**Lake Champlain Long-Term Water Quality and Biological Monitoring Program**

**Project Description**

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**Prepared by**

**Vermont Department of Environmental Conservation**

**Watershed Management Division**

**1 National Life Drive, Main Bldg**

**Montpelier, VT 05620 -3522**

**(802) 828-1535**

**and**

**New York State Department of Environmental Conservation**

**Region 5**

**P.O. Box 296**

**Ray Brook, NY 12977-0296**

**(518) 897‑1241**

**with support from**

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**Lake Champlain Basin Program**

**P.O. Box 204**

**54 West Shore Rd.**

**Grand Isle, VT 05458**

**(802) 372-3213****Project Background and Purpose**

The Lake Champlain Long-Term Water Quality and Biological Monitoring Project began in 1992. The project is conducted annually by the Vermont Department of Environmental Conservation (DEC) and the New York State DEC, with funding provided by the Lake Champlain Basin Program and the two states.

The current monitoring effort grew from the Lake Champlain Diagnostic-Feasibility Study conducted by Vermont DEC and New York State DEC (1997). The Diagnostic-Feasibility Study focused primarily on the measurement of phosphorus and chloride concentrations in the lake and its tributaries to support a phosphorus loading budget and mass balance model for Lake Champlain. The Diagnostic-Feasibility Study also provided vertical water column profile data on several other water quality measurements at deep-water stations. The present long-term monitoring project continued sampling a subset of the lake and tributary station network that was established for the previous Lake Champlain Diagnostic-Feasibility Study, and extended the program to include a broader range of chemical and biological measurements.

The purposes, scope, and methods for the current monitoring project are described in annual work and quality assurance project plans, approved by the U.S. Environmental Protection Agency. One of the original purposes was to provide a current limnological survey of Lake Champlain, including a data set that would support the development of hydrodynamic, eutrophication, and food web models for the lake (e.g., Applied Science Associates, Inc.1996, Levine *et al.*1997, HydroQual, Inc. 1995). The primary purpose of the project was redefined in 1995 to be the detection of long-term environmental change in the lake, and the sampling approach was modified to more efficiently serve this purpose. The list of sampling variables was narrowed to include those lake and tributary constituents judged by the Lake Champlain Basin Program Technical Advisory Committee to be the most meaningful for assessing the long-term effects of management actions and other changes in the environment. Optimum sampling frequencies were determined from a statistical power analysis. The power analysis was conducted to ensure that sample sizes would be adequate, but not excessive, for the purpose of statistically documenting the anticipated magnitude of water quality changes in the lake and its tributaries over time.

The Technical Advisory Committee of the Lake Champlain Basin Program reviewed the project again in 2006-2007 and began to incorporate the concept of “ecological indicators” into the work plan. Criteria for these indicators require that they be ecologically and socially relevant, measurable, statistically sound, and interpretable (Watzin *et al.* 2005). Changes to the monitoring approach were implemented to more closely align sampling parameters and methodology with ecological indicators to provide quantifiable measures of overall ecosystem health. This is an on-going process and sampling will continue to incorporate elements of the ecological indicators program over the next several years.

The project data are stored in a computerized database and are freely available on request and on the Internet to researchers, management agencies, consultants, students, and the general public. The purpose of this report is to describe the project methods and document the database for users of the data.

# Sampling and Analytical Methods

Detailed descriptions of the field sampling and analytical methods and quality assurance procedures can be found in the annual [Work and Quality Assurance Project Plan](http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/lp_2015ltmpqapp.pdf) (New York State DEC and Vermont DEC 2015). A brief summary of methods is provided here.

The sampling station network includes the core set of 15 lake stations and 22 tributary stations shown in Figure 1 and listed in Table 1. The tributary stations are located as near to the river mouths as possible on rivers which have continuous flow gages operated by the U.S. Geological Survey (USGS) or the Quebec Ministry of Sustainable Development, Environment, and Parks (MDDEP). Most lake and tributary stations have been sampled consistently during the entire monitoring period since 1992, with the exception of lake stations 9 and 16, which were added in 2001, and station 51, which was added in 2006. The sampling station on Rock River was added in 2007, and sites on Stevens Brook and Jewett Brook were added late in 2008. In 2010, a USGS gaging station was installed on the Mill River, bringing the total tributaries monitored to 22. Other lake stations listed in Vermont DEC and New York State DEC (1997) have been sampled during short-term surveys for a limited number of water quality measurements. In 2015, the gage was discontinued on Putnam Creek in New York.

The 15 core lake stations are sampled for most chemical tests using Kemmerer or Van Dorn water bottle devices, with discrete depth samples combined to form vertical water column composites. The lake stations are sampled approximately biweekly from May to mid-October each year. When thermal stratification exists, composite samples (composed of 2-3 discrete-depth samples) are obtained from both the epilimnion and hypolimnion layers. Temperature and dissolved oxygen concentrations are measured in vertical profile at discrete depths at the deeper stations. Chlorophyll-a is sampled as a vertically integrated composite of the photic zone, defined as twice the Secchi disk depth.

Quantitative biological sampling in the lake for phytoplankton, zooplankton, and mysids is conducted concurrently with the water quality sampling. Beginning in 2006, net phytoplankton and zooplankton have been sampled biweekly. Mysids are sampled monthly, six months per year. Zooplankton and mysid samples are analyzed at the Lake Champlain Research Institute (SUNY-Plattsburgh) under contract with the New York State DEC. Beginning in 2006, phytoplankton samples have been analyzed by the Vermont DEC. Routine monitoring for spiny waterflea (*Bythotrephes longimanus*) in the Champlain Canal and Glens Falls Feeder Canal, initiated in 2012, was terminated following confirmation of its presence in Lake Champlain in 2014. Sampling effort has since been re-directed to assess distribution and densities in the lake beginning in 2015.

Close-interval, *in situ* vertical profiles for temperature, dissolved oxygen, pH, specific conductance, and turbidity were obtained at some sites in the lake by New York beginning in 1992 using a multi-probe sonde unit. Vermont also acquired a multi-probe sonde in 2006, providing close-interval profiles for temperature, dissolved oxygen, pH, and specific conductance at all sites. In 2011, a Chlorophyll-A probe was added to the sonde, and in 2016 a new sonde was acquired with a phycocyanin probe.

Tributary samples are obtained from bridges using depth and velocity-integrating sampling devices. Sampling effort focuses on a high proportion of samples during high flow conditions in order to improve the precision of tributary annual mass loading estimates (Vermont DEC and New York State DEC 1997) and the target is currently set at 13. Beginning in 2006, four additional collections during base flow conditions were added to the workplan.

A list of the tests sampled in the lake and the tributaries and the current chemical analytical methods is given in Table 2. During the period of this program, chemical analyses have been conducted by the Vermont DEC Laboratory, the New York State Department of Health Laboratory, and other private contracted laboratories in New York. In some cases, samples were split in the field and analyzed concurrently at laboratories in both states. Currently, all samples are analyzed at the Vermont Agriculture and Environmental Laboratory (formerly the VT DEC laboratory) only. Care should be taken by data users when combining results of samples analyzed at different laboratories. A previous analysis of paired samples (Vermont DEC and New York State DEC 1998) revealed small but statistically significant differences between the results obtained by the different laboratories for many of the tests. The laboratory where each sample was analyzed (VT or NY) is recorded in the project database and available [online](http://dec.vermont.gov/watershed/lakes-ponds/monitor/lake-champlain).



Figure 1. Lake and tributary sampling sites.

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| Table 1. List of lake and tributary sampling stations and their locations. The station codes used in the database for the tributary stations are given in parentheses. |
| **Lake Station** | **Latitude N** | **Longitude W** | **Tributary Station** | **Latitude N** | **Longitude W** |
| 2 | 43° 42.89' | 73° 22.98' | Winooski (WINO01) | 44° 31.52' | 73° 15.41' |
| 4 | 43° 57.10' | 73° 24.47' | Otter (OTTE01) | 44° 09.94' | 73° 15.40' |
| 7 | 44° 07.56' | 73° 24.77' | Missisquoi (MISS01) | 44° 55.23' | 73° 07.63' |
| 91 | 44° 14.53' | 73° 19.75' | Lamoille (LAMO01) | 44° 37.96' | 73° 10.39' |
| 161 | 44° 25.55' | 73° 13.92' | Poultney (POUL01) | 43° 34.24' | 73° 23.53' |
| 19 | 44° 28.26' | 73° 17.95' | Pike (PIKE01) | 45° 07.38' | 73° 04.18' |
| 21 | 44° 28.49' | 73° 13.90' | Lewis (LEWI01) | 44° 14.80' | 73° 14.77' |
| 25 | 44° 34.92' | 73° 16.87' | Little Otter (LOTT01) | 44° 12.24' | 73° 15.11' |
| 33 | 44° 42.07' | 73° 25.09' | LaPlatte (LAPL01) | 44° 22.21' | 73° 13.01' |
| 34 | 44° 42.49' | 73° 13.61' | Saranac (SARA01) | 44° 41.52' | 73° 27.19' |
| 36 | 44° 45.37' | 73° 21.30' | Ausable (AUSA01) | 44° 33.63' | 73° 26.95' |
| 40 | 44° 47.12' | 73° 09.73' | Mettawee (METT01) | 43° 33.33' | 73° 24.10' |
| 46 | 44° 56.90' | 73° 20.40' | Great Chazy (GCHA01) | 44° 58.81' | 73° 25.96' |
| 50 | 45° 00.80' | 73° 10.43' | Bouquet (BOUQ01) | 44° 21.84' | 73° 23.41' |
| 512 | 45° 02.50' | 73° 07.78' | Little Ausable (LAUS01) | 44° 35.65' | 73° 29.79' |
|  | Salmon (SALM01) | 44° 38.40' | 73° 29.70' |
| Putnam (PUTN01)6 | 43° 57.35' | 73° 25.99' |
| Little Chazy (LCHA01) | 44° 54.12' | 73° 24.88' |
| Rock River (ROCK02)3 | 44° 59.49' | 73° 04.22' |
| Stevens Brook (STEV01) 4 | 44° 50.95’ | 73° 07.15’ |
| Jewett Brook (JEWE02)4 | 44° 51.37’ | 73° 09.06’ |
| Mill River (MILL01)5 | 44° 46.46’ | 73° 08 39’ |
| 1 Added in 2001. 6Discontinued in 20152 Added in 2006.3 Added in 2007.4 Added in 2008.5Added in 2010. |

Table 2. Current Analytical Methods for Tests Included in the Project Database.

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| **Measurement** | **Test Code** | **Reporting Units** | **Method Reference3** | **Method Number** |
| Total Phosphorus | TP | μg/L | APHA (2005) | 4500-P H |
| Dissolved Phosphorus | DP | μg/L | APHA (2005) | 4500-P H |
| Ortho-Phosphorus1 | OP | μg/L | USEPA (1983) | 365.1 |
| Chloride | TCl, DCl | mg/L | APHA (2005) | 4500-Cl G |
| Dissolved Silica2, 4 | DSi | mg/L | APHA (2005) | 4500-SiO2 F |
| Alkalinity | RegAlk | mg/L | APHA (2005) | 2320-B |
| Total Nitrogen | TN | mg/L | APHA (2005) | 4500-N C |
| Total Kjeldahl Nitrogen1 | TKN | mg/L | USEPA (1983) | 351.2 |
| Total Nitrate/Nitrite Nitrogen1 | TNOX | mg/L | USEPA (1983) | 353.2 |
| Total Ammonia Nitrogen1 | TNH3 | mg/L | USEPA (1983) | 350.1 |
| Total Suspended Solids5 | TSS | mg/L | APHA (2005) | 2540-D |
| Total Organic Carbon1 | TOC | mg/L | USEPA (1983) | 415.2 |
| Dissolved Organic Carbon1 | DOC | mg/L | USEPA (1983) | 415.2 |
| Dissolved Inorganic Carbon1 | DIC | mg/L | APHA (1995) | 4500-CO2 |
| Iron1 | TFe | μg/L | USEPA (1994) | 3005A (Fe digestion) 6020A |
| Calcium, Magnesium, Sodium, Potassium4 | TCa, TMg, TNa, TK | mg/L | USEPA (1994) | 6020-A |
| Lead1 | Pb | μg/L | USEPA (1983) | 239.2 |
| Dissolved Oxygen2 | DO | mg/L | APHA (2005)Hydrolab (1997, 2006) | 4500-OC |
| Chlorophyll-a2 | Chla | mg/L | USEPA (1997)Hydrolab (1997) | 445.0 |
| Temperature | TempC | °C | VT DEC (2012)YSI (1998)Hydrolab (1991) | 3.7.2 |
| Conductivity | Cond | μS/cm | VT DEC (2012)YSI (1998)Hydrolab (1991) | 3.7.2 |
| pH | pH |  | VT DEC (2012)YSI (1998)Hydrolab (1997) | 3.7.2 |
| Secchi Disk Depth2 | Secchi | m | VT DEC (2012) | 3.2.1 |
| Net phytoplankton, total density | NP\_Tot\_den | cells/L | APHA 2005 | 10200 F 2a |
| Net phytoplankton, total biovolume | NP\_Tot\_bio | μm3/L | Wetzel and Likens 2000 |  |
| Net phytoplankton, Cyanobacteria density | NP\_Cya\_den | cells/L | APHA 2005 | 10200 F 2a |
| Net phytoplankton, Cyanobacteria biovolume | NP\_Cya\_bio | μm3/L | Wetzel and Likens 2000 |  |
| Net phytoplankton, Chlorophyta density | NP\_Chl\_den | cells/L | APHA 2005 | 10200 F 2a |
| Net phytoplankton, Chlorophyta biovolume | NP\_Chl\_bio | μm3/L | Wetzel and Likens 2000 |  |
| Net phytoplankton, Chrysophyta density | NP\_Chr\_den | cells/L | APHA 2005 | 10200 F 2a |
| Net phytoplankton, Chrysophyta biovolume | NP\_Chr\_bio | μm3/L | Wetzel and Likens 2000 |  |
| Net phytoplankton, Pyrrophyta density | NP\_Pyr\_den | cells/L | APHA 2005 | 10200 F 2a |
| Net phytoplankton, Pyrrophyta biovolume | NP\_Pyr\_bio | μm3/L | Wetzel and Likens 2000 |  |
| Net zooplankton, total density | NZ\_Tot\_den | organisms/m3 | APHA 2005 | 10200 G |
| Net zooplankton, Cladoceran density | NZ\_Cla\_den | organisms/m3 | APHA 2005 | 10200 G |
| Net zooplankton, Copepod density | NZ\_Cop\_den | organisms/m3 | APHA 2005 | 10200 G |
| Net zooplankton, Rotifer density | NZ\_Rot\_den | organisms/m3 | APHA 2005 | 10200 G |

1 No longer included in the sampling program.

2 Not currently sampled in the tributaries. Chlorophyll-a was sampled in tributaries from 1995-2005.

3 APHA = American Public Health Association

 USEPA = U.S. Environmental Protection Agency

 VT DEC = Vermont Department of Environmental Conservation

 YSI = Yellow Springs Instrument, Corp.

4 Sampled on five year cycle between 2005 and 2010. Beginning 2011, silica will be sampled each visit and metals will be sampled 3x annually..

5 Not sampled in the lake after 2005.

# Project Database

The project database is maintained by the Vermont DEC on its computer network using the commercial database program Microsoft® Access 2003 in conjunction with a SQL® server. Daily backup is provided, and copies of backup files are archived in separate locations. The SQL Server’s robust security features are used to prevent editing or deletion of the original data by users other than the authorized database administrators. Copies of the current database are also available at the New York State DEC.

In 2008, a major reorganization of the database was initiated to improve the database design and replace three Microsoft Access® databases with a single SQL Server database. The use of the SQL Server database improves query performance and allows the use of the T-SQL database language to create more advanced queries. The data tables were normalized to conform to relational database requirements and new tables were added to store plankton data. The SQL Server database was made accessible from both the internal Vermont DEC Access front-end databases and the public web server Lake Champlain Monitoring Program application, which resulted in the elimination of multiple and duplicative Access databases. A single database improves the efficiency of storing and updating data and improves the accuracy of the data as additions and changes are made only in one database. SQL Server Views were created to increase the speed and functionality of the Lake Champlain Monitoring web application.

Database integrity is enforced in several ways. Primary keys are defined to uniquely identify each record in the database and prevent duplication. The primary keys are composed of multiple fields that uniquely identify each sample (e.g., field id, station, date). Foreign keys and check constraints on fields are used to ensure that only valid data are entered.

The database is updated annually within a few months of the end of the field season. Data are freely available to other government agencies, researchers, consultants, students, and the general public. Water chemistry data and plankton summaries can be downloaded via the Internet (<http://dec.vermont.gov/watershed/lakes-ponds/monitor/lake-champlain>). Other electronic formats or paper copies are available upon request. Data are also uploaded to EPA’s “STORET” data system annually. Table 3 provides a crosswalk of Champlain stations and corresponding STORET location identifiers.

 Table 3. Crosswalk of Champlain station names with STORET location identifiers.

| **Champlain Station** | **Waterbody Type** | **STORET Identifier** |
| --- | --- | --- |
| 02 | Lake | 503387 |
| 04 | Lake | 503288 |
| 07 | Lake | 500449 |
| 09 | Lake | 500451 |
| 16 | Lake | 503506 |
| 19 | Lake | 500458 |
| 21 | Lake | 500459 |
| 25 | Lake | 503519 |
| 33 | Lake | 500468 |
| 34 | Lake | 503485 |
| 36 | Lake | 500470 |
| 40 | Lake | 503488 |
| 46 | Lake | 503535 |
| 50 | Lake | 503515 |
| 51 | Lake | 500476 |
| AUSA01 | Trib | 500500 |
| BOUQ01 | Trib | 500498 |
| GCHA01 | Trib | 500492 |
| JEWE02 | Trib | 500665 |
| LAMO01 | Trib | 501794 |
| LAPL01 | Trib | 501594 |
| LAUS01 | Trib | 500501 |
| LCHA01 | Trib | 500490 |
| LEWI01 | Trib | 500503 |
| LOTT01 | Trib | 501371 |
| METT01 | Trib | 500508 |
| MILL01 | Trib | 501563 |
| MISS01 | Trib | 500505 |
| OTTE01 | Trib | 500509 |
| PIKE01 | Trib | 500512 |
| POUL01 | Trib | 500578 |
| PUTN01 | Trib | 500495 |
| ROCK02 | Trib | 500652 |
| SALM01 | Trib | 500502 |
| SARA01 | Trib | 500491 |
| STEV01 | Trib | 501575 |
| WINO01 | Trib | 501903 |

Chemistry results for both tributary and lake samples are maintained in a single table, named ‘ChemistryData,’ distinguished by waterbody type, station name, field accession number, visit date, collection method, and analysis type. The analytical results for each water quality sample are contained in database fields with names corresponding to the test codes indicated in Table 2. Each chemical test field in the database has an associated remark field in which “less than” or “greater than” signs are entered where necessary for results below or above analytical detection limits. Additional database codes are noted in Table 4.

The tributary stations were sampled during 1990-1992 for total phosphorus, dissolved phosphorus, and chloride by the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997) using the same sampling and analytical methods employed by the current long-term monitoring program. These earlier tributary data have been added to the project database.

Plankton data are housed in two tables. The first, ‘PlanktonData,’ contains the original count data distinguished by plankton type (phytoplankton, zooplankton), station name, field accession number, species name, visit date, sample type, and result type. The second, ‘PlanktonStats,’ contains data aggregated by major taxonomic group. During phytoplankton analysis, organisms are frequently observed outside of the designated counting boundaries. These are noted as “present but not counted” and are not quantified or incorporated into summary statistics. The data available for download from the web interface include phytoplankton cell densities and biovolumes, and zooplankton densities, grouped by major taxonomic category. Counts by individual taxa will eventually be added to the web page, but are currently available only by request. Multiprobe data were made available for download via the website in 2014.

Additional tables store tributary flow data, wastewater treatment facility data, plankton taxonomic information, and station location coordinates. These data are not available through the web page but can be obtained by request. Mysid and spiny waterflea data are housed with the NY DEC and also available upon request.

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| Table 4. Additional database codes. |
| **Data Table** | **Data heading** | **Data code** | **Description** |
| Chemistry | WaterbodyType | TribLake | TributaryLake |
|  | CollectionMethod | CompDH59KemmererThermisterSecchiHoseCompKemm | Depth/flow integrated samplerKemmererThermisterSecchi diskIntegrated sample by hoseComposite by Kemmerer |
|  | Depth |  | Sample depth (m) |
|  | Stratum | EHPU | EpilimnionHypolimnionProfileUnstratified(as of 2009, ‘com’ is no longer noted) |
|  | QA | AD | Field sampleField duplicate sample |
|  | Lab | NYVT | Location (state) of lab responsible for analysis |
| Plankton | PlanktonType | PhytoZoo | PhytoplanktonZooplankton |
|  | Depth |  | Integrated net tow or hose collection depth (m) |
|  | QA | ADDCQCC | Field sampleField duplicate sampleLaboratory duplicate count (phyto. only)Repeat Aliquot count (phyto. only) |
|  | SampleType | Net tow, 63µmNet tow, 153µm | Plankton net, 63µm mesh, 13cm diameterPlankton net, 153µm mesh, 30cm diameter |
|  | ResultType | BiovolumeCell densityColony densityOrganism density | BiovolumeNumber of cells (phytoplankton only)Number of Colonies (phytoplankton only)Number of individuals (zooplankton only) |
|  | IsPresentNotCounted | -1 | Taxon present in sample outside of counting boundaries (phytoplankton only) |

Flow rates in the monitored tributaries are continuously measured by the USGS or the Quebec MDDEP. A list of the downstream-most flow gages on these tributaries is given in Table 5. The flow data can be used with the water quality sampling results to estimate mass loading rates, and for other purposes. The historical daily flow data for many of the USGS gages are available at the following website: <http://waterdata.usgs.gov/vt/nwis/rt>

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| Table 5. List of U.S. Geological Survey (USGS) and Quebec Ministry of Sustainable Development, Environment, and Parks (MDDEP) stream flow gages on monitored tributaries. |
| **Tributary** | **Gage Location** | **State** | **Reference No.** | **Agency** |
| Ausable | Au Sable Forks | NY | 4275500 | USGS |
| Bouquet | Willsboro | NY | 4276500 | USGS |
| Great Chazy | Perry Mills | NY | 4271500 | USGS |
| Little Ausable | Valcour | NY | 4273800 | USGS |
| Little Chazy | Chazy | NY | 4271815 | USGS |
| Mettawee | Middle Granville | NY | 4280450 | USGS |
| Putnam6 | Crown Point Center | NY | 4276842 | USGS |
| Salmon | S. Plattsburgh | NY | 4273700 | USGS |
| Saranac | Plattsburgh | NY | 4273500 | USGS |
| Pike | Bedford | QC | 030420 | MDDEP |
| Pike1 | Notre-Dame-de-Stanbridge | QC | 030424 | MDDEP |
| Lamoille | E. Georgia | VT | 4292500 | USGS |
| LaPlatte | Shelburne Falls | VT | 4282795 | USGS |
| Lewis | N. Ferrisburg | VT | 4282780 | USGS |
| Little Otter | Ferrisburg | VT | 4282650 | USGS |
| Missisquoi | Swanton | VT | 4294000 | USGS |
| New Haven2 | Brooksville | VT | 4282525 | USGS |
| Otter | Middlebury | VT | 4282500 | USGS |
| Poultney | Fair Haven | VT | 4280000 | USGS |
| Winooski | Essex Jct. | VT | 4290500 | USGS |
| Rock1 | St. Armand | QC | 030425 | MDDEP |
| Stevens3 | St. Albans | VT | 4292770 | USGS |
| Jewett4 | St, Albans | VT | 4292810 | USGS |
| Mill5 | St, Albans | VT | 4292750 | USGS |
| 1New gages on the Pike and Rock were installed by Quebec MDDEP in 2002.2The New Haven River is a tributary to the Otter Creek that is not directly sampled by the project, but is included in the gage network to supplement the hydrologic coverage for the Otter Creek watershed.3New gage on Stevens Brook was installed by USGS in 2005.4New gage on the Jewett Brook was installed by USGS in 2008.5New gage on Mill River was installed by USGS in 2010.6The gage on Putnam Creek was discontinuedin 2015. |

# Accessing the Data

The project website ([http://dec.vermont.gov/watershed/lakes-ponds/monitor/lake-champlain)](http://dec.vermont.gov/watershed/lakes-ponds/monitor/lake-champlain) provides the ability for data users to selectively view the original data for specific sampling stations, time periods, and analytical tests using simple, interactive query forms. Beginning in 2009, users have a choice to view a webpage or download the data as an EXCEL® spreadsheet. They also may choose to download only the current year’s data for all stations and dates, or all data available for a particular station. The project’s webpage includes links to the necessary metadata descriptions needed to properly interpret the data summaries, including the project quality assurance plan, this project description, and a summary of field and analytical methodology used over the life of the project.

 Simple summary figures have been prepared for each parameter currently sampled. Cumulative data are presented on the website as box plots of the median, 10th, 25th, 75th and 90th percentiles for each station for the entire sampling period. Annual data are presented as scatterplots with trend lines determined by Lowess smoothing analysis. Lake data are presented as both annual and cumulative summaries of unstratified and epilimnetic samples. Tributary data are presented as cumulative summaries only. Plankton data are presented as annual and cumulative summaries for total plankton and the major taxonomic groups. Figures are updated annually after the new data are reviewed and added to the database.

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