VERMONT WATER USE DATA AND RESEARCH

U S Geological Survey Non-Competitive Grant G15AS00001

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TABLE OF CONTENTS

Introduction

The State of Vermont recognizes that there can be impacts to the use and quality of our waters and as a result, the Department of Environmental Conservation (DEC) in the Agency of Natural Resources (ANR) employs regulatory processes for managing such impacts in addition to developing methods for evaluating the resource. The Drinking Water and Groundwater Protection Division (DWGWPD), the Vermont Geological Survey (VGS), and the Watershed Management Division (WSMD) in DEC are actively working on groundwater and surface water issues through development of framework characterization data and through permitting programs.

Groundwater provides approximately seventy percent of Vermont's drinking water. In the past forty years stewardship over this resource has increased to address evolving issues. In the late 1960s in response to drought, Vermont well drillers began filing reports of wells drilled. In the late 1970s public water systems began testing new wells for interference with neighboring wells. In the 1980s groundwater quality problems emerged ranging from naturally occurring radionuclides and arsenic to man-made solvents and petroleum products. Clean up efforts began to address groundwater contamination from waste disposal sites, and source water protection area mapping and protection planning began for public water system wells. In the 1980s and 1990s rules were adopted to better protect new wells from septic systems following increased concerns of pathogens. Groundwater issues now include areas of low yielding wells, lowering health standards for naturally occurring elements, and concerns about locating and protecting future municipal sources of drinking water. Today virtually all wells and water systems are permitted under the Vermont Water Supply Rules (1992, 2005, 2010) adopted by the Agency of Natural Resources.

Passed during the 2006 session of the 2005 Biennium, Act 144 authorized the evaluation of statewide groundwater management and protection. Section 5 of Act 144 directed the Agency of Natural Resources to report on:

(1) An analysis by the agency of natural resources of whether the withdrawal of groundwater or bottling of drinking water in certain geographic areas of the state has impacted the use or quality of groundwater or surface water for domestic drinking water or other purposes;

(2) A listing of any areas identified under subdivision (1) of this section, a summary of how the agency of natural resources responded to groundwater or surface water shortages in those areas, and agency recommendations on how to avoid similar impact areas in the future;

(3) A compilation of groundwater supply information included in the well completion or closure reports submitted to the agency of natural resources in the last 15 years by licensed well drillers;

(4) The amount of drinking water approved for bottling per day from each source in the state permitted under 10 V.S.A. § 1675 for use by a bottled water facility;

(5) Any groundwater mapping completed by the agency; and

(6) Any other information deemed relevant by the agency.

In response to Act 144, the VGS conducted an analysis of existing water well data and datasets (Gale and others, 2009) and Vermont Rural Water Association reviewed well interference data. ANR contracted with the USGS to produce a water use study. The study by Medalie and Horn (2010), partially funded through the DEC, made use of available data to estimate use values and produced a water use database (VWU) for the State. The report also identified data limitations such as inaccurate water well locations, assumed values for coefficients such as per-capita water withdrawals, lack of seasonal data, and lack of site-specific data. Medalie and Horn (2010) pointed out that a major missing component of the water resource assessment was detailed information on groundwater withdrawals. Groundwater use and withdrawal in Vermont is only regulated through permitting of Potable and Public water sources and large (>57,600 GPD) commercial and industrial withdrawals. While it is reasonable to assume that there is a sufficient supply of groundwater for current uses, the impacts of groundwater withdrawal are not regularly or systematically evaluated, and much of what we know about the use and impact of groundwater within the state is based on estimates, primarily from the 2010 Medalie and Horn report.

The Vermont legislature passed Act 199 in 2008 and declared Vermont's groundwater a public trust. A permitting process and reporting of large groundwater withdrawals followed. Groundwater withdrawal permits and reporting requirements in DWGWPD are for groundwater withdrawals that do not meet the exemption criteria listed in Act 199 as follows: withdrawals used exclusively for fire suppression, or other public emergencies; domestic, residential use; farming; dairy processing and milk handlers licensed in accordance with 6 V.S.A. subsection 2721; closed loop, standing column, or similar non-extractive geothermal heat pumps; public transient and non-transient, non-community water systems not withdrawing more than 57,600 GPD for commercial, industrial, purposes; for the investigation or remediation of a release of a hazardous material that is being supervised by the Secretary under 10 V.S.A., Section 6615b or 10 V.S.A., Chapter 159, subchapter 3; and public community water systems as defined in 10 V.S.A. subsection 1671. Bulk and bottled water suppliers of any size are required to obtain a Source Water Permit pursuant to the Environmental Protection Rules (EPR), using Chapter 21, the Water Supply Rule and the requirements of Chapter 24, the Groundwater Withdrawal Reporting and Permitting Rule. Existing groundwater withdrawals of greater than 20,000 gallons per day need to be reported annually to ANR.

Water Use and Work Plan Development

The DEC seeks better quality water withdrawal and consumptive use data to apply towards water budget analyses and towards identification of geographic areas in need of detailed groundwater and hydrogeological information. Vermont's Regional Planning Commissions requested our assistance in defining areas at higher risk during drought and in understanding groundwater availability. The USGS, through the water use grant process as authorized by the SECURE Water Act, is working with states to develop higher quality water use data.

The long-term grant objective is to improve availability, quality, compatibility and delivery of water-use data. Vermont does not currently report water use data to the USGS. Medalie and Horn, 2010, did not attempt to fit the Vermont data into the USGS Site Specific Water-Use Data System (SWUDS) or the New England Water Use Data System (NEWUDS) which have "exacting requirements" since they would not accommodate available data. The water use database delivered by USGS to ANR is a "stand alone" MS Access database which has not been updated or reviewed since 2010. Water distribution data is collected by the DWGWPD from some public water system operators, although the data is not made publically available via the web site. The Work Plan proposed will allow Vermont to build internal databases, move data to standardized formats, and develop a system for data export and reporting to USGS. This will be the first systematic report of water use data to the USGS.

The first grant phase was to develop a work plan in coordination with the USGS and all Divisions in the Department of Environmental Conservation. We also reached out to the Agency of Agriculture. The DEC sub-contracted a large portion of the planning work and conducted the following activities during 2015-2016: 1) Produced an inventory of data held by the DEC including the number of records, whether or not geographic data existed for the record, the data format, and dates of records; 2) Reviewed existing data formats, reporting methods, and data collection methods; 3) Identified methods and resources required to increase data quality in each major USGS water withdrawal reporting category; 4) Developed a work plan, timeline and budget that would have the greatest impact on improving water use data collected in Vermont.

During the 2015 grant year we hired a non-profit, Vermont Rural Water Associates (VRWA), to assess and inventory the current state of data collected in Vermont. The inventory is presented in Table 1. VRWA conducted interviews with DEC personnel to ascertain the format and quality of data held in the Department. The majority of groundwater and surface water data is held and maintained by 1) DWGWPD in either the SDWIS database for public supplies or in the Well Completion Report database, or 2) WSMD (surface water) in excel spreadsheets or as pdf documents. Data is collected as pdf files, in databases, in word documents, and on paper.

DATA DESCRIPTION	RELEVANT USGS CATEGORIES	FORMAT	DATASET/FILE NAME	FIELDS	GPS LOCATION Y/N	STREET ADDRESS Y/N	NUMBER OF RECORDS	DATA START DATE	DATA END DATE	NOTES	WORK PLAN	SOURCE	GROUNDWATER /SURFACE WATER	Funding amounts (removed)	PRIORITY
USGS Vermont Water Use database: USGS, funded through the State of Vermont, delivered a water use database in MS Access. Data was based on estimated values and data available through 2005. Metadata includes data sources and methods. No data is routinely reported to USGS.											Conduct full review, edit and update of the VWU MS Access database (2010). Include new data sources, 12 digit WBD, and potentially export data or re-design database to be compatible with in-house datasystems.	DWGWPD	G/S		High - Years 1-4
Monthly reported water withdrawals for CWS, NTNC, and those TNCs that are disinfecting. Water use data reported include gallons used, water source (ground or surface water). The usage data is contained in the GEC_WATER_USAGE table (the field is gwu_gallons_used). Reports are received in paper format, entered into SWWU by staff, scanned and archived. Reported monthly. Minimum reporting value is 0.	Public Supply, Commercial, Industrial, Irrigation - Golf Courses, Crops, Livestock	Microsoft SQL 11	SDWIS/GECWS	Reporting year, Water system ID, Facility ID (water source), total gallons/bulk or bottle gallons by month	Y - incomplete	Y - incomplete	Database 106,037 / PDFs archive 35,574	1995	Present	A)Water use information must be correlated to other tables in the SDWIS database for information on the actual location of intakes for mapping purposes and assignment to HUC 8. B) Many USGS categories are relevant here, but without knowing about the PWS customers, we can't determine where the water is going geographically or to what customer type (homeowner, commercial, golf course, etc). Many PWS do not meter individual customers.	A) Correlate monthly water use data to other tables within SDWIS as necessary to determine intake locations. Integrate with VMU database. B) Require PWS to meter each customer and report monthly usage by USGS category. C) Assign HUC 8 and 12 digit WBD.	DWGWP	G/S	For A and B,	High - Years 1-2
Well driller reports submitted to DWGWPD. Data includes 64 fields such as location , depth, static water level, gravel or bedrock well, and yield. Types of materials and depths are available in tables. Locations prior to 2010 are highly suspect. The well completion database is part of the GEC_WS but there is also a scanned archive of PDFs. A "well use code" of 1 indicates domestic. Reported at time of drilling. Minimum reporting requirement is 0.	Self-Supplied Domestic	Microsoft SQL 11	GEC_WS/Well Completion Report Database	Well use code	12481/105,248 have a GPS location; 12220 have an E911 address location. Data checked 9/7/2016	A portion has a physical address or the address of the property owner whether on premises or not.	Estimated 106,000	1966	Present	A) Locations are known to be inaccurate. DEC developed protocols to attach wells logs to E911 addresses. B) Many wells are missing tags. DEC has protocol for assigning new tags. C) Transcription errors resulted in numerical errors in the database. D) Many records are incompete or missing data.	A) Employ previously developed protocols to link well locations to well record to improve accuracy and allow for placement in HUC 8 and in 12 digit WBD. B) Clerically review records to correct errors. C) Review materials and assign hydrogeologic codes. Codes are based on porosity and permeabily and impact interpretations of rate of infiltration. These are used for water budget calculations. D) Review/verify bedrock/gravel well designations.	DWGWP	G	For A -D,	High - Years 1-2
Effluent data pertaining to 94 municipal, 95 industrial facilities and 42 pretreatment permits. A majority of effluent data is required to be reported on a monthly basis, however there are several that are permitted to report quarterly, semiannually and annually. Reports come in hard copy format (though the pretreatment facilities can submit hard copy or electronic). Reported monthly, semi-annually or annually.	Commercial, Industrial, Aquaculture, Mining, Thermoelectric	Microsoft SQL 11	Wastewater Inventory Database (WWInv)	Permitee, permit number, month/year, total flow (mgd). The Permit Program Category field could be used to differentiate industry types.	Y* - incomplete	Y	Estimated 44,000	2000	Present	Some water withdrawal data for industrial facilities may be in SDWIS. However, there are facilities using water that will only be reported as effluent. The effluent data will need to be correlated to the facility for mapping using the permit database, which is also in SQL. Latitude and longitude is not complete and what they do have may be out of date.	A) Correlate reported discharges to permits database for precise location of outflows. B) Compare to SDWIS and eliminate duplicate records (those facilities already reporting gallons pumped on their monthly reports). C) Require each source be listed on monthly reports. D) Assign HUC 8 and 12 digit WBD.	WSMD	G/S		Medium - Years 3-5
Report of groundwater withdrawals of greater than 20,000 GPD. Water usage is reported annually on hard copy and maintained in a text file by DWGWPD. There is also a permitting requirement for withdrawals >57,600 GPD; 1 permit has been issued to date. Reported annually. Minimum reporting requirement is 20,000 GPD.	Industrial, Commercial, Aquaculture, Mining, Thermoelectric, Irrigation - Golf Course, Livestock	Microsoft Word	File name: GW Withdrawals 2008-2013 Greater than 20.docx	System name, town, use in GPD, year	N	N	39	2008	2014	A) The list of facilities reporting is likely be incomplete.	A) Obtain GPS locations for source(s). B) Create spreadsheet or database for data, methods for updating data, and to track water usage including facility and well locations. C) Determine if source is in bedrock or surficial materials. D) Assign HUC 8 and 12 digit WBD.	DWGWPD	G		High - Year 1
There is no known source of water use data for this category within DEC. Agricultural activities are exempt from reporting their water withdrawals. However, the United States Agency of Agriculture conducts Farm and Ranch Irrigation Survey every five years, with the results available on their web site. This may provide good estimates statewide, but will lack site specific data required to meet Tier 1 standards. Only large farms withdrawing more than 57,600 GPD are required to report.	Irrigation - Crop, Livestock	PDF	FRIS	Table 12: Calves and Cattle Inventory / Tables 9+10: Crop Irrigation	N	N		2003	2013		A) Develop comprehensive list of agricultural facilities and locations. B) Use FRIS data to populate water usage fields every 5 years. B) Use cattle counts to estimate usage for the Livestock category. C) Enact legislation to remove the farm exemption from the water withdrawal reporting rules. D) Assign HUC 8 and 12 digit WBD.	Agency of Agriculture	G/S	Requires regulatory change.	Low
Flow Protection Program reports with flow rates from 20-25 facilities are submitted to Jeff Crocker (WSMD) periodically (with some facilities required to submit quarterly). These are run of river projects so outflow is required to match inflows. Hourly data is reported periodically. Minimum reporting value is 0.	Hydroelectric Power	Excel	Y: drive, Flow Protection Program folder, folder by project	Hourly streamflow data	Y	N	Approx 1,000	1996	Present		A) Standardize the water use report format. B)Formalize database for the withdrawal information. C) Assign HUC 8 and 12 digit WBD.	WSMD	S		High - Years 3-5
Flow Protection Program reports from 20 snowmaking facilities are submitted to Jeff Crocker (WSMD) monthly during the snowmaking season. There is no standard to the report format as these systems are unique. Streamflow data is hourly from SCADA system. Reported monthly. Minimum reporting value is 0.	Commercial (snow making)	Excel	Y: drive, Flow Protection Program folder, folder by project	Hourly streamflow data, gallons pumped	Y	N	Approx 1,800	1998	Present		A) Standardize the water use report format. B)Formalize database for the withdrawal information. C) Assign HUC 8 and 12 digit WBD.	WSMD	S		High - years 1-3
Flow Protection Program files are submitted to Jeff Crocker (WSMD) in late November under conditions of their permit. There is no standard to the report format as these systems are unique. This is not a comprehensive list of golf courses, just those using surface water for irrigation (a total of 5). Minimum reporting value is 0.	Irrigation - Golf Courses	Excel	Y: drive, Flow Protection Program folder, folder by project	Hourly streamflow data, gallons pumped	Y	N	Approx 75	2004	Present		A) Standardize the water use report format. B)Formalize database for the withdrawal information. C) generate a complete list of golf courses and their GPS location. D) Assign HUC 8 and 12 digit WBD.	WSMD	S		High - Years 3-5
Flow Protection Program files are submitted to Jeff Crocker (WSMD) annually under conditions of their permit. There is no standard to the report format as these systems are unique. This is a relatively small number of projects (5) including a paper mill, asphalt plant, gravel pit, power plant and lumber mill. Minimum reporting value is 0.	Industrial, Mining, Thermoelectric	Excel	Y: drive, Flow Protection Program folder, folder by project	Hourly streamflow data, gallons pumped	Y	N	Approx 25	2004-2006 depending on industry	Present		A) Standardize the water use report format. B)Formalize database for the withdrawal information. C) Assign HUC 8 and 12 digit WBD.	WSMD	S		Medium- Years 3-5
All data											Develop and implement data quality and data control assurances and procedures; recommend ideal minimum reporting requirements and propose public interface for data.	DWGWPD			High - Years 1-5

Some data submitted in pdf format is excluded from the databases and spreadsheets. For example, although Vermont has the data on file and has the capacity to distinguish surface water from groundwater withdrawals for public water supplies (Baseline Goal, Tier 1), that data is not currently tracked.

Methods to Upgrade Data in USGS Categories

Data types and quality were reviewed by USGS category and are also summarized by dataset in Table 1. Furthermore, documentation of data used and estimation methods used by Medalie and Horn (2010) is provided in Appendix A. In areas where regulatory or legislative changes would be required in order to meet Tier Level requirements, the data upgrade was placed into a low priority status since we are unable to provide any accurate assessment of personnel time, costs or potential outcome.

<u>Public Supply:</u>

Tier 0: Achieved with the exception of "Deliveries to domestic users not quantified". PWS report withdrawals monthly, but not by customer type (domestic, commercial, etc). A regulatory change is necessary to require Public Water Supply (PWS) to report water deliveries by customer type.

Tier 1: Achieved with the following exceptions:

- "Deliveries to domestic users reported". PWS report withdrawals monthly, but not by customer type (domestic, commercial, etc). A regulatory change is necessary to require PWS to report water deliveries by customer type.
- "GW withdrawals by aquifer designation". Comprehensive statewide aquifer maps do not exist, although groundwater, surface water, gravel or bedrock designations can be determined and verified for public supply and for those private water wells (drilled between 1966 and present) included in the well driller database.

Tier 2: As with the lower tiers, a regulatory change is needed to require PWS to report by customer type. It will also be necessary to correlate the monthly withdrawal reports with other data in the SDWIS database to determine water purchased by consecutive systems and withdrawals by source/intake.

Tier 3: "Interbasin transfers reported" and "internal, non-revenue uses and losses reported" are goals that could be achieved with more rigorous mapping and reporting requirements. "Use of reclaimed wastewater for public/landscape irrigation" may be irrelevant in that there is no known use of reclaimed wastewater for this purpose.

Important notes concerning all tiers:

- TNCs are not required to report withdrawal information unless they continuously disinfect. This accounts for 600-700 water systems.
- Monthly report forms would require revisions to accommodate expanded water use information. The Global Environmental Consulting, Inc (GEC) software application SWWU (Safe Water Water Usage which connects to the Safe Drinking Water Information System -SDWIS) would also require modifications to accept the expanded monthly report information.
- PWS withdrawals do not equal PWS deliveries. An estimated 10-15% is unaccounted for. Proper metering and leak repair are essential first steps in reducing this. There are also PWS that do not have metered customers. A study of those systems and their customer numbers would need to be conducted before any estimation on time and costs associated with adding meters could be offered.

As part of the regulatory requirement that compels PWS to report by user type, the PWS will need education and financial assistance with metering and clerical work.

Relevant data sets: Refer to accompanying inventory spreadsheet

<u>Self-supplied domestic (non-public):</u>

Tier 0: The "Use of 1990 census to estimate self-supplied populations" would need to be used in conjunction with the values for population served by PWS.

Tier 1: As with above, the "Self-supplied domestic populations" can only be determined by subtracting PWS population served from the total population. The other elements on Tier 1 rely on mapping of populations and PWS to HUC8, county and source.

Tier 2: These goals require studies of metered domestic withdrawals which requires the cooperation and education of domestic users and the installation of meters. Cost and time to implement depends on the scope of the study. The goals also call for improved estimates using PWS service areas, property data and other methods. A study of possible estimation method improvements would be necessary.

Important note concerning all tiers:

- Proper mapping of private wells in the state of Vermont is essential in meeting the Tier 1 goals. This project, which will involve clerical review of records in each county, is estimated to take 1-2 years. The clerical review would not just update location, but correct errors and add information missing from the well driller reports.

Relevant data sets: Refer to accompanying inventory spreadsheet

Industrial:

Tier 0: A regulatory change may be necessary in order to require self-supplied industrial facilities to report annual withdrawals per Tier 0 standards. It is assumed most of the facilities in this category are Non-Transient Non-Community (NTNC) so they currently provide monthly withdrawal reports, but their process water is probably not the same potable source. Some facilities may currently report water withdrawals (rivers/streams or PWS as a source, for example) or discharges (to Watershed Management) in accordance with their permitting requirements, but there is not one rule that addresses all water users in this USGS category.

Tier 1: As with Tier 0, it will be necessary to identify which facilities fall under this USGS category. SIC codes can be assigned based on industry type. "Groundwater withdrawals reported with reference to aquifer" will rely on the existence of accurate well locations and associated data.

Tier 2: The goals related to withdrawals by site specific intake/well and water type would be achieved as part of the regulatory change needed to compel water use reporting. Those Tier 2 goals related to deliveries from Public Supply or other sources would be met with the regulatory changes suggested in the Public Supply category (water use reported by customer type, unless they are NTNC as described above).

Tier 3: These goals relate to consumptive use and discharges. A working knowledge of the manufacturing process would be necessary, along with the possible addition of meters, to achieve these goals. Site specific discharges may already be reported to WSMD.

Relevant data sets: Refer to accompanying inventory spreadsheet

* There is a well use code on the well driller reports specific to Industrial but it is known that the well driller report database is incomplete/inaccurate.

Irrigation - Crops:

No water use information in this category is collected by DEC or the Agency of Agriculture.

Tier 0: Data on "Annual aggregate withdrawals" can be found in the USDA FRIS census (Tables 9+10, Crop Irrigation) reports, though the census is only conducted every five years.

Tier 1: These goals refer again to aggregate areas, but are more specific to irrigation methods and water source – information that does not seem to be included in the USDA FRIS census. Acres irrigated, however, is included though it's noted in the Tier 1 goals that the areas should be summarized by county and HUC 8 which would require further work.

Tier 2: These goals generally relate to site specific withdrawals. Legislative action and a significant regulatory change would be required to necessitate the reporting of site specific water withdrawal data. It is possible that in the near future, proposed changes to required agricultural practices could result in the reporting of some or all surface water withdrawals for crop irrigation.

Tier 3: The "consumptive use and conveyance loss" estimations (by aggregate area) can be achieved using known water withdrawal data, standard industry coefficients and rainfall data. "Site specific return flows reported" may be calculated similarly, using site specific data as available from USDA or some other source.

Relevant data sets: Refer to accompanying inventory spreadsheet.

* There is a well use code on the well driller reports specific to Agricultural but it is known that the well driller report database is incomplete/inaccurate.

Irrigation - Golf Courses:

Tier 0: The "Location-specific list of golf courses" could be acquired from a number of nationwide business database compilers (Dun and Bradstreet for example). Online research may also yield a comprehensive list.

Tier 1: These goals relate to site specific withdrawals by month (also by source and acres irrigated). There is currently no single reporting requirement that covers all golf courses. Those using river/stream sources for irrigation currently report hourly streamflow data, as do courses using water delivered from PWS. However, it's important to note that it is the PWS that has the records on their customer water use; regulatory changes mentioned previously would make more accurate data available to the state in these situations.

Tier 2: The goal "acres irrigated reported by type of irrigation" could be achieved with the regulatory change mentioned above, and "Consumptive use estimates by course" can be achieved by correlating rainfall and other weather data to the reported water usage information for each site.

Relevant data sets: Refer to accompanying inventory spreadsheet.

Thermoelectric:

Tier 0: These goals require a list of thermoelectric plants with information on the type of water sources used. Similar to the list of golf courses needed (see above), it may be necessary to acquire a database from an outside source such as Dun and Bradstreet. We then need to conduct a survey or coordinate site visits to understand the water sources. It is probable that

not every small thermoelectric plant is currently reporting water withdrawals, although most should be reporting discharges to Watershed Management. With the closure of the Vermont Yankee Nuclear Plant, only two facilities now report.

Tier 1: These goals require a good deal of site specific information for thermoelectric plants (type of cooling system, net power generation, return flows) as well as monthly withdrawal information by water source. It may be necessary to make a regulatory change that specifically targets thermoelectric plants although much of the general plant information could be obtained through voluntary means (surveys, site visits).

Tier 2: The two goals in Tier 2 refer to "consumptive" use. Withdrawal information that is reported under the proposed regulatory change above could be compared with the outflow information that should be available for most/all plants in this category to determine "consumptive use".

Relevant data sets: Refer to accompanying inventory spreadsheet.

<u>Livestock:</u>

Tier 0: This goal calls for "Locations and water source for major livestock operations". It will be necessary to define "major" but there is at least one livestock operation that reports >20,000 GPD currently. In any case, it will be necessary to build a database of all livestock operations or obtain external data.

Tier 1: These goals require actual water use information (annual) to be reported for major facilities, along with information on the water sources used. Since such agricultural activities are currently exempt from any reporting requirements, it will be necessary to enact legislation to require reporting. It may also be possible to obtain from the USDA the site specific data as compiled during their regular FRIS survey (table 12: Calves and Cattle inventory) and make estimations based on those numbers.

Tier 2: Similar to Tier 1, but now including all (not just major) facilities. Again, it will be necessary to work with a comprehensive database of these facilities and develop the necessary regulatory changes. The Tier 2 goal of "Site-specific animal type and counts" could potentially tie in with the USDA FRIS survey mentioned above. The USDA may have site specific information, though the published census reports are listed by county.

Tier 3: This goal of "Improved and verified coefficients for water use per head" could be met by consulting with Agency of Agriculture personnel and comparing past coefficients to current industry standards.

Important notes:

These facilities use a mix of groundwater and surface water and some receive public-supplied water. Those receiving public supplied water would be included on the PWS usage reports if the goals of the Public Supply category are met (PWS required to report monthly usage by customer type).

It may also be worth noting that the "well use" code on some well driller reports could be used to identify facilities in this category. There is a well use code on the well driller reports specific to Agricultural but it is known that the well driller report database is incomplete/inaccurate.

Relevant data sets: Refer to accompanying inventory spreadsheet.

Mining:

Tier 1: These goals are not site specific, but rather call for withdrawals by county and HUC 8. However, it will be necessary to assemble a database of all the mining facilities that fit the USGS description before such data can be acquired. Some facilities already report water use (>20k GPD, withdrawals from rivers/streams, etc) but it is not known which facilities do not currently report withdrawals. Some discharges will be reported to Watershed Management but it may require more research into the nature of water use in mining facilities to understand how the wastewater discharges relate to the process and the permitting requirements of the facilities.

Tier 2: These goals are site-specific and refer to annual and monthly withdrawals as well as the site-specific commodity identified. As suggested in Tier 1, it will be necessary to build a comprehensive database of these facilities and most likely establish a regulatory change that would target these facilities specifically. Extraction operations in Vermont are identified in the US Department of Labor Mine Safety and Health Agency (MSHA) inspection lists.

Tier 3: These goals refer to the "water use by process" and "discharge from dewatering." A greater understanding of the types of facilities and their processes will be gained by the construction of the comprehensive database suggested above. Dewatering is regulated through discharge permits and underground injection control permits.

Important note:

Along with potential regulatory changes, it may be necessary to assist facilities with the installation of meters and education on reporting requirements.

Relevant data sets: Refer to accompanying inventory spreadsheet.

Aquaculture:

Tier 0: This simply calls for a list of facilities. There are federal, state and private facilities in Vermont. There are various reporting requirements for each, so it will likely be necessary to

assemble a database of all facilities before the goals of this or any higher tiers are met. Fish and Wildlife should be able to supply the foundation for such a database.

Tier 1: These goals are not site-specific but do require the reporting of annual withdrawals by county and HUC 8. Withdrawals from rivers/streams are currently reported, as well as discharges for most or all facilities. It is generally assumed that discharges match withdrawals, so it may be as simple as using discharge data as supplied by Watershed Management. However, some facilities are open air, so evaporation and rainfall can cause discharge volumes to differ from withdrawal volumes.

Tier 2: These call for site-specific monthly withdrawals (and general facility information which would be a part of the database suggested above). This would most likely require a regulatory change specific to hatchery withdrawals and possible metering at the facilities.

Note that aquaculture facilities using rivers/streams as a source are considered de minimis and do not have a reporting requirement.

Relevant data sets: Refer to accompanying inventory spreadsheet.

<u>Commercial:</u>

Tier 1: These goals (not site-specific) call for "Annual/monthly deliveries from PWS for commercial use". PWS currently report monthly water withdrawals/deliveries, but not by customer type. It is therefore impossible to know which PWS customer falls into this USGS category. It would be possible to assemble a database of known "commercial" facilities and determine which were served by PWS; then target them specifically with a new reporting requirement. Also, the regulatory change suggested in Public Supply would provide water withdrawal information monthly by customer type. The recently promulgated Groundwater Withdrawal Permitting and Reporting Rule includes both industrial and commercial withdrawals >20,000 GPD that are not PWS. Medalie delivered a documentation of data and estimation of values methods summary (Appendix A) to the DEC as part of the Medalie and Horn (2010) report.

Tier 2: These site-specific goals refer to annual/monthly withdrawals for *self-supplied establishments.* Many of these commercial facilities will be NTNC (25 for greater employees) and will report monthly; many facilities will not. It will be necessary to identify these facilities and establish a means of acquiring monthly water use data – either by regulatory requirement or some other means.

Relevant data sets: Refer to accompanying inventory spreadsheet.

* There are several well use codes on the well driller reports that include commercial uses, but it is known that the well driller report database is incomplete/inaccurate.

Hydroelectric:

Tier 1: All the Tier 1 goals appear to be met as regulations are in place through WSMD to manage streamflows/river levels. Site specific data is reported. However, the information on each hydroelectric project is organized separately in folders, with no consistent format between projects. Although the data is delivered to WSMD in Excel format, it is on a periodic basis for most (some deliver quarterly). This process would need to be streamlined/standardized to improve the flow of useful and relevant information to USGS. General information on hydroelectric plants can also be supplied by the Vermont Public Service Board / FERC – Federal Energy Regulatory Commission.

Relevant data sets: Refer to accompanying inventory spreadsheet.

Wastewater Treatment:

Tier 1: These goals refer to deliveries from WWTPs to other users (by category such as industrial, commercial, etc). There are apparently no treatment plants delivering reclaimed water to other users in the state of Vermont.

Relevant data sets: Refer to accompanying inventory spreadsheet.

Over-Arching Work Plan Components and Priorities

In addition to detailed work plan development, there are several over-arching criteria required by USGS:

- All data must be stored in an electronic format.
- A description of methods used to estimate values, coefficients, and/or other data must be provided.
- A description of data quality assurance and control procedures must be provided.
- Non-sensitive data, that is available for export or download from the state agency database, must be available to the USGS.
- The data must be made available to the USGS at the HUC8, county level, and aquifer (for groundwater sources).
- Interaction with USGS Water Science center personnel is required.

All inventoried datasets will be brought into compliance with the over-arching USGS criteria as defined above. Surface water and groundwater will be distinguished, as will

groundwater from bedrock or gravel wells. Data quality assurance control and procedures will be developed and implemented and data will be available electronically.

High Priority, Years 1-4: Review and Update of the USGS Vermont Water Use Database, 2010

In 2010, USGS delivered a report and a MS Access relational database to the State of Vermont which provided an estimate of water use drawn from numerous data sources and from estimated values (Medalie and Horn, 2010). Since that time, surface water use was substantially reduced due to the closure of the Vermont Yankee Nuclear Power Plant in Vernon, VT. Total water withdrawals are now roughly the same between surface water and groundwater.

The VWU contains over 36,000 records of site-specific data for public and non-public water supply facilities. A top priority for Vermont is to conduct a complete review of data and update of values in the USGS VWU database, to re-design the database to be readily compatible with other in-house systems, and to extract data in the compatible USGS water use categories. As examples, seasonal surface water use in snow-making areas is available and can be tracked; a recent requirement to report groundwater withdrawals in exceedance of 20,000 gallons per day can be tracked and could be included in the appropriate categories. A review will highlight areas where data is now reported instead of estimated, provide for numerous updates to properties and uses (commercial, industrial and population served), and when combined with the recent well interference study (2009) for 203 public community water systems will allow us to update locations, water source (surface water or groundwater) and groundwater aquifer type (bedrock, gravel, or spring) for each well in the system. The inventory of self-supplied industrial facilities will be updated and maintained. Details related to data improvement for USGS categories are provided below:

Primary costs are for salary and benefits to conduct the data review, update/edit data, and manipulate the database. We anticipate the project to be equivalent to 0.5 fte for two years or 1 fte for a two year grant period ($92,000).

High Priority, Years 1-2: Well Completion Report Database and GIS derivatives

A primary source of sub-surface and groundwater information for the State is the well completion report database. The water well database contains records from more than 105,000 wells completed between 1966 and the present. The database includes data for 64 different fields, including why the well was drilled (ex. new, replace existing supply, deepen existing), 23 different well use codes (ex. domestic, heating, industrial, agricultural), well statistics such as yield, depth, casing length, and screening, date completed, well type (gravel or bedrock), and location information. The dataset also includes depth drilled and types of materials drilled through. This information is key to understanding porosity and permeability of sub-surface

materials and in the development of water budget analyses. However, the data was derived from well driller reports and the accuracy of the data is varied.

In the 2005-2006, the Vermont Legislature passed Act 144 which directed the Agency of Natural Resources to provide a compilation summary of water well log completion data. The VGS reviewed the data and developed a derivative data set in ArcGIS in order to view the data geographically and with the associated surficial and bedrock materials. Work done to date with the data was summarized in an Open File Report in 2014: Gale, M., Springston, G., Van Hoesen, J. and Becker, L., 2014, A GIS-based approach to characterizing Vermont's groundwater resources: VGS Open File Report VG14-3. During the process of working with the data, numerous errors and issues with the data were discovered. However, time constraints did not allow us to conduct a full review of the database.

A key component of the water use work plan is to complete the work to obtain more accurate well locations for 9 remaining counties, to correct errors in the database, and to provide metadata related to data quality. The dataset provides the information about sub-surface materials which allow us to interpret infiltration rates within small watersheds and to eventually develop accurate water budget data. Location data will also allow us to assign both HUC 8 and the 12 digit WBD code. Understanding flows within the smaller watersheds is important in a geographically and geologically diverse state such as Vermont.

We have completed the well location project in 5 Vermont counties; 9 counties remain. Completion of the well location work will mark significant progress towards the State goal to produce a reliable water well dataset and subsequently use the data for groundwater favorability maps, water budgets, and drought resistance.

Work in each county requires salary and benefits plus some travel to meet with Town Listers or Clerks. Estimated time to produce the revised well location data per county is 5-7 weeks for a total of approximately 54 weeks and estimated mileage is 45,000 miles. We anticipate using contractual labor, state employees and student interns for portions of the project over a two – three year time period.

High Priority: Capture of Flow Protection Program Data and Database Construction

Hourly streamflow data and gallons pumped is reported annually or periodically as part of permit conditions for several programs (see Table 1). Construction of a standardized spreadsheet or database and summary of the information on an annual and monthly basis by HUC 8 or 12 digit WBD code would allow us to capture and report roughly 3000 records which date back to 1998. Due to the small geographic area for most of the recharge areas and watersheds in Vermont, reporting by both 12 digit WBD and HUC 8 is preferable.

List of Acronyms

CWS	Community Water System
DWGWPD	Drinking Water and Groundwater Protection Division
GEC_WS	Global Environmental Consulting_Water Supply
NTNC	Non-Transient Non-Community Water System
SCADA	System Control and Data Acquisition
SDWIS	Safe Drinking Water Information System
SWWU	Safe Water Water Usage
TNC	Transient Non-Community Water System
VGS	Vermont geological Survey
WBD	Watershed Boundary Dataset
WSMD	Watershed Management Division
WWInv	Waste Water Inventory

References Cited

Gale, M.H., Springston, G., Becker, L., and Knox, R., 2009, Statewide analyses of bedrock water well data: Vermont Geological Survey Open File Report VG09-8, 7 plates. (Also available at: http://www.anr.state.vt.us/dec/geo/gwaterSTATEinx.htm)

Gale, M., Springston, G., Van Hoesen, J., and Becker, L., 2014, A GIS-based approach to characterizing Vermont's groundwater resources: Geological Society of America Abstracts with Program, Northeastern Section (49th annual) Meeting,V. 46, p. 47. (Also available at: http://www.anr.state.vt.us/dec/geo/gwaterSTATEinx.htm)

Medalie, L. and Horn, M.A., 2010, Estimated water withdrawals and return flows in Vermont in 2005 and 2020: USGS SIR 2010-5053, 53 p.

APPENDIX A

DOCUMENTATION FOR THE PUBLIC SUPPLY WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601

Sources of data and contacts

1. U.S. Bureau of the Census 2005 estimated population from the internet; at URL http://www.census.gov/popest/cities/tables/SUB-EST2005-05-50.xls. Reference: Table 4: Annual Estimates of the Population for Minor Civil Divisions in Vermont, Listed Alphabetically Within County: April 1, 2000 to July 1, 2005 (SUB-EST2005-05-50) Source: Population Division, U.S. Census Bureau; Release Date: June 21, 2006
2. 2005 Sanitary Survey database from Jay Rutherford at Vermont Department of Environmental Conservation, Water Supply Division; 802-241-3400; Jay.Rutherford@state.vt.us.
3. SDWIS database for public water suppliers, accessed as MS Excel Pivot Tables 11/28/2006 from the internet; at URL http://www.epa.gov/safewater/data/pivottables.html

Method

1. Population served: The SDWIS database (source #3) provided information on populations served by public suppliers and whether the sources of water were ground or surface water. Data on individual public-supply systems were aggregated by county and by HUC. HUCs were assigned to public suppliers as follows. If there was a town name as part of the public supplier name, that town was assigned to a HUC based on where its population center was located. For all the small systems that were mobile home parks or condos, populations served were assigned generally to the largest HUC that was overlain with the county. In cases of the largest public supply sytems that straddled 2 HUCs, populations served (distribution system) were halved between the 2 adjacent HUCs. In the case of Winhall Stratton FD #1 WSID VT0005305, the SWDIS population served was changed from 10000 to 170, the latter number being the population of the town. The population served listed in SDWIS was inflated because it is a ski town.
2. Ground and surface-water withdrawals were provided by the Vermont Water Supply Division Sanitary Survey database (source #2). For some small public suppliers for which there were no reported volumes, withdrawals were estimated based on a per-capita estimate of 60 gallons per person per day times the population served. However, none of these amounted individually to more than 0.0003 MGD, and the total from these small estimated systems did not even change total withdrawals by 0.01 MGD.

Highlights

Total population served increased by 77,770 people (22%) between 2000 and 2005. This breaks down to a 27% increase in populations served by ground-water sources and a 19% increase in populations served by surface-water sources. Total withdrawals by public suppliers decreased from 59.97 to 45.89 MGD (23%), which breaks down to a 29% decrease in withdrawals from ground-water sources and a 21% decrease in withdrawals from surface-water sources.

Part of the explanation for why withdrawals for public supply were much lower in 2005 than in 2000 and even slightly lower in 2005 than in 1995 (46.68 MGD) while populations served have increased steadily over the years, is that as public-supply water gets more expensive, people are demanding more and better meters (D. Nealon, Vermont Water Supply Division, 3/20/07, oral

commun.). Thus, reported withdrawal data are getting more accurate compared to data from 5 and 10 years ago, when estimates for billing usually were made to err on the high end of possible values.

Another part of the reason withdrawals for public supply in 2000 were much greater than withdrawals in 2005 could be because 2000 withdrawals by county were estimated and 2005 withdrawals were based on reported data. Withdrawals in 1995 also were based on data reported to the Vermont Water Supply Division. The 2000 withdrawals for public supply were estimated based on the % population served times the total commercial and industrial use (estimated based on number of employees times SIC-code water-use coefficients) plus domestic deliveries (estimated based on population served times per-capita water use of 85 gallons), plus 15 % unaccounted-for water (estimated). There is a lot of uncertaintly associated with so many points of estimation. Furthermore, the 2005 per-capita estimate was reduced to 55 or 60 gallons, as explained in method 4 of the domestic documentation section.

DOCUMENTATION FOR THE COMMERCIAL WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. Vermont County and Industry – 2005 monthly employment from Quarterly Census of Employment and Wages, released August 30, 2006, accessed from the internet on 3/20/07 at http://www.vtlmi.info/detftp.htm
2. Snowmaking data (2005) from Brian Fitzgerald at Vermont Department of Environmental Conservation, Water Quality Division; phone 802-241-3468; brian.fitzgerald@state.vt.us
3. Information on some NC and NTNC systems from the Sanitary Survey database, from Jay Rutherford at Vermont Department of Environmental Conservation, Water Supply Division; 802-241-3400; Jay.Rutherford@state.vt.us.

Method

1. Deliveries from public suppliers to commercial users was calculated for each county as the volume left over from public-supply withdrawals less 7.5% unaccounted-for use, less domestic deliveries, less industrial deliveries. Total commercial deliveries statewide were about 23% of public-supply withdrawals, which was close to the 21% for New Hampshire. The unaccounted-for percent was taken as the difference between total water produced less total water sold by Champlain Water District, the largest public supplier in Vermont in 2005, who accounted for 22% of water withdrawals by public suppliers in Vermont.
2. Site-specific data for commercial water use were entries categorized as NC or NTNC and considered commercial users from the Vermont Water Supply Division's Sanitary Survey database. Site-specific data also included withdrawals reported to the Vermont Water Quality Division database from snowmaking facilities (all surface water).
3. Total aggregate commercial water use was based on the total number of commercial employees in each county from source #1 above times a generic water-use coefficient of 75 gallons per employee per day. The number of commercial employees was derived as the total covered annual average employment for the county less the number of employees involved in goods-producing operations (which includes natural resources and mining, construction, and manufacturing). Thus, commercial employment winds up including the service-providing occupations plus government employees. The number of people employed by the companies for which there were commercial site-specific data were subtracted from the county-wide total commercial employment.

   The generic coefficient was an average value from coefficients developed by Marilee Horn in 2000 for the commercial catetgory. The range of commercial coefficients from table 1 of the 2000 documentation, shown below, was 51 to 106 gallons per day. Because this range was fairly narrow, and because 2005 employment was distributed evenly throughout the range of commercial SIC codes, using an average of 75 gallons for all commercial employment in the county seemed appropriate.
4. Total commercial water use was calculated as aggregate commercial water use as derived in step #3 above added to site-specific commercial water use.
5. Self-supplied commercial use was calculated as total commercial use less public supply deliveries to commercial users. In cases of some counties, shown below, total commercial use

was adjusted upward if the calculation resulted in a negative number. These adjustments were justified because these counties contained fairly large cities or developed areas that were known to have fairly widespread public-supply coverage including substantial commercial use, whereas the remaining areas of these counties consists of very small towns with minimal public-supply coverage. This logic was arrived at based on phone calls that were made to public suppliers inquiring about deliveries to the largest industrial users, when I was routinely told that the biggest customers were hospitals, schools, malls, and other commercial users. Thus, I thought it was more correct to adjust total commercial use upward than to adjust deliveries from public suppliers downward (to prevent negative numbers).

Commercial withdrawals using surface water included snowmaking and the few other facilities known to use surface water. All other self-supplied commercial use was assumed to use ground water.

COUNTY	INCREASE IN COMMERCIAL USE	LARGE DEVELOPED AREA
Addison	0.6	Middlebury
Bennington	0.15	Bennington & Manchester
Caledonia	0.4	St. Johnsbury
Franklin	0.75	St. Albans
Grand Isle	0.03	South Hero

Highlights

Total commercial use decreased from 27.21 MGD to 25.19 MGD (7%). While withdrawals of surface water for commercial use decreased by 0.51 MGD (9%), and deliveries from public suppliers to commercial users decreased from 13.76 to 10.42 MGD (24%), withdrawals from ground water increased from 7.58 to 9.42 MGD (24%).

It is difficult to pinpoint reasons for differences in water use for the commercial category between the 2000 and the 2005 compilations. Both compilations relied largely on estimates based on employment data and water-use coefficients. I would have expected that actual public-supply deliveries to commercial users would be larger in 2005 than in 2000, because as time goes on, public-supply distribution increasingly tends to cover town or city centers and commercial hubs. However, commercial deliveries in 2005, calculated as the residual of public-supply withdrawals after other deliveries were subtracted out, was limited in volume to the smaller value of public-supply withdrawals in 2005 compared to 2000.

Table 1. Method for determining commercial water use

SIC GROUP	SIC CATEGORY	SIC CODE	MEDIAN EMPLOYEE WATER-USE COEFFICIENT (gal/employee/day)
24	Transportation	40-49	51
25	Wholesale trade	50-51	58
26	Retail trade	52-59	58
27	Finance, insurance, real estate	60-67	71
28	Services	70-89	106
29	Public administration	91-97	106

DOCUMENTATION FOR THE DOMESTIC WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. U.S. Bureau of the Census 2005 estimated population from the internet; at URL http://www.census.gov/popest/cities/tables/SUB-EST2005-05-50.xls. Reference: Table 4: Annual Estimates of the Population for Minor Civil Divisions in Vermont, Listed Alphabetically Within County: April 1, 2000 to July 1, 2005 (SUB-EST2005-05-50) Source: Population Division, U.S. Census Bureau; Release Date: June 21, 2006
2. SDWIS database for public water suppliers, accessed at MS Excel Pivot Tables on 11/28/2006 from the internet, at URL http://www.epa.gov/safewater/data/pivottables.html
3. Per capita use estimate of 75 GPD is taken from table 16, annual domestic coefficient from 44 towns in the New Hampshire Seacoast from the *draft* USGS SIR report, "Methods for and estimates of 2003 and projected water use in the Seacoast Region, Southeaster, New Hampshire", by Marilee Horn, Sarah Flanagan, and Richard Moore. Contact Marilee Horn, New Hampshire WSC, 603-226-7806.
4. USGS National Map website, nationalmap.gov, accessed 3/1/07.
5. Interactive Mapping website for private well locations operated by the Vermont Agency of Natural Resources (http://maps.anr.state.vt.us/website/welldriller/viewer.htm), accessed 3/1/07.
6. Vermont Department of Health, Gail Center, 863-7233.
7. Vermont Department of Environmental Conservation, Ernie Christianson, 879-5675

Methods

1. Self-supplied population for every County was the difference between the 2005 estimated population and the population served by public supply.
2. Withdrawals for self-supplied domestic use were calculated as the self-supplied population times the per capita estimate of 75 gallons per person per day. Inititally, assume all self-supplied withdrawals were from ground water.
3. Self-supplied surface-water withdrawals were estimated as follows. Start with the counties that are known to have some seasonal camps that pipe in surface water from lakes. They usually bring in bottled water for drinking. Gail Center (telephone conversation on 3/1/07), helped to identify some of these lakes, including a couple in Orange County (Lake Morley and Lake Fairlee), Orleans County (Crystal lake), Franklin County (Lake Carmi), and Rutland County (Lake Bomoseen and Lake St. Catherine). From the USGS National Map website (data source #4), zoom into the surface-water body while activating the layers for TerraServer USA digital orthophoto imagery and Vermont structures (data layer from the Vermont Center for Geographic Information Emergency E911—where data were collected 1996-1998). Print out the resulting map. Then, go to the Vermont Mapping website for private well locations (data source #5), zoom to those surface-water bodies, and print out resulting maps with symbols for well locations. By counting structures bordering the lake that do not have wells, get a rough estimate of the number of structures that use a surface-water source of water. Develop an annual water-use coefficient to multiply by this number of structures, based on 2.5 people per house, 75 gallons per person per day, and a 90-day season of residency.

For counties that border Lake Champlain, there are too many camps on the lake to make a worthwhile estimate using the method described above. Ernie Christianson verified on 3/14/07 that there are a substantial number of pre-existing exempt shoreline camps and homes that use lake water, but there is no entity or agency that compiles data on this. As a result of the conversation with Ernie Christianson, I decided to show small volumes of surface-water withdrawals for domestic use as a token indication that this practice occurs. Franklin County shows the largest withdrawals from the Lake for domestic use because there are many camps and relatively few public suppliers. Chittenden County shows a smaller volume because, while some surface water is withdrawn by camps in Milton and Colchester, most of the rest of the county is on public supply. Grand Isle and Addision County have some, but an unknown number of camps that use lake water.

After these estimates for surface-water withdrawals were entered into the domestic spreadsheet, the estimates of ground-water withdrawals for domestic use were adjusted downward by these amounts to preserve the original values of self-supplied withdrawals, which were based on the self-supplied population times the per capita estimate.

4. Deliveries from public suppliers to domestic users were calculated as populations on public supply times a per-capita coefficient. Per-capita coefficients used for deliveries were slightly less than those for self-supplied users because people tend to use more water if they are not paying a public supplier for it. Also, if water delivered to domestic users was based on the per-capita coefficient of 75 gallons, there would be very little of the public-supply withdrawal total left over for commercial use (see method for estimating public-supply deliveries to commercial users). Therefore, the per-capita coefficient used for deliveries from public suppliers was 60 gallons per person per day. The coefficient was 55 gallons per person per day for Essex, Windham, and Windsor Counties to avoid the mathematical impossibility of more deliveries than withdrawals by public suppliers.

Highlights

Computed self-supplied population decreased by 62,530 (25%) between 2000 and 2005 because the population on public supply increased much more than the total population increased.

Self-supplied withdrawals for domestic use decreased substantially from 21.04 to 13.91 MGD (34%). This decrease was partly attributable to a decrease in the self-supplied population served and partly attributable to the decrease in the per-capita water-use coefficient from 85 to 75 gallons. Deliveries from public supply to domestic users decreased from 30.35 to 25.84 MGD (15%). This decrease can be entirely traced to the difference in per-capita water-use coefficient from 85 gallons to 60 or 55 gallons (a 29% decrease), which more than compensates for the increase in population served by public suppliers.

DOCUMENTATION FOR THE INDUSTRIAL WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. IWR-Main Model; Institute for Water Resources—Municipal and Industrial Needs Water Use Forecasting; U.S. Army Corps of Engineers; Davis, W.Y. et al., IWR Report 88-R-6. This data source was used to create the table of water-use coefficients by 2-digit SIC code shown below.
2. Various industrial facilities throughout the state.
3. Various public suppliers throughout the state for billing records on largest users.
4. U.I. Covered employment and wages, by county, accessed on 12/6/06 at http://www.vtlmi.info/indareanaics.cfm?areatype=04
5. Vermont Employer database, accessed from 3/5/07 through 3/9/07 at http://www.vtlmi.info/employer.cfm
6. Virginia Little, Chief, Vermont Agency of Natural Resources, Wastewater Management Divison, 802-241-3833, ginny.little@state.vt.us
7. 2005 Sanitary Survey database, Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Supply Division, phone 802-241-3400; contact Jay Rutherford, Jay.Rutherford@state.vt.us.
8. U.S. EPA Permit Compliance System database, accessed online at http://oaspub.epa.gov/enviro/ef_home2.water from January through March, 2007.

Method

1. Site-specific industrial withdrawals were compiled from a list of potentially large industrial water users from data source #'s 5 (manufacturing facilities with a large number of employees), 6 (list of NPDES industrial discharges for facilities permitted to discharge > 20,000 gallons per day), 7 (NC and NTNC systems with water-use data), and 8. When available, information on sources of water and volumes of use were collected from the same sources. For facilities on the list without complete information, either the facility or the local public supplier was telephoned for information on the source(s) of water and on actual or approximate volumes of use. A 3- or 4-digit NAICS code and the number of employees was assigned to each individual facility from data source #5.
2. Water use by aggregated industrial users was calculated by multiplying the number of employees for each 3-digit NAICS code for each county (from data source #'s 4 and 5) by an NAICS-derived water-use coefficient (table 2 below). For each county, the number of employees for each 3-digit NAICS code was adjusted by subtracting the number of employees at facilities accounted for on a site-specific basis.
3. Deliveries from public suppliers to aggregated industrial users were estimated by multiplying total aggregated industrial water use (from step 2 above) times the percent of each county's total population that was served by public supply.
4. Self-supplied withdrawals from ground water by aggregated industrial facilities was estimated by multiplying total aggregated industrial water use (from step 2 above) times the percent of each county's public-supply withdrawals that was from ground-water sources.

5. Self-supplied withdrawals from surface water by aggregated industrial facilities was estimated by multiplying total aggregated industrial water use (from step 2 above) times the percent of each county's public-supply withdrawals that was from surface-water sources.
6. Total ground- and surface-water withdrawals and public-supply deliveries for industrial use was calculated for each county as the sum of withdrawals or deliveries by individual facilities plus estimates for withdrawals or deliveries by aggregated users.

Highlights

Industrial water use decreased by 0.98 Mgal/d (6.5%), from 15.05 to 14.07 MGD, between 2000 and 2005. During the same period, ground-water withdrawals for industrial use decreased by 0.31 Mgal/d (15%), surface-water withdrawals increased by 1.25 Mgal/d (26%), and deliveries from public suppliers decreased by 1.92 Mgal/d (24%). Thus, the increase in withdrawals from surface water almost completely offsets the decrease in deliveries from public supply, resulting in just a small change in total industrial use. Similar to the explanation in the highlights section of commercial use, some of the decrease in deliveries from public supply may be a result of the higher estimate for public-supply withdrawals in 2000 compared to 2005.

Table 2. Method for determining industrial water use—updated with NAICS codes

SIC CATEGORY	SIC CODE	NAICS CODE	MEDIAN EMPLOYEE WATER-USE COEFFICIENT (gal/employee/day)
Construction	15-17	233-235	35
Food	20	311	469
Tobacco	21	312	217
Textile Mill Products	22	313, 314	315
Apparel	23	315	13
Lumber and wood	24	321	78
Furniture	25	337	30
Paper	26	322	863
Printing	27	323	42
Chemicals	28	325	289
Petroleum	29	324	1045
Rubber	30	326	119
Leather	31	316	148
Stone, clay, glass, concrete	32	327	202
Primary metal	33	331	178
Fabricated metal	34	332	95
Machinery	35	333	58
Electrical equipment	36	334, 335	71
Transportation equipment	37	336	63
Instruments	38	339	66
Jewelry, precious metals	39		36

DOCUMENTATION FOR THE THERMOELECTRIC WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. U.S. Department of Energy, 2005, Energy Information Administration, Form EIA-906 and EIA-920 databases, accessed from the internet on November 29, 2006 at: http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html
2. U.S. Department of Energy, 2005, Energy Information Administration, Form EIA-860, accessed from the internet on November 29, 2006 at: http://www.eia.doe.gov/cneaf/electricity/page/eia860.html
3. EIA form 767 as provided by the USGS National water-use program.
4. U.S. EPA Permit Compliance System (PCS) database, accessed online at http://oaspub.epa.gov/enviro/ef_home2.water from January through March, 2007.
5. Virginia Little, Chief, Vermont Agency of Natural Resources, Wastewater Management Divison, 802-241-3833, ginny.little@state.vt.us
6. Burlington Electric Department, John Irving, 802-658-0300, jirving@burlingtonelectric.com.

Methods

1. Net power generation was obtained from EIA form 906/920 (source #1).
2. Water withdrawal data—(there were no records in the EIA-767 cooling system database for facilities in Vermont)
    i. —for the Vermont Yankee nuclear facility in Windham County was taken as the 2005 discharge volume reported in the PCS database (source #4).
    ii. —for the McNeil Generating Station in Chittenden County was obtained via an email request to Burlington Electric Power (source #6).
    iii. —at the Ryegate wood chip power plant in Caledonia County was obtained from the discharge monitoring report provided by the Vermont Wastewater Management Division (source #5).

Highlights

Over 99% of thermoelectric water use and about 91% of the power generated was attributable to a nuclear power plant in southern Vermont which uses Connecticut River water for once-through cooling. Between 2000 and 2005, water use at the nuclear plant increased by 67 MGD (19%) and power generated decreased by 5%.

Combined power generation at the 2 biomass plants in Vermont increased by 20 Gigawatt hours (5%) between 2000 and 2005 and water use decreased from 1.21 to 0.54 MGD (55%). This large decrease in withdrawals was probably due to the difference in method of data collection—in 2000, data were estimated based on the generation/withdrawal ratio from the 1995 compilation and in 2005, data were obtained directly from plant managers at the facilities.

DOCUMENTATION FOR THE IRRIGATION WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. U.S. Department of Commerce, Bureau of the Census, 2002 Census of Agriculture, Volume 1 Geographic Area Series, "Table 10: Irrigation", accessed on 12/1/2006 at http://www.nass.usda.gov/census/census02/volume1/vt/st50_2_010_010.pdf
2. List of golf courses in Vermont and yards per golf course were found in The Vermont Atlas and Gazatteer, 2000, DeLorme Publishing Company, Freeport, Maine.
3. Golf course list was supplemented by accessing the internet on 11/30/2006 at: http://www.thegolfcourses.net/golfcourses/VT/Vermont.htm
4. 2005 precipitation and air temperature data for Vermont was retrieved from the internet; at URL http://cdo.ncdc.noaa.gov/pls/plclimprod/somdmain.somdwrapper?datasetabbv=DS3220&countryabbv=&GEORegionabbv=&Forceoutside=
5. Water Use Verification in the Merrimack River Basin, New Hampshire Department of Environmental Services, Rick Chormann, 603- 271-1975.
6. New Hampshire Water User Registration database; New Hampshire Department of Environmental Services; Water Management Bureau; phone 603-271-1975; contact Rick Chormann.
7. Fennessey, N.M., and Vogel, R.M., 1996, Regional models of potential evaporation and reference evapotranspiration for the northeast USA, Journal of Hydrology 184:337-354.
8. NRCS National Engineering Handbook Part 652 Irrigation Guide, Chapter 4: Water requirements, accessed from the internet on 12/18/2006 at http://www.wcc.nrcs.usda.gov/nrcsirrig/irrig-handbooks-part652-chapter4.html
9. 2005 Crop Weather Summary of the New England Agricultural Statistics, accessed from the internet on 12/18/2006 at http://www.nass.usda.gov/nh/P041-2005CropWeatherSummary.pdf, precipitation and temperature summary, p. 41.

Methods

1. Acres irrigated for crops for each county were taken from the 2002 Census of Agriculture (source #1).
2. Acres irrigated for golf courses were estimated using an average of 20 acres irrigated per 9 holes (source #'s 2, 3, and 5).
3. Withdrawals for crop irrigation were estimated by calculating average monthly crop evapotranspiration (ET) using the Fennessey and Vogel method (source #7), which required monthly average air temperature, longitude and elevation. This method was theoretically an improvement over the method used in previous compilations, which assumed 4 inches of water were required per month during the growing season, irregardless of climatic conditions. Monthly 2005 temperature data were retrieved for all NWS stations in Vermont from source #4, averaged by county, and converted to degrees Celsius. For longitude and elevation, the average longitude and elevation of the MCD that was closest to each county's cendroid was used.

   The potential irrigation season was assumed to be May through September. May 2005 irrigation was assumed to be nil, based on the 2005 Crop Weather Summary (source #9), which stated that sold moisture levels were rated near or above 40% surplus all month. June through September crop ET (calculated using formula in Fennessey and Vogel article and based on variables as described in previous paragraph) was converted to inches. Effective precipitation was assumed to be 70% of total precipitation (NRCS Part 652 Irrigation Guide—source #8). Monthly net irrigation requirement was calculated as crop ET minus effective precipitation.

Irrigation requirement was multiplied times acres irrigated to get irrigation water withdrawals, converted to million gallons, summed up for the season, and divided by 365 to get MGD.

[Monthly crop ET values, calculated according to the method described in the previous paragraphs, came out to be very close to values for Worcester, MA that were provided as an example in the Fennessey and Vogel article, fig. 2. In the article, values for Worcester were shown in 2 ways with almost identical results: (1) using the method described in the article and (2) using the classic but data intensive Penman-Monteith method.]

4. Withdrawals for golf-course irrigation were estimated as 0.005 MGD per 1000 yards. The 2000 coefficient, 0.007 MGD, was updated using data from 55 sites that reported withdrawals in 2005 to the New Hampshire Water-Users Registration Program. The standard deviation of the coefficients derived from 2005 data was 0.0035 (compared to 0.013, which was the standard deviation of the coefficient used previously). Withdrawal data were available for 1 golf course (Sugarbush, in Washington County), as provided with snowmaking data for the resort.
5. Surface-water withdrawals were estimated as 90% and ground-water withdrawals were estimated as 10% of total withdrawals.

Highlights

Total withdrawals for cropland and golf-course irrigation decreased from 3.77 to 3.14 MGD (17%) between 2000 and 2005. It would be misleading to directly compare withdrawls for 2000 and 2005 because of changes in the coefficient for estimating withdrawals at golf courses and the method for estimating withdrawals for crops. Changing the water-use coefficient for estimating withdrawals at golf courses from 0.007 MGD per 1000 yards in 2000 to 0.005 MGD in 2005 contributed to a decrease of 1.2 MGD from 2000 to 2005 for withdrawals at golf courses. While reported water withdrawals for irrigating crops increased by 0.56 MGD from 2000 to 2005 (77%), the methods used to derive these estimates were completely different and a trend over time should not be considered.

It makes more sense to compare acres irrigated over time because the methods to estimate this parameter did not change. Fewer acres were irrigated on both cropland and golf courses between 2000 and 2005. Cropland irrigated acres decreased by 9% and golf-course irrigated acres decreased by 5%. A possible explanation is that there was about 1.5 more inches of precipitation during the 2005 irrigation season compared to the 2000 irrigation season. Counties with a substantial increase in irrigated acreage were Addison, Essex, Grand Isle, Lamoille, Orange, Rutland, and Washington. These increases were largely offset by significant decreases in irrigated acres that were seen in Caledonia, Chittenden, Orleans, and Windsor Counties.

DOCUMENTATION FOR THE LIVESTOCK WATER-USE CATEGORY—VERMONT

Storage of data: Electronic data are stored in spreadsheets on the local (D) drive on PC: Gs/Igsadaewfs-vt11 at D:\Laurafiles\WaterUse\compilation05\VT.

Compiler: Laura Medalie (lmedalie), 802-828-4512, USGS, P.O. Box 628, Montpelier, VT 05601.

Sources of data and contacts

1. Annual Bulletin of the New England Agricultural Statistics, 2005, Vermont Cattle County Estimate, accessed on 5/9/2007 at http://www.nass.usda.gov/nh/P085-2005VermontCattleCountyEstimates.pdf
2. Penn State College of Agricultural Sciences, Cooperative Extension, fact sheet F-195 entitled "Agricutural water needs and sources water supply", accessed on 5/9/2007 at http://www.age.psu.edu/extension/factsheets/f/F195.pdf
3. John Lovelace estimates of livestock water use provided by USGS water-use website at: http://water.usgs.gov/usgs/watuse/2005compilation/livestock/data2005/index.html

Methods

1. Total livestock water use according to John Lovelace's estimates based on 2002 data for number of animals were amended because 2005 data on number of cows per county were available from source #1 for Vermont. Since 91 percent of the statewide decrease in total cattle and calves were accounted for by the decrease in milk cows between 2002 and 2005, the change in livestock water use solely reflects the change in the number of milk cows. For each county, the change in number of milk cows between 2002 and 2005 times the coefficient of 35 gallons per animal per day (source #2) was calculated. This decrease in livestock water use was prorated to John Lovelace's numbers as 75 percent to ground-water and 25 percent to surface-water withdrawals—the same percentages he used to allocate withdrawals between ground- and surface water. John Lovelace's livestock water use is greater than what would be calculated based solely on coefficients and number of animals because he factored in about an extra 25 percent for milkhouse and parlor use (washing and flushing various pieces of equipment).