PREPARED IN COOPERATION WITH THE
VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION

WATER-RESOURCES INVESTIGATIONS REPORT 93-4097
Horn, M.A., and Medalie, L., 1995
Estimated withdrawals and use of freshwater in Vermont, 1990

INTRODUCTION

In 1977, the Congress of the United States, recognizing the need for accurate, comprehensive, and comparable information on water use, directed the U.S. Geological Survey (USGS) to establish a National Water-Use Information Program to complement other USGS programs on the availability and quality of the Nation's water resources. The Water-Use Program is a cooperative project between USGS offices and various State agencies who are responsible for water-resources management. Currently (1995), a cooperative water-use program is in place in Vermont and the other five States in New England. These six individual programs are closely coordinated to promote development of uniform water-use data bases.

This report was prepared in cooperation with the Vermont Department of Environmental Conservation and is based on data for Vermont that were compiled for a national report (Solley and others, 1993). National compilations of water-use information have been done every 5 years since 1950. The 1990 report is one of six reports being prepared for the New England States.

The purpose of this report is to provide information on water use in Vermont to Federal and State agencies, water-resources professionals, and individuals interested in water-conservation issues. The report focuses on freshwater withdrawals and instream use for hydroelectric-power generation during 1990. Water withdrawals and use are reported in million gallons per day and are generally derived by dividing total annual withdrawals and use by 365 days. This procedure does not alter the values reported for water-use activities that are fairly constant throughout the year, such as domestic withdrawals; however, for water-use activities with significant seasonal variations (such as snowmaking, sand-and-gravel mining, and irrigation), the average daily withdrawal rate is smaller than the actual daily withdrawal rate during the season of activity. Data are aggregated by river basin, which is the most commonly used water-resource planning unit in New England. In most cases, however, river-basin boundaries do not coincide with State boundaries, and the data reported here are only for the part of each river basin within the State of Vermont. The river basins are equivalent to hydrologic cataloging units that were delineated by the USGS in cooperation with the U.S. Water Resources Council. A complete description of the units can be found in Seaber and others (1987).

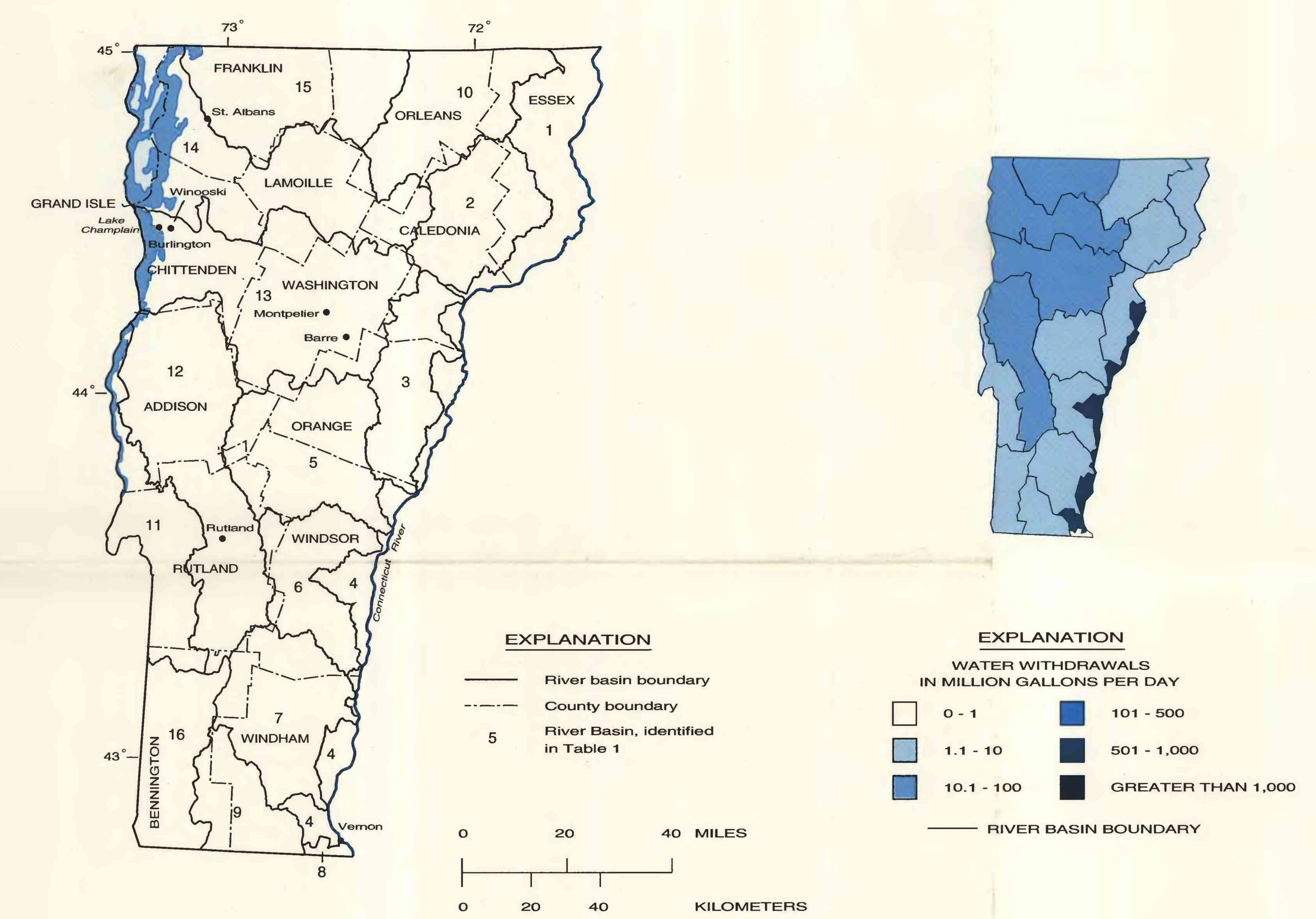
Most of the data in this report were estimated because the State of Vermont does not have a water-use permit or registration program through which water-use data could be routinely collected. Three types of estimating methods were used: (1) Public supply and some industrial withdrawals were estimated based primarily on owner-supplied site-specific information, such as number of customers; (2) thermoelectric and mining withdrawals and hydroelectric instream use were estimated based on State-provided information by multiplying an easily obtained characteristic, such as amount of power generated, by a coefficient; (3) domestic, some industrial, commercial, and agricultural withdrawals were estimated by multiplying aggregated data, such as census population data, by a coefficient (U.S. Department of Commerce, 1989a, 1989b, 1991).

REFERENCES CITED

Seaber, P.R., Kapinos, F.P., and Knapp, G.L., 1987, Hydrologic unit maps: U.S. Geological Survey Water-Supply Paper 2294, 63 p.
Solley, W.B., Pierce, R.R., and Perlman, H.A., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.
U.S. Department of Commerce, 1989a, 1987 census of agriculture, volume 1--geographic area series, part 45--Vermont State and county data: Washington D.C., Bureau of the Census, publication AC87-A-45, 235 p.
----- 1989b, 1987 census of retail trade, geographic series, Vermont: Washington D.C., Bureau of the Census, publication RC87-A-46, 46 p.
----- 1991, 1990 census of population and housing, summary population and housing characteristics, Vermont: Washington D.C., Bureau of the Census, publication 1990/CPH-1-8, 64 p.

CONVERSION FACTORS

Multiply	by	To obtain
inch	25.4	millimeter
square mile	2.590	square kilometer
million gallons per day	0.04381	cubic meter per second



Base from U.S. Geological Survey data, 1:2,000,000, 1972

Index maps of Vermont showing river basins (larger map) and total freshwater withdrawals by river basin (smaller map), 1990.

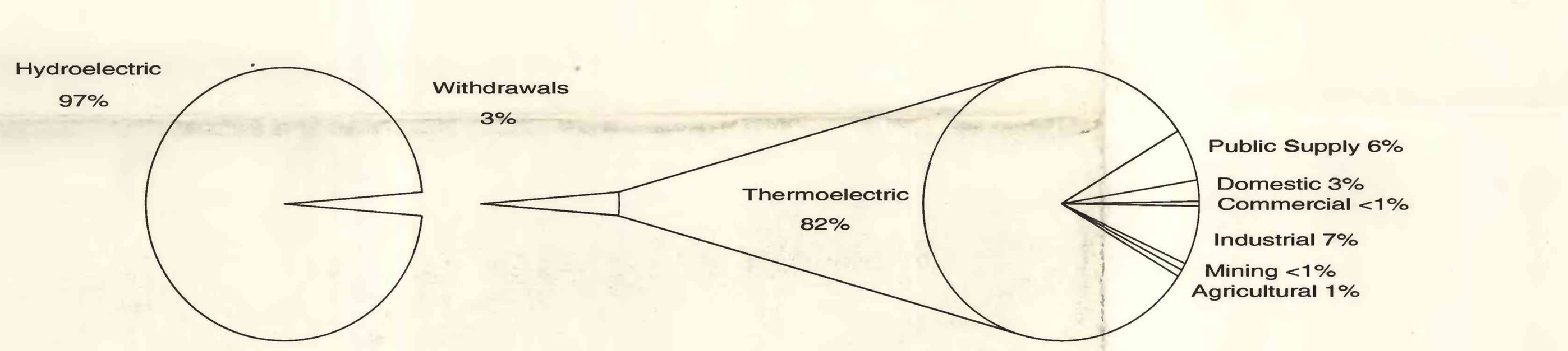
Table 1.--Area, population, and estimated withdrawals and hydroelectric instream use of water for river basins in Vermont, 1990

[Units are in million gallons per day (Mgal/d), except where noted; population numbers are rounded to the nearest hundred people; other numbers are rounded to nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding; mi ^{2}, square miles]

					Estimated withdrawals									
						Self-supplied								
Map code	River Basin	Hydrologic cataloging unit	Area[1] (mi ^{2})	Population (thousands)	Public supply	Domestic	Commercial	Industrial	Mining	Agriculture	Thermoelectric	Total withdrawals	Hydroelectric instream use
1	Upper Connecticut	01080101	527	6.2	0.4	0.1	0.1	4.9	0.0	0.1	0.0	5.5	230
2	Passumpsic	01080102	496	20.5	1.8	.8	.2	.0	.0	.2	.0	3.0	1,100
3	Waits	01080103	441	10.5	.2	.6	.2	.3	.0	.3	.0	1.5	.0
4	Upper Connecticut-Mascoma	01080104	376	39.4	1.7	1.9	.1	2.7	.0	.1	518	525	5,140
5	White	01080105	703	24.1	1.6	.6	.2	.2	.0	.4	.0	3.0	.0
6	Black-Ottauquechee	01080106	418	20.3	2.2	.7	.1	.0	.0	.1	.0	3.1	334
7	West	01080107	612	19.5	1.3	.0	.3	.1	.0	.1	.0	1.9	101
8	Middle Connecticut	01080201	19	2.8	.0	.2	.0	.0	.0	.0	.0	.2	.0
9	Deerfield	01080203	272	6.6	1.2	.2	.1	.1	.0	.1	.0	1.7	472
10	St. Francois	01110000	590	20.7	2.3	.4	.1	1.0	.0	.6	.0	4.4	504
11	Lake George	02010001	509	21.3	.7	.9	.2	.1	.0	.4	.0	2.3	.0
12	Otter	02010002	1,090	73.7	5.1	1.5	.4	14.1	2.8	1.1	.0	25.1	4,040
13	Winooski	02010003	1,220	162	9.7	3.8	.9	3.9	.6	.7	.6	20.1	2,930
14	Lamoille	02010005	1,130	77.8	5.3	3.0	.7	1.0	.0	1.0	.0	11.0	2,360
15	Missisquoi	02010007	707	25.0	1.7	.8	.2	14.5	.3	1.4	.0	18.9	460
16	Hudson-Hoosic	02020003	495	32.6	3.5	1.0	.0	.8	.0	.0	.0	5.3	.0
	TOTAL		9,605	563	38.7	16.5	3.8	43.7	3.7	6.6	519	632	17,700

[1] Areas given for the Upper Connecticut, Upper Connecticut-Mascoma, Middle Connecticut, Deerfield, Lake George, and Hudson-Hoosic basins are calculated because river-basin boundaries extend beyond State boundaries; areas for other basins are from Seaber and others (1987).

A water withdrawal generally refers to water removed for use from streams, reservoirs, or the ground. However, water can also be used without being moved from the stream channel--this is called instream use. The dominant instream use in Vermont is for hydroelectric-power generation. Hydroelectric instream use is discussed separately from withdrawals in this report for two reasons. First, unlike withdrawals, virtually no change in the quantity of the water takes place during hydroelectric instream use. Second, the volume of water used for hydroelectric-power generation is so large that it overshadows the combined withdrawals for all other uses. In Vermont, hydroelectric instream use is almost 30 times the total withdrawals. Other important instream uses include navigation, wastewater assimilation, recreation, and aquatic habitat.



Total withdrawals and hydroelectric instream use 18,300 million gallons per day

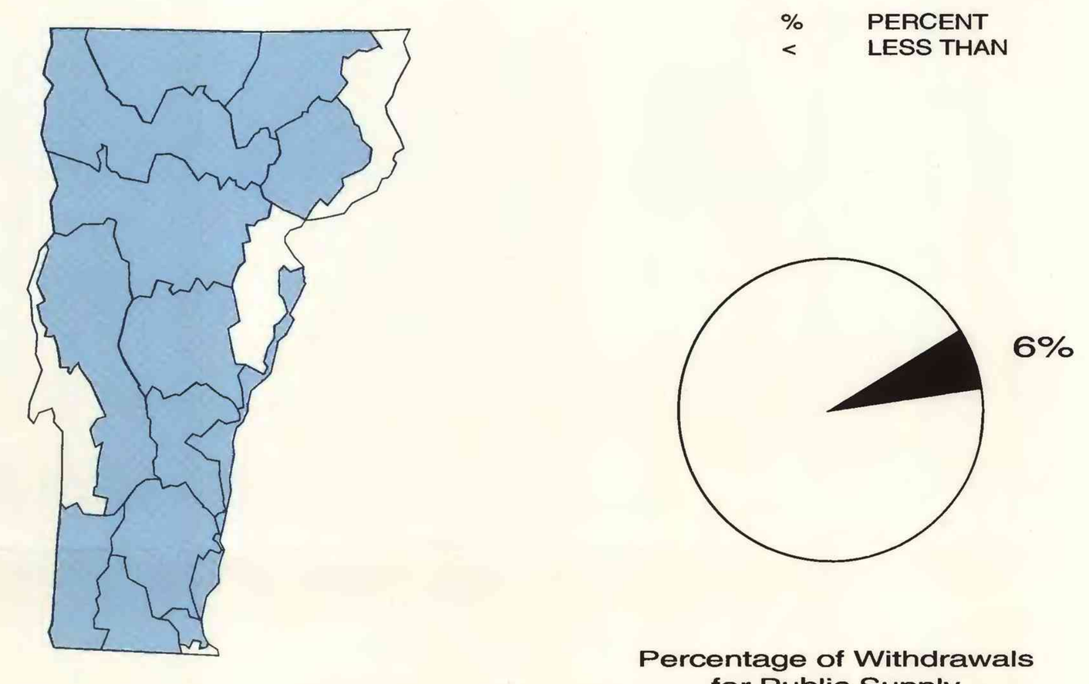
Total withdrawals 632 million gallons per day

EXPLANATION
< LESS THAN
% PERCENT

Hydroelectric instream use and total withdrawals in Vermont, 1990

WITHDRAWALS BY WATER-USE CATEGORY AND RIVER BASIN

EXPLANATION
WATER WITHDRAWALS IN MILLION GALLONS PER DAY
0 - 1
1.1 - 10
10.1 - 100
101 - 500
501 - 1,000
GREATER THAN 1,000
RIVER BASIN BOUNDARY
% PERCENT
< LESS THAN

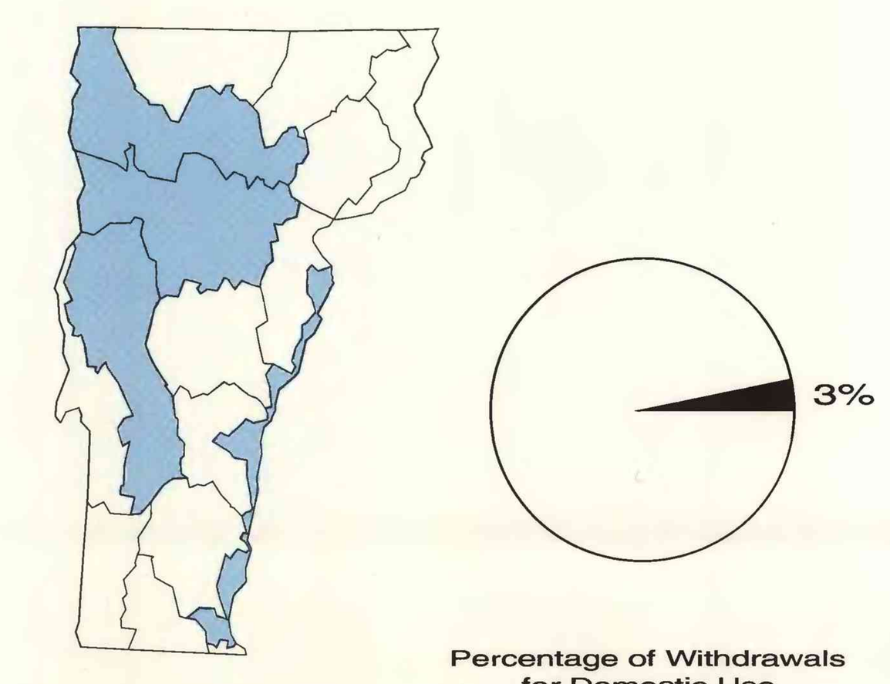


Percentage of Withdrawals for Public Supply

Public-Supply Withdrawals

Public-supply withdrawals: Water withdrawn by public and private water suppliers who provide water to various users, such as domestic, commercial, and industrial users, and thermoelectric powerplants. Public supply also includes public use, losses, and transfers to other public suppliers or basins.

* Public-supply withdrawals, 38.7 million gallons per day, accounted for 6 percent of total withdrawals.
* Public suppliers served approximately 333,300 people or about 59 percent of the State's population.
* The largest withdrawals for public supply were in the Winooski, Lamoille, and Otter River Basins, which include the cities of Burlington, Montpelier, Barre, Rutland, St. Albans, and Winooski.

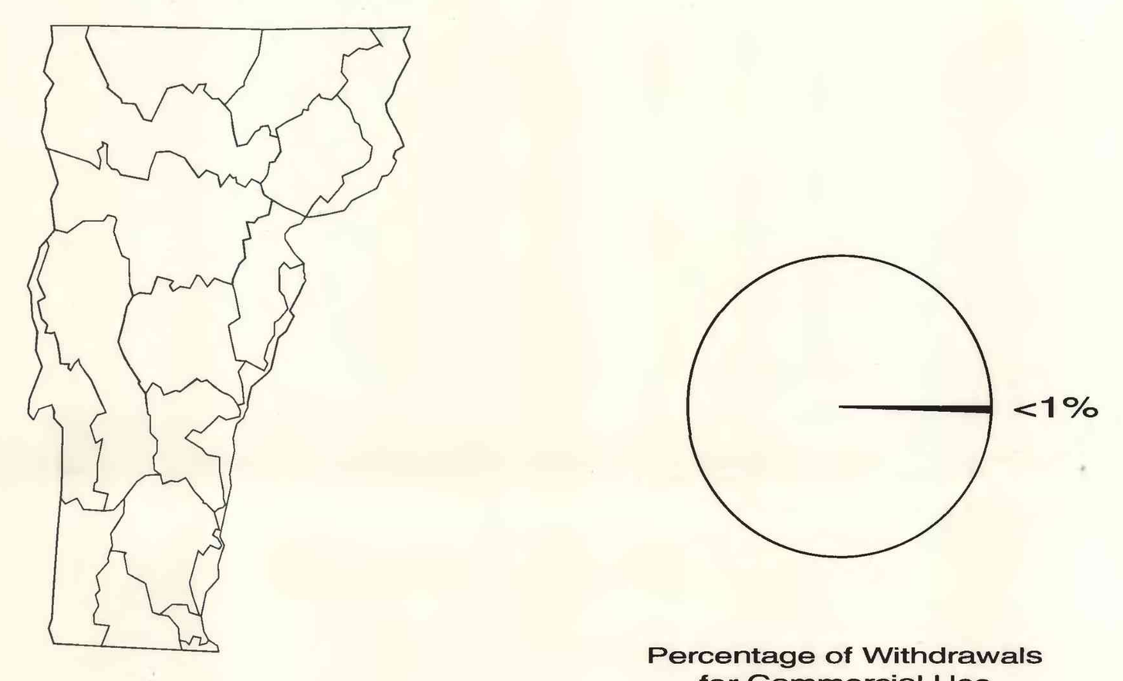


Percentage of Withdrawals for Domestic Use

Domestic Withdrawals

Domestic withdrawals: Water withdrawn for normal household purposes in homes, apartments, or in any place where people are included in a census survey. Domestic withdrawals include water used for drinking, preparing food, bathing, washing clothes or dishes, flushing toilets, and watering lawns and gardens.

* Domestic self-supply withdrawals, 16.5 million gallons per day, accounted for 3 percent of total withdrawals.
* Approximately 229,500 people or about 41 percent of the State's population were self-supplied.
* The largest withdrawals for domestic self-supply were in the Winooski and Lamoille River Basins, the areas with the largest suburban populations.

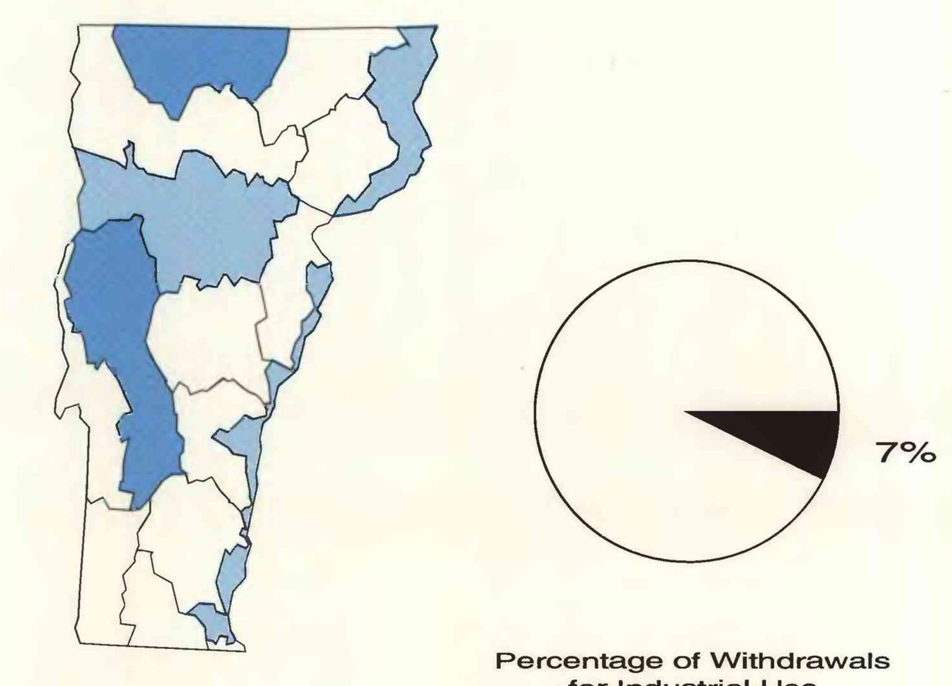


Percentage of Withdrawals for Commercial Use

Commercial Withdrawals

Commercial withdrawals: Water withdrawn for use in motels, hotels, restaurants, office buildings, and other commercial facilities, plus institutions, such as hospitals or schools. Water withdrawn for air conditioning and fish hatcheries also is included.

* Commercial self-supplied withdrawals, 3.8 million gallons per day, accounted for less than 1 percent of total withdrawals.
* The largest withdrawals for commercial-self supply were in the Winooski and Lamoille River Basins because of a large number of eating establishments in these basins.

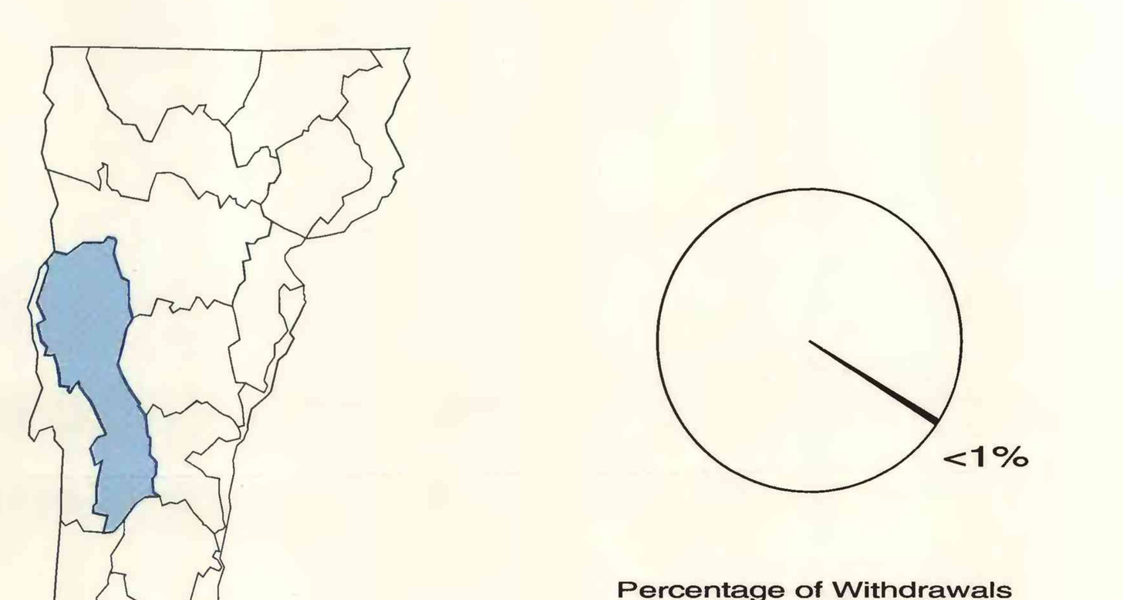


Percentage of Withdrawals for Industrial Use

Industrial Withdrawals

Industrial withdrawals: Water withdrawn for use in fabricating, processing, washing, and cooling industrial materials.

* Industrial self-supplied withdrawals, 43.7 million gallons per day, accounted for 7 percent of withdrawals.
* The lumber-and-wood-product and the paper-and-allied-product industries were the largest industrial groups withdrawing water.
* The largest withdrawals by industries were in the Missisquoi River Basin in the northern part of Vermont and in the Otter River Basin in the west-central part of Vermont. Major industrial withdrawals were also concentrated along the Connecticut River and Lake Champlain.

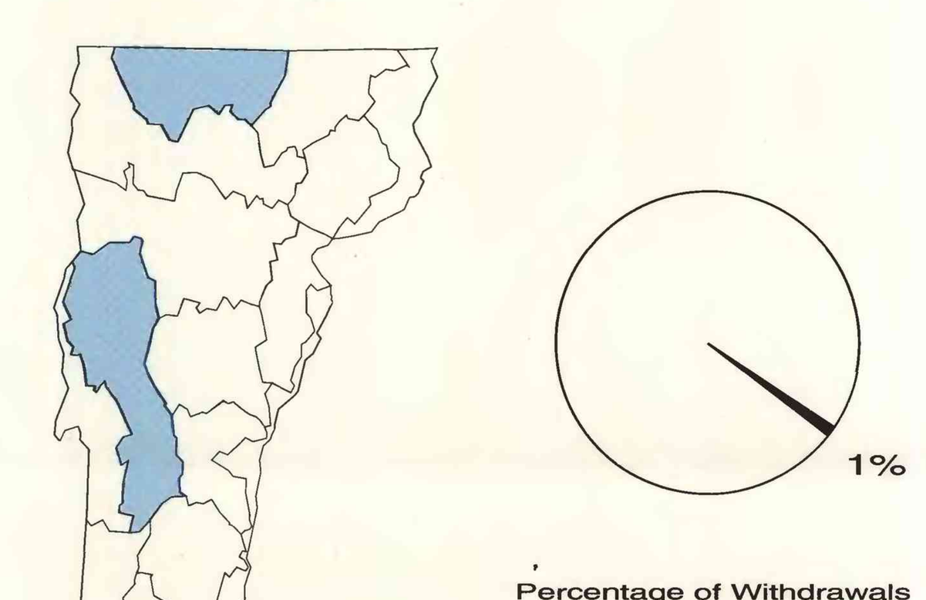


Percentage of Withdrawals for Mining Use

Mining Withdrawals

Mining withdrawals: Water withdrawn for use in the extraction of minerals, which includes withdrawals associated with quarrying, dewatering, milling (crushing, screening, washing, flotation), and other preparations customarily done at the mine site or as part of a mining activity.

* Mining withdrawals, 3.7 million gallons per day, accounted for less than 1 percent of total withdrawals. All mining operations in Vermont were assumed to be self-supplied.
* The only significant withdrawals for mining were in the Otter, Winooski, and Missisquoi River Basins.
* Dimension stone and crushed sand and gravel are the major mineral commodities in Vermont, in terms of quantity produced.

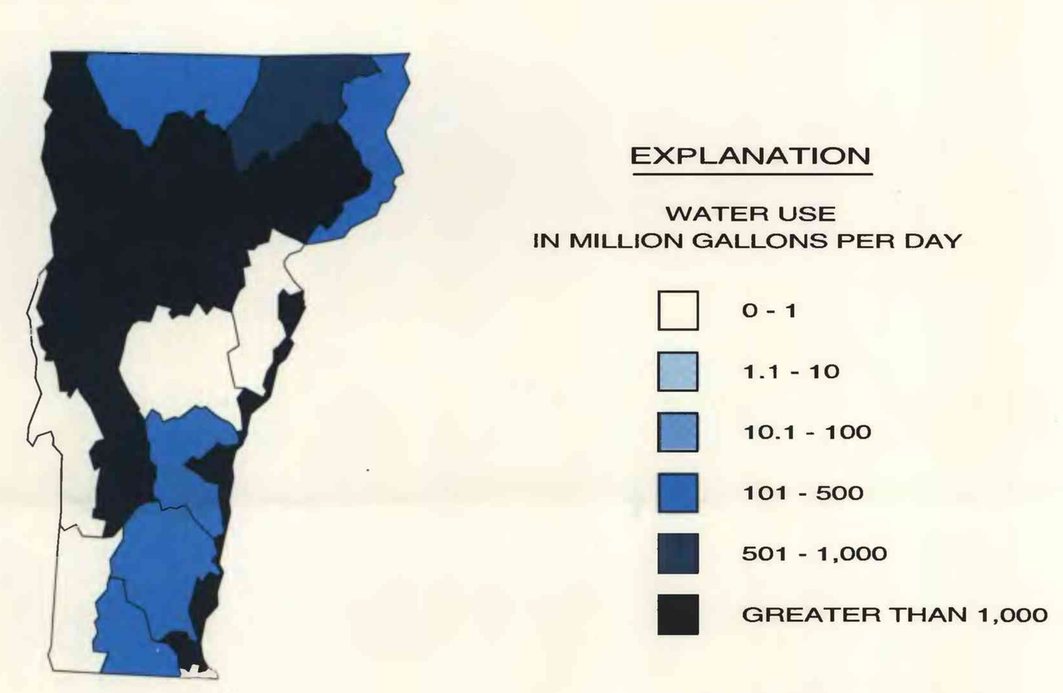


Percentage of Withdrawals for Agricultural Use

Agricultural Withdrawals

Agricultural withdrawals: Water withdrawn for use in irrigation and livestock watering.

* Agricultural withdrawals, 6.6 million gallons per day, accounted for 1 percent of total withdrawals. All agricultural withdrawals in Vermont were assumed to be self-supplied.
* The largest withdrawals for agriculture were in the Missisquoi, Otter, and Lamoille River Basins.
* The primary use for agricultural withdrawals was for livestock watering.

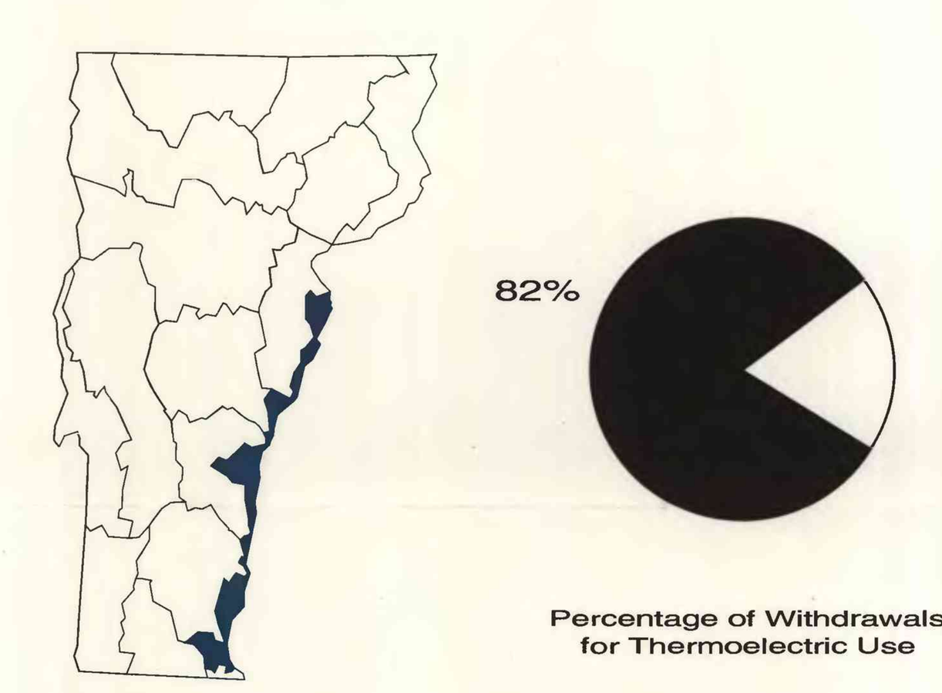


EXPLANATION
WATER USE IN MILLION GALLONS PER DAY
0 - 1
1.1 - 10
10.1 - 100
101 - 500
501 - 1,000
GREATER THAN 1,000
RIVER BASIN BOUNDARY

Hydroelectric Instream Use

Hydroelectric instream use: Water used in the generation of electricity at plants where the turbine generators are driven by moving water.

* Hydroelectric instream use, 17,700 million gallons per day from many small plants, uses 28 times the total volume of water withdrawn for all other uses.



Percentage of Withdrawals for Thermoelectric Use

Thermoelectric Withdrawals

Thermoelectric withdrawals: Water withdrawn for use in the process of generating thermoelectric power. The water is primarily used for cooling.

* Self-supplied withdrawals for thermoelectric-power generation, 519 million gallons per day, which were primarily for one plant, accounted for 82 percent of total withdrawals.

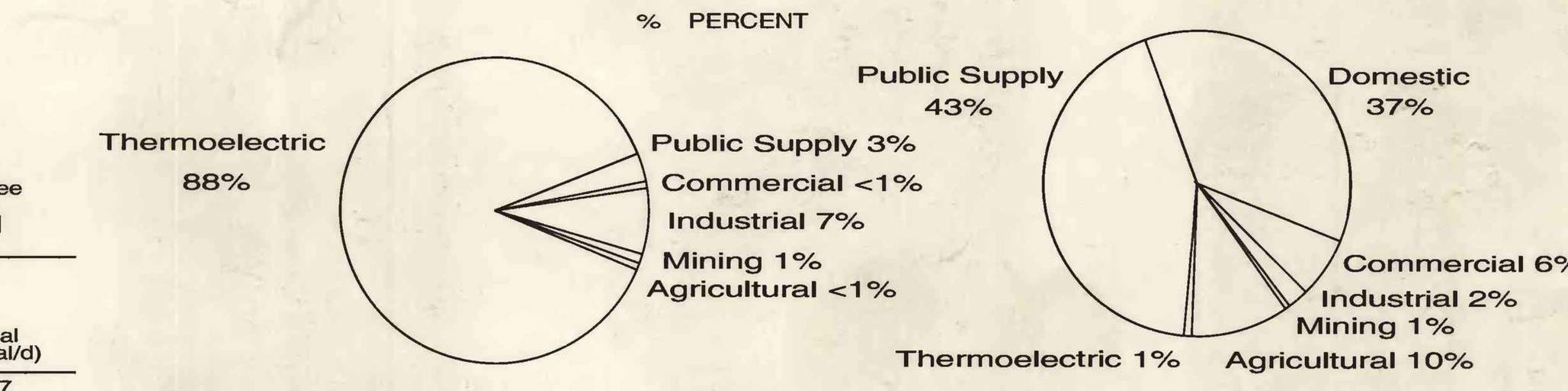
SURFACE-WATER AND GROUND-WATER WITHDRAWALS

Table 2.--Withdrawals of water by category and source in Vermont, 1990

[Numbers are rounded to the nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding; Mgal/d, million gallons per day]

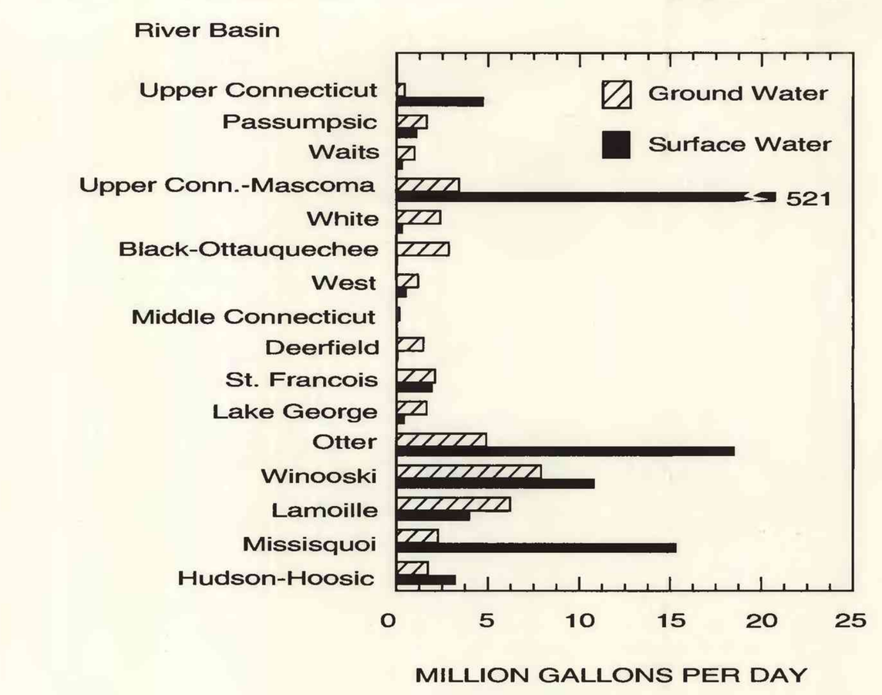
	Source		
Category	Ground water (Mgal/d)	Surface water (Mgal/d)	Total (Mgal/d)
Public supply	19.3	19.4	38.7
Domestic	16.5	.0	16.5
Commercial	2.8	1.0	3.8
Industrial	1.0	42.7	43.7
Mining	.3	3.4	3.7
Agriculture	4.6	2.0	6.6
Thermoelectric	.4	518	519
TOTAL	44.9	587	632

EXPLANATION
< LESS THAN
% PERCENT



Surface-water withdrawals in Vermont by category, 1990
587 million gallons per day

Ground-water withdrawals in Vermont by category, 1990
44.9 million gallons per day



Withdrawals in Vermont by river basin and source, 1990

Surface water is water that is present at land surface, such as in streams, reservoirs, and lakes. The major fresh surface-water bodies in Vermont are the Connecticut River along the eastern border with New Hampshire and the Lake Champlain system along the western border with New York.

During 1990, surface-water withdrawals were 587 million gallons per day and accounted for 93 percent of total withdrawals in Vermont. The largest surface-water withdrawals were in the Upper Connecticut-Mascoma, Otter, Missisquoi, and Winooski River Basins. The largest withdrawals in the Winooski and Missisquoi River Basins were from Lake Champlain. The largest surface-water withdrawal, 518 million gallons per day, was used for cooling in the thermoelectric plant on the Connecticut River just north of the Vernon Dam. This withdrawal accounted for 88 percent of total surface-water withdrawals. Withdrawals for industrial use, 42.7 million gallons per day, accounted for 7 percent of total surface-water withdrawals.

Ground water is the subsurface water that is present beneath the water table in soils and geologic formations that are fully saturated. When geologic formations yield significant quantities of water, they can be referred to as "aquifers." Vermont has three main types of aquifers--those in glacial deposits (such as stratified drift or till), in crystalline bedrock (such as schist), and in carbonate bedrock (such as limestone or marble).

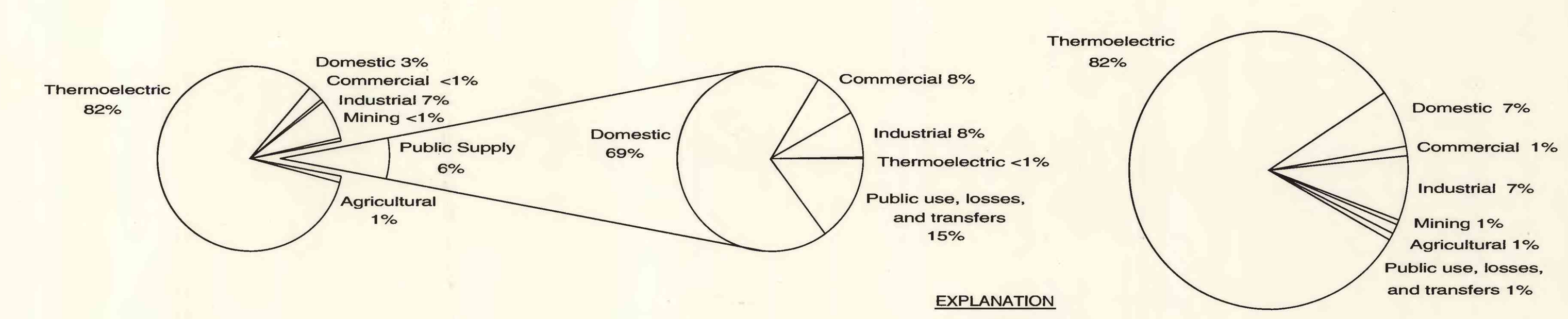
During 1990, ground-water withdrawals were 44.9 million gallons per day and accounted for 7 percent of total withdrawals in Vermont. The largest ground-water withdrawals were in the Winooski, Lamoille, and Otter River Basins from aquifers in stratified drift. The largest ground-water withdrawals, 19.3 million gallons per day, were for public supply and accounted for 43 percent of total ground-water withdrawals. Most of these withdrawals were from large-diameter wells (greater than or equal to 8 inches) in stratified-drift aquifers. Withdrawals for domestic use, 16.5 million gallons per day, accounted for 37 percent of total ground-water withdrawals. Most of these withdrawals were from 6-inch diameter wells in crystalline-bedrock aquifers.

SELF-SUPPLY WITHDRAWALS AND PUBLIC-SUPPLY DELIVERIES

Total withdrawals
632 million gallons per day

Public supply deliveries
38.7 million gallons per day

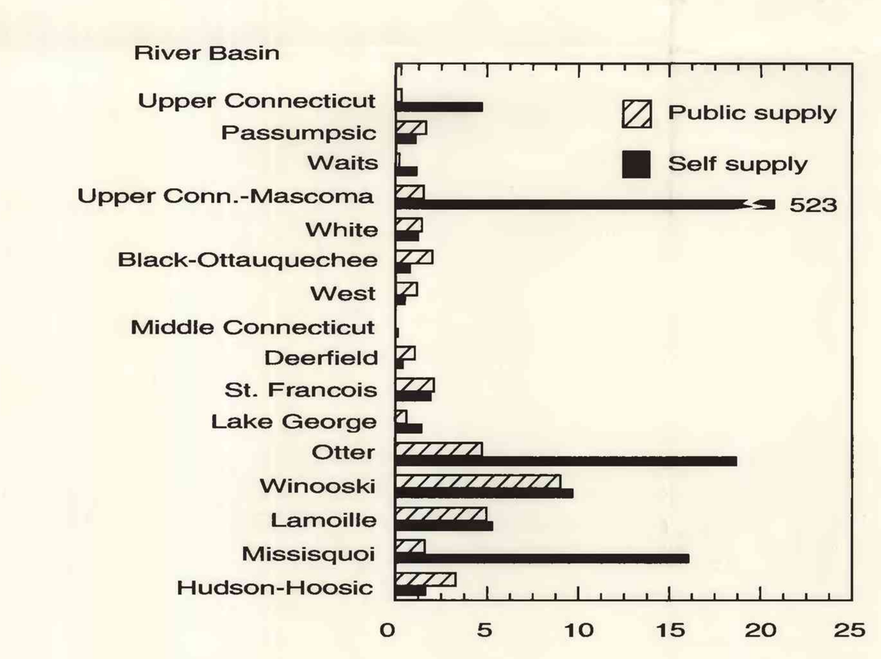
Total water use
(withdrawals and deliveries)



EXPLANATION
< LESS THAN
% PERCENT

Total withdrawals and distribution of public-supply deliveries in Vermont, 1990

Total water use in Vermont by category, 1990
632 million gallons per day



Self supply withdrawals and public-supply deliveries in Vermont, 1990

Public supply is water withdrawn by public and private water suppliers who provide water to various users, such as domestic, commercial, and industrial users, and thermoelectric powerplants. It also includes public use (water used for fire fighting, hydrant flushing, sanitation, and parks), losses that result from leaks in the distribution system, transfers to or from other river basins, and meter errors that may over-register or under-register the actual volume of water flowing through the meter. In the table below, large positive values in the column headed "Public use, losses, and transfers" reflect large exports of public-supply water to other river basins.

During 1990, withdrawals for public supply were 38.7 million gallons per day, about 6 percent of the water withdrawn in Vermont. (Public use, losses, and transfers were included in this amount.) The largest public-supplied deliveries were in the Winooski, Lamoille, and Otter River Basins, where public-supply systems in the cities of Burlington, Montpelier, Barre, Rutland, St. Albans, and Winooski served residents and local commercial and industrial users. Domestic deliveries, 26.6 million gallons per day (69 percent), were the largest category of public supply.

Self-supply water is water that is withdrawn from a surface-water or ground-water source by a user rather than obtained from a public supplier. During 1990, self-supply withdrawals were 593 million gallons per day, almost 94 percent of water withdrawn in Vermont. Cooling water for the thermoelectric powerplant on the Connecticut River in the Upper Connecticut-Mascoma River Basin, 518 million gallons per day, accounted for the largest use of self-supply water. Excluding withdrawals for thermoelectric powerplants, the largest self-supply withdrawals were in the Otter, Winooski, and Missisquoi River Basins. Industrial and domestic uses accounted for the second and third largest withdrawals of self-supply water.

Total water use is the quantity of water used for a specific category and is the combination of self-supply withdrawals and public-supply deliveries. For example, the domestic-use category, which only accounts for 3 percent of total withdrawals, is the third largest total water-use category (7 percent) in Vermont.

Table 3.--Use of water by category and supply type in Vermont, 1990

[Numbers exclude hydroelectric instream use; values are rounded to nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding; Mgal/d, million gallons per day]

	Supply type		
Category	Public supply (Mgal/d)	Self supply (Mgal/d)	Total (Mgal/d)
Domestic	26.6	16.5	43.1
Commercial	3.1	3.8	6.9
Industrial	3.1	43.7	46.8
Mining	.0	3.7	3.7
Agriculture	0.0	6.6	6.6
Thermoelectric	.1	519	519
Public use, losses, and transfers	5.8	.0	5.8
TOTAL	38.7	593	632

Table 4.--Population with public- and self-supply water, and public supply deliveries of water in Vermont, 1990

[Units are in million gallons per day (Mgal/d), except where noted; population numbers are rounded to the nearest hundred people; other numbers are rounded to the nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding]

			Public-supply deliveries					
River Basin	Population with public supply (thousands)	Population with self supply (thousands)	Public use, losses, and transfers	Domestic	Commercial	Industrial	Thermoelectric	Total
Upper Connecticut	4.9	1.3	0.1	0.3	0.0	0.0	0.0	0.4
Passumpsic	9.9	10.6	.3	1.3	.1	.1	.0	1.8
Waits	2.5	8.0	.0	.2	.0	.0	.0	.2
Upper Connecticut-Mascoma	12.6	26.8	.2	1.3	.1	.1	.0	1.7
White	15.5	8.6	.3	1.1	.1	.1	.0	1.6
Black-Ottauquechee	11.0	9.3	.3	1.7	.1	.1	.0	2.2
West	18.9	.6	.1	1.0	.1	.1	.0	1.3
Middle Connecticut	.0	2.8	.0	.0	.0	.0	.0	.0
Deerfield	3.6	3.0	.2	1.0	.0	.0	.0	1.2
St. Francois	14.7	6.0	.3	1.6	.2	.2	.0	2.3
Lake George	8.6	12.7	.2	.5	.0	.0	.0	.7
Otter	53.2	20.5	.8	3.7	.3	.3	.0	5.1
Winooski	109.3	52.7	1.3	6.3	1.1	.9	.1	9.7
Lamoille	36.6	41.2	.8	3.9	.3	.3	.0	5.3
Missisquoi	14.1	10.9	.2	1.3	.1	.1	.0	1.7
Hudson-Hoosic	18.1	14.5	.6	1.5	.6	.8	.0	3.5
TOTAL	333.3	229.5	5.8	26.6	3.1	3.1	.1	38.7

INTERIOR--GEOLOGICAL SURVEY, RESTON, VIRGINIA--1995

For additional information write to:
District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275

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ESTIMATED WITHDRAWALS AND USE OF FRESHWATER IN VERMONT, 1990

By
M.A. Horn and Laura Medalie
1995