 | 1.17                                   |       |
|                  |                          |                          | 1023                 | 0710     | Subtotal                               | 1.17  |
|                  |                          |                          | 1023                 |          | Total                                  | 1.17  |
|                  |                          |                          |                      |          | ====                                   |       |
|                  |                          |                          |                      |          | Grand Total                            | 26.78 |



1/ Not applicable, most of city not on public supply





**EXPLANATION**


Transfer, in million gallons per day

**LOSS**

-  2.00 - 1.00
-  1.00 - 0

**GAIN**

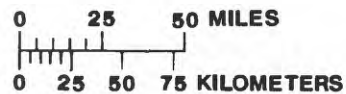
-  0 - 1.00
-  1.00 - 2.30

-  37 Point of transfer on exporting conveyance, number refers to Table 2

**0706** Hydrologic subregion

Base from U.S. Geological Survey State base map, 1965

**SCALE**



**Figure 4.--1985 net gains or losses due to interbasin transfer.**



A suggested refinement of this study would be improvement and analysis of the percentage of withdrawal exported, given in table 2. These percentages are commonly gross estimates based on topographic maps and data reported either in the Minnesota Water-Use Data System, by Oberts (1984), or by the Metropolitan Waste Control Commission (1984). The accuracy of the estimates could be refined with further study by local water managers. For consistency, the percentage estimates assume that any ground-water infiltration or connection of storm sewers occurs on the source side of the boundary. Analysis of these percentages may provide useful insights. For instance, flowmeter measurements of the sewer system in the City of Harmony (reference number 46) indicate that a maximum of 25 percent of public-supply withdrawals enters the sewers and that ground-water infiltration probably is the major source of interbasin diversion along this conveyance. A drought which lowers the water table below the sewer pipe could greatly affect the amount exported.

Subsequent studies are needed to determine the effect of diversions identified in this study on the quantity and quality of the water resources.

These studies might include:

- 1) better definition of ground-water divides to assess the effect of pumpage on interbasin diversions.
- 2) documentation of historical changes in water quality in source and receiving waters.
- 3) generalization of hydrologic effects by transfer category and comparison to similar effects in other geographic or geologic areas.
- 4) modeling of water budgets for subregions incorporating interbasin-transfer data.
- 5) assessment of the risk that the diversion might negatively affect future economic development in the source area by restricting the availability of water.

#### SUMMARY

Water is exported from 8 of the 13 subregions examined in this study using 57 conveyances. These conveyances originate in 16 counties and range from the 4 conveyances exporting less than 0.01 Mgal/d to an export of 3.45 Mgal/d from the City of Edina's sewer system conveyance (reference number 33). Four of the conveyances (reference numbers 9, 10, 33 and 36 on fig. 4) account for 41 percent of the exports between subregions. The total amount of water exported by the 57 conveyances was about 26.8 Mgal/d in 1985. The City of Hopkins public-supply conveyance (reference number 34), built in 1880, is the oldest conveyance. Historical trends can be examined by applying the percentage of export in table 2 to historical pumpage totals available in the Minnesota Water Use Data System. Data for 1973-82 are listed by Mooty and Jeffcoat (1986, table 3) for several conveyances. The history of interbasin transfer in the drainage-ditch category gives insight to the hydrologic effects of large transfers of water and provides information needed by water-system managers and planners in developing water budgets.

## LITERATURE CITED

- Faustini, John and K. R. Bradbury, 1985. Significance of drainage ditches as hydrogeologic boundaries in the Central Sand Plain of Wisconsin. In: Abstracts of the American Water Resources Association, Wisconsin Section Annual Meeting, LaCrosse, p. 35.
- Gianessi, L. P., 1981. Detailed facility file records from the Resources for the Future environmental data inventory (REDI) - State of Minnesota: U.S. Geological Survey unpublished files, 40 p.
- King, K. E., 1980. A history of drainage law in Minnesota with special emphasis on the legal status of wet lands: University of Minnesota Water Resources Research Center Bulletin 106, Minneapolis, 48 p.
- League of Women Voters of Minnesota, 1984. Minnesota's liquid asset - Water use and policy options: League of Women Voters of Minnesota Facts and Issues, p. 10
- Metropolitan Waste Control Commission (MWCC), 1984. 1984 treatment plant report: MWCC Report No. QC 84-94, 182 p.
- Minnesota Department of Natural Resources, 1974. Drainage ditch inventory - 1973: Minnesota Department of Natural Resources unpublished report, 280 p.
- \_\_\_\_\_, 1979. State of Minnesota watershed boundaries: Minnesota Department of Natural Resources, St. Paul, Scale 1:500,000.
- Mooty, W. S., and H. H. Jeffcoat, 1986. Inventory of interbasin transfers of water in the eastern United States: U.S. Geological Survey Open-File Report 86-148, 47 p.
- Oberts, G. L., 1984. Water use in the Twin Cities Metropolitan Area--an update: Metropolitan Council of the Twin Cities Area Publication No. 10-84-068, 44p., 2 appendices.
- Palmer, Ben, 1915. Swampland drainage with special reference to Minnesota: University of Minnesota Studies in the Social Sciences No. 5, Minneapolis, 105 p.
- Quade, H. W., K. W. Boyum, D. O. Braaten, Donald Gordon, C. L. Pierce, A. Z. Silis, D. R. Smith, and W. C. Thompson, 1980. The nature and effects of county drainage ditches in south central Minnesota: University of Minnesota Water Resources Research Center Bulletin 105, Minneapolis, 121 p.
- Snavely, D. S., 1986. Water-use data-collection programs and regional data base of the Great Lakes-St. Lawrence River Basin States and Provinces: U.S. Geological Survey Open File Report 86-546, 204 p.
- U.S. Geological Survey, 1976. Hydrologic unit map - 1974, State of Minnesota: U.S. Geological Survey, scale 1:500,000.