New Hampshire Volunteer Lake Assessment Program

2014
Dartmouth Lake Sunapee
Regional Report

May Pond, Washington, NH

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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New Hampshire
Volunteer Lake Assessment Program
2014 Dartmouth Lake Sunapee Regional Report

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REGIONAL HIGHLIGHTS

- The Dartmouth Lake Sunapee region (DLS) consists of those towns in New Hampshire's *Sullivan County*, southern parts of *Grafton County* and western parts of *Merrimack County*.

- Regional freshwater recreation, including boating, fishing and swimming, generates approximately **$7.5 million dollars in sales, $2.5 million in household income, and 119 jobs annually** (Nordstrom, 2007).

- **A perceived decline in water quality** as measured by clarity, levels, flows, aesthetic beauty, or misuse could result in approximately **$2.3 million in lost revenue**, **$790,000 in lost income and 38 lost jobs** (Nordstrom, 2007).

- Regional population is expected to grow by **45,000 people by 2030** with the greatest growth anticipated for Hanover, Lebanon, Enfield, Canaan, Claremont, Newport, and Sunapee.

- The region is home to over **20,000 acres of lakes, rivers and wetlands**. Over **8,000 acres or 36 percent** of water resides in towns predicted to experience the heaviest population growth.

- The regional average summer air temperature was equal to the historical regional average conditions in 2013 and 0.7˚ F below average in 2014, as reported in Lebanon, NH Regional average surface water temperatures were equal to the historical regional average, as recorded by VLAP, in 2013 and 1.2˚ F above average in 2014. Regional average summer precipitation was 2.75 inches above the historical regional average in 2013 and 0.21 inches below average in 2014.

- The region consists of **136 lakes** or great ponds. Regional water quality data is collected at **40 lakes participating in VLAP** while the remaining **70 percent of lakes are sparsely monitored** through the Lake Trophic Survey Program.

- Regional lakes are classified into three categories that describe the overall health of the lake as oligotrophic, mesotrophic or eutrophic by the NHDES Lake Trophic Survey Program. Thirty-five lakes are oligotrophic, 56 are mesotrophic, 14 are eutrophic, and 31 are un-assessed for trophic class. Eighteen oligotrophic and 22 mesotrophic lakes participate in VLAP.

- VLAP lakes are monitored at the deepest point on the lake and at streams entering or exiting the lake. Lakes are monitored monthly during the summer season to establish baseline water quality data and discern long term water quality trends that provide information on overall waterbody health.

- Regional trend analysis performed on historical water quality data found no significant trend for parameters acid neutralizing capacity (ANC), chlorophyll-*a*, and epilimnetic conductivity and total phosphorus. Transparency and epilimnetic pH significantly decreased, and epilimnetic turbidity significantly increased which indicates declining conditions.

DLS WATER QUALITY INDICATORS

The following describes the water quality indicator measured through VLAP, the regional trend that was detected and the current status of the indicator. Trends were determined with a non-parametric Mann-Kendall trend test of the annual medians for each parameter.

Exotic Species	Chlorophyll-a	Transparency	Phosphorus	Dissolved Oxygen	pH	Conductivity	Chloride	Turbidity

Indicator	Trend	Description
	N/A	Three lakes in the DLS region and the Connecticut River are infested with and exotic species. Two lakes are infested with Eurasian milfoil, and one with Curly-leaf Pondweed. The Connecticut River is infested with Rock Snot, or *Didymosphaenia geminata*, as well as European Naiad and Curly-leaf Pondweed. Management activities to control exotic plants occur at all lakes; however the river infestations have not been managed.
	↔	No significant regional chlorophyll-*a* trend from 1985 - 2014. Regional median chlorophyll-*a* is 2.37 mg/m^3 and representative of Oligotrophic conditions or low chlorophyll levels. Lake specific trend analysis indicates indicates one lake deep spot with significantly increasing (worsening) chlorophyll-*a*, six lake deep spots with significantly decreasing (improving) chlorophyll-*a*, and 32 lake deep spots with stable chlorophyll-*a* trends.
	↓	Significantly decreasing (worsening) regional transparency trend meaning that lake clarity has declined from 1985 - 2014. However, the regional median transparency is 4.0 meters and representative of oligotrophic or very good conditions. Lake specific trend analysis indicates 11 lake deep spots with significantly decreasing (worsening) transparency, two lake deep spots with significantly increasing (improving) transparency, and 26 lake deep spots with stable transparency trends.
	↔	No significant regional epilimnetic phosphorus trend from 1985 - 2014. Regional median epilimnetic phosphorus is 8 ug/L and representative of oligotrophic or very good conditions. Lake specific trend analysis indicates six lake deep spots with significantly decreasing (improving) epilimnetic phosphorus and 33 lake deep spots with stable epilimnetic phosphorus trends.
	N/A	Dissolved oxygen levels fluctuate temporally and spatially within a lake system. Ideal levels are between 6.0 and 8.0 mg/L. The average whole water column dissolved oxygen level from 1985 to present is 6.85 mg/L and sufficient to support aquatic life.
	↓	Significantly decreasing (worsening) regional epilimnetic pH trend from 1985 - 2014. Regional median epilimnetic pH is 6.71 and within a desirable pH range however fluctuates widely from approximately 5.50 to 7.50. Lake specific trend analysis indicates nine lake deep spots with significantly decreasing (worsening) epilimnetic pH, five lake deep spots with significantly increasing (improving) epilimnetic pH, and 25 lake deep spots with stable epilimnetic pH trends.
	↔	No significant regional epilimnetic conductivity trend from 1985 - 2014. The regional median epilimnetic conductivity is 64.3 uMhos/cm which is within a desirable range however individual lake conductivity fluctuates widely from approximately 11.0 to 177.0 uMhos/cm due to differences in watershed development. Lake specific trend analysis indicates 11 lake deep spots with significantly increasing (worsening) epilimnetic conductivity, 8 lake deep spots with significantly decreasing (improving) epilimnetic conductivity, and 20 lake deep spots with stable epilimnetic conductivity trends..
	↔	No significant regional epilimnetic chloride trend from 2002 - 2014. Regional median epilimnetic chloride is 9 mg/L and much less than acute and chronic chloride standards. Lake specific epilimnetic chloride levels range from approximately 5 to 30 mg/L. Chloride trend analysis is not conducted on individual lakes.
	↑	Significant increasing (worsening) regional epilimnetic turbidity trend from 1992 - 2014. Regional median epilimnetic turbidity is 0.78 NTU and is indicative of average water quality however median values have increased particularly since 2002. Turbidity trend analysis is not conducted on individual lakes.

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INTRODUCTION AND HISTORY

New Hampshire is home to approximately 1200 lakes and ponds, and thousands of river miles. Protecting our lakes and rivers is critical to sustaining New Hampshire's drinking water resources, aquatic and natural environments, and recreational and tourism industries.

The New Hampshire Department of Environmental Services (NHDES) recognizes the importance of these waterbodies in maintaining a healthy ecosystem for our current and future generations. Protecting high-quality waters, and restoring those that are impaired, requires coordination and partnership between federal, state and local governments, non-profits, regional commissions, lake associations and watershed residents.

To help citizens assess the health of New Hampshire's lakes and ponds, NHDES established the Volunteer Lake Assessment Program (VLAP) in 1985. The program is a volunteer-driven cooperative effort between the State and local governments, lake associations and lake residents. VLAP trains citizen volunteer monitors to collect water quality data at lakes and their associated tributaries on a monthly basis during the summer. VLAP compiles, interprets and reports the data back to state, federal and local governments, lake associations and lake residents.

VLAP volunteer monitors are invaluable stewards for New Hampshire's lakes. Volunteer monitoring allows NHDES to establish a strong set of baseline chemical and biological data, determine long-term water quality trends and identify emerging water quality issues. NHDES acts on these findings through its funding and regulatory programs. Volunteers use this information to educate lake and watershed residents, businesses and local governments on best management practices to keep New Hampshire's lakes and ponds clean. They have been, and will continue to be, a key element in protecting the integrity of New Hampshire's lakes.

PROGRAM OVERVIEW

VLAP is a cooperative program between NHDES and lake residents and associations. Approximately 500 volunteers monitor water quality at 170 lakes throughout New Hampshire through VLAP. Interest in the program has grown drastically in the past ten years as citizens have become more aware of the connections between land use activities and water quality. Volunteer monitors continually collect high-quality data on their local waterbodies and educate watershed residents.

Volunteer monitors are trained by NHDES to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a NHDES biologist on a biennial basis. This visit is a valuable event in which the volunteer monitors have an opportunity to discuss water quality and watershed concerns and receive recommendations on potential remediation activities. Also, the event allows NHDES biologists to perform a field sampling techniques audit to evaluate volunteer monitor's ability to collect quality data, and to collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months.

To further encourage volunteer monitoring, NHDES, established partnerships with the Lake Sunapee Protective Association (LSPA), Colby Sawyer College (CSC) in New London, NH and Plymouth State University (PSU) in Plymouth, NH to operate VLAP satellite laboratories. These satellite laboratories serve as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis. These strategic locations serve the Dartmouth Lake Sunapee, North Country and White Mountain regions.

The data gathered by the volunteers are reviewed by NHDES quality assurance officers and satellite laboratory managers and imported into NHDES' Environmental Monitoring Database (EMD). During the winter, NHDES biologists review and interpret the water quality data, perform trend analyses, and compile the results into annual reports. The high quality data gathered through VLAP also helps NHDES to conduct statewide surface water quality assessments. Assessment results are submitted to the Environmental Protection Agency (EPA) by NHDES every two years as a requirement of the Clean Water Act.

Once the volunteer monitors receive the data and the annual report for their lake, NHDES encourages the volunteers to relay that information to their respective associations, organizations, businesses and local governments. Volunteers are also kept informed of the latest in lake management and water quality issues through an annual newsletter, technical and educational materials, regional workshops and information on important legislation. In addition, NHDES biologists give presentations at lake association meetings and participate in youth education events. Educational initiatives, such as those mentioned above, allow volunteers to recognize potential water quality or shoreland violations around the lake and report their findings to NHDES.

MONITORING AND PARAMETER SUMMARY

VLAP encourages the collection of comprehensive data sets on key water quality parameters to determine overall health of the system. Lakes and tributaries are sampled several times each year over a period of years. This establishes baseline water quality data and allows for the discernment of long-term water quality trends. These trends depict lake health and provide invaluable information to NHDES' mission to protect New Hampshire's lakes. The sampling efforts of the volunteer monitors supplement the environmental monitoring efforts of NHDES. Only through the assistance of volunteer monitors can such a high volume of sampling be accomplished throughout the state.

NHDES recognizes the importance of collecting data sets that are representative of varying conditions. VLAP has an EPA-approved Quality Assurance Project Plan (QAPP). The QAPP identifies specific responsibilities of NHDES and volunteers, sampling rationale, training procedures, data management and quality control. NHDES and volunteers adhere to the QAPP regime to ensure high quality and representative data sets are collected.

Volunteers collect samples once per month in June, July and August, with some lakes monitored more or less frequently. Samples are collected at approximately the same location each month at each of the deep spot thermal layers, major tributaries (those flowing year round) and seasonal tributaries during spring run-off. The samples are analyzed for a variety of chemical and biological parameters including: pH, ANC, conductivity, chloride, turbidity, total phosphorus and *E. coli* (optional). Additional in-lake data are also collected at the deep spot including lake transparency (with and without a viewscope), chlorophyll-a, phytoplankton, and dissolved oxygen and temperature profiles. Volunteer monitors are also trained to identify and collect samples of suspicious aquatic plants and cyanobacteria.

Environmental outcomes are measured by making comparisons to established New Hampshire medians, averages, ranges of lake water quality and state water quality standards. If analytical results for a particular sampling station frequently exceed state water quality averages or standards, then additional sampling to identify potential pollution sources is necessary. Volunteers often conduct storm event sampling, tributary bracket sampling and spring run-off sampling to better assess watershed health and provide additional data to guide lake management decisions.

Appendix A includes a summary of each monitoring parameter and Appendix B includes recommended best management practices to remediate pollution sources.

DARTMOUTH LAKE SUNAPEE REGIONAL SUMMARY

The Dartmouth Lake Sunapee region (DLS) consists of those towns in New Hampshire's Sullivan County, southern parts of Grafton County and western parts of Merrimack County. Bordering portions of the Connecticut River and Vermont, the area is home to Dartmouth College in Hanover and pristine Lake Sunapee, Mount Sunapee and Sunapee State Park.

Freshwater resources in the DLS region provide valuable drinking water and recreational opportunities and play an important role in the regional economy. Freshwater recreation, including boating, fishing and swimming, in the DLS region generate approximately $7.5 million dollars in sales, $2.5 million in household income, and 119 jobs annually (Nordstrom, 2007). A perceived decline in water quality, as measured by water clarity, aesthetic beauty, or overuse, could result in approximately $2.3 million dollars in lost revenue, $790,000 in lost household income and 38 lost jobs (Nordstrom, 2007).

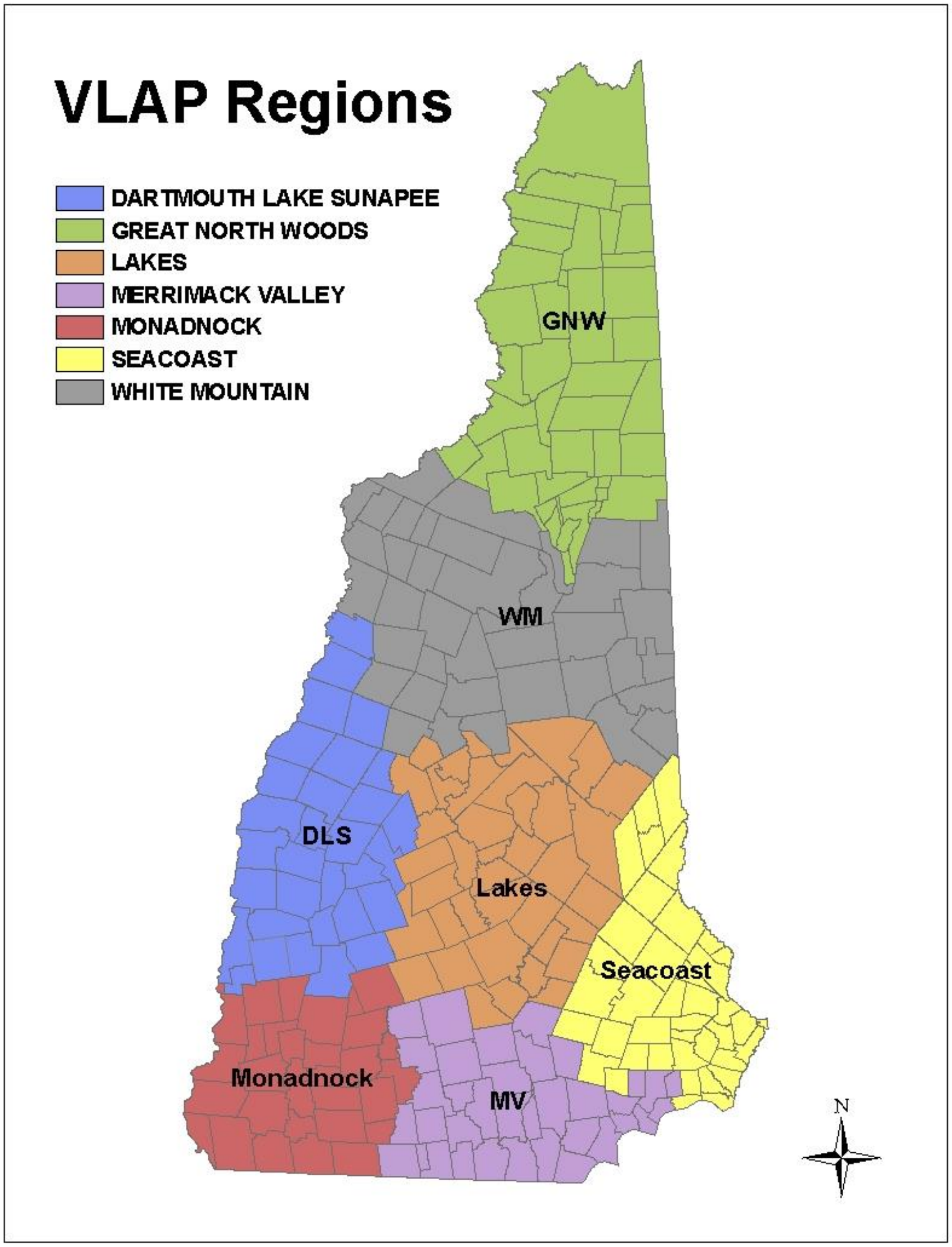


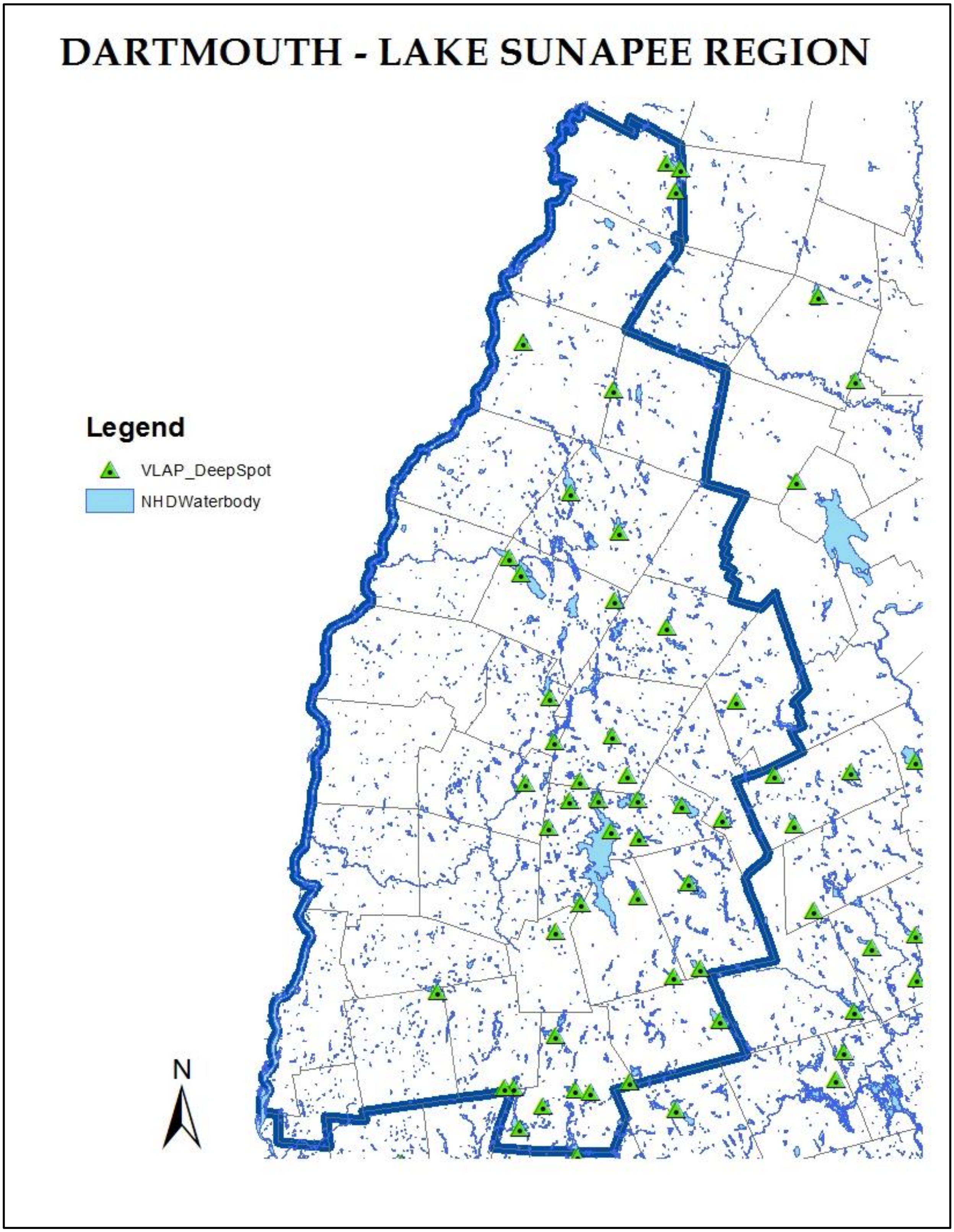
Figure 1. VLAP Regions

Similarly, a decline in water clarity alone can result in a decrease in New Hampshire lakefront property values. A one meter decrease in water clarity can lead to an average decrease in property values of between 0.9%and 6.0% in New Hampshire (Gibbs, Halstead, Boyle& Huang, 2002). This may negatively impact property tax revenues, especially in a state where there are approximately 64,000 vacation homes concentrated around the Lakes Region (lakes), Seacoast (ocean) and North Country (skiing) (Loder, 2011). According to a 1999 publication of the Society for the Protection of New Hampshire Forests, "The Economic Impact of Open Space in New Hampshire," vacation homes contribute approximately $286 million to state and local tax revenues (note: open space includes lakes). For a town with a large number of lakefront homes (vacation or residential), a decline in water clarity can cause decreased property values and local tax revenue.

The DLS region encompasses the Level 8 Hydrologic Unit Code (HUC) Watersheds of the Connecticut River from Waits River to Millen River, including Bellows Falls and Vernon Dam, and the Contoocook River. The HUC boundary defines a specific drainage basin of a major river or series of smaller rivers. There are 18 HUC 8 watersheds in New Hampshire. There are seven VLAP regions (Figure 1). The DLS Region (Figure 2) consists of 40 VLAP lakes as follows. Individual reports for each lake can be found in Appendix E.

Lake Name	**Town**	**Lake Name**	**Town**
Crescent Lake	Acworth	Todd Lake	Newbury
Lake Massasecum	Bradford	Little Lake Sunapee	New London
Canaan St. Lake	Canaan	Messer Pond	New London
Goose Pond	Canaan	Pleasant Lake	New London
Rockybound Pond	Croydon	Baptist Pond	Springfield
Waukeena Lake	Danbury	Dutchman Pond	Springfield
Mill Pond	East Washington	Kolelemook Lake	Springfield
Mascoma Lake	Enfield	Lake Sunapee	Sunapee
Spectacle Pond	Enfield	Ledge Pond	Sunapee
Rand Pond	Goshen	Mountainview Lake	Sunapee
Kilton Pond	Grafton	Otter Pond	Sunapee
Eastman Pond	Grantham	Perkins Pond	Sunapee
Stocker Pond	Grantham	Blaisdell Lake	Sutton
Long Pond	Lempster	Kezar Lake	North Sutton
Post Pond	Lyme	Ashuelot Pond	Washington
Reservoir Pond	Lyme	Halfmoon Pond	Washington
Armington Lake	Piermont	Island Pond	Washington
Katherine Lake	Piermont	May Pond	Washington
Tarleton Lake	Piermont	Millen Pond	Washington
Chalk Pond	Newbury	Chase Pond	Wilmot

Figure 2. DLS Region VLAP Lakes



Land Use and Population Growth

According to the 2010 update of the Society for the Protection of New Hampshire Forests' publication "New Hampshire's Changing Landscape 2010," New Hampshire's population is expected to increase by 180,000 through 2030 (Figure 3). Almost 70% of that growth will occur in the Southeastern part of the state, particularly in Merrimack, Hillsborough and Rockingham counties.

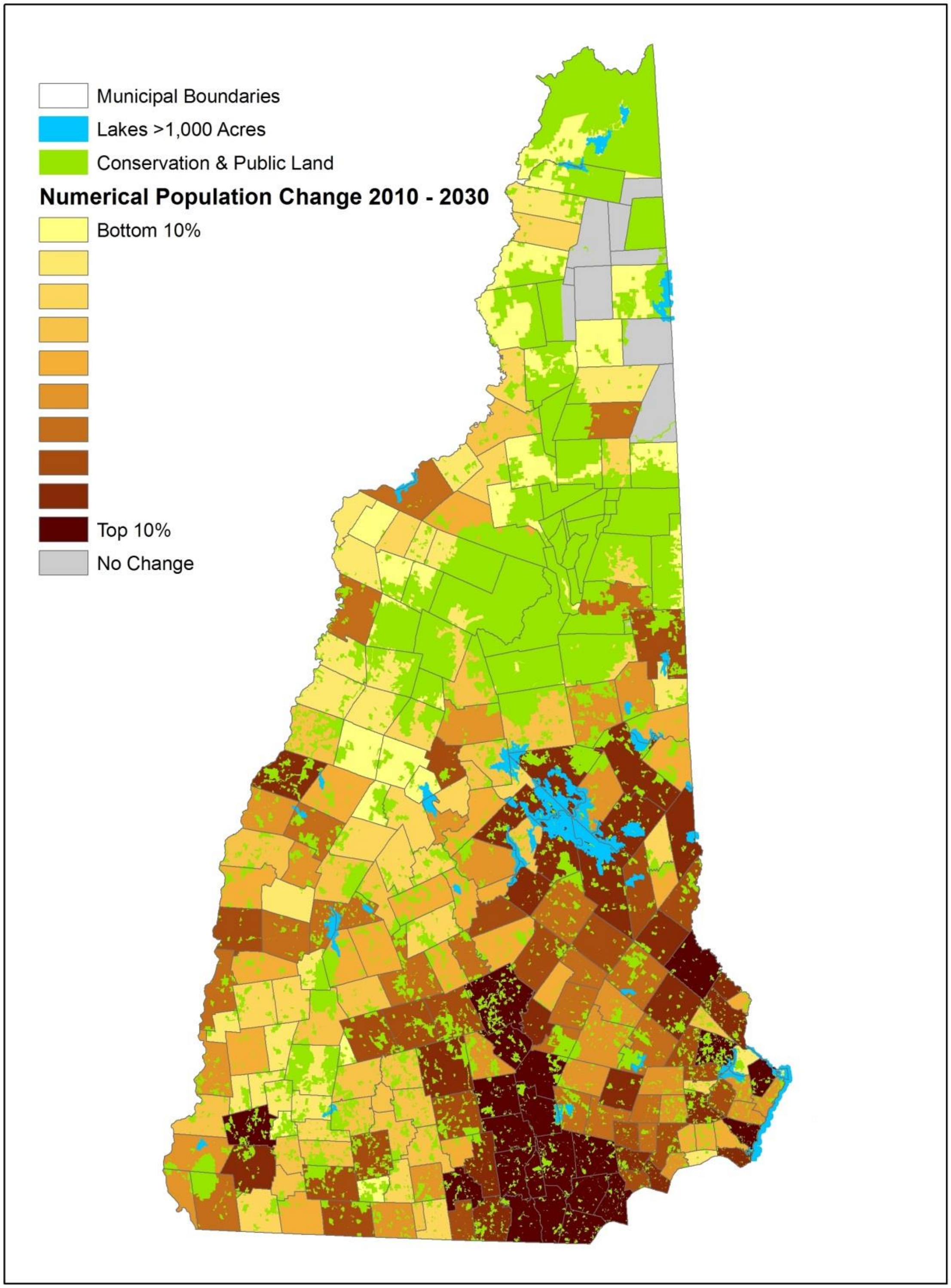
The population is anticipated to grow by approximately 45,000 people in Sullivan, Grafton and Merrimack counties by 2030. The majority of growth is estimated to follow main road corridors and urbanizing areas and is anticipated to be greatest in the towns of Hanover, Lebanon, Enfield, Canaan, Claremont, Newport and Sunapee.

The DLS Region is home to over 20,000 acres of water (lakes, river and wetlands). Forty-five percent of this water is located in Sullivan County, 33% is located in Grafton County, and 22% is located in Merrimack County. Over 8,000 acres of water occurs in the towns predicted to experience the heaviest population growth in these three counties, representing approximately 36% of the total waterbody acreage in the DLS region.

Major land use categories in the DLS region are agriculture, forest and residential, except for the more urbanized areas of Lebanon, Hanover, Claremont and Newport. Population growth and land use change go hand-in-hand. Growing populations necessitate land clearing to accommodate new homes, housing complexes, roadways and commercial businesses. Developed land corresponds to more impervious surfaces such as roadways, driveways and rooftops. It also corresponds to the loss of tree canopy coverage, unstable sediments, wildlife habitat loss and vegetative buffer loss. Consequences of development can negatively affect our waterbodies through increases in stormwater runoff, water temperatures, erosion, turbidity and nutrients, as well as shifts in aquatic life, aquatic plant, algae and cyanobacteria growth.

Population growth in the DLS region could impact a large portion of its waterbodies. Efforts should be made to evaluate current land use activities, infrastructure and regional water quality. This information should facilitate a plan to accommodate projected population growth while conserving and protecting valuable land and water resources.

Figure 3. NH Population Growth Per Town 2010-2030



EXOTIC SPECIES

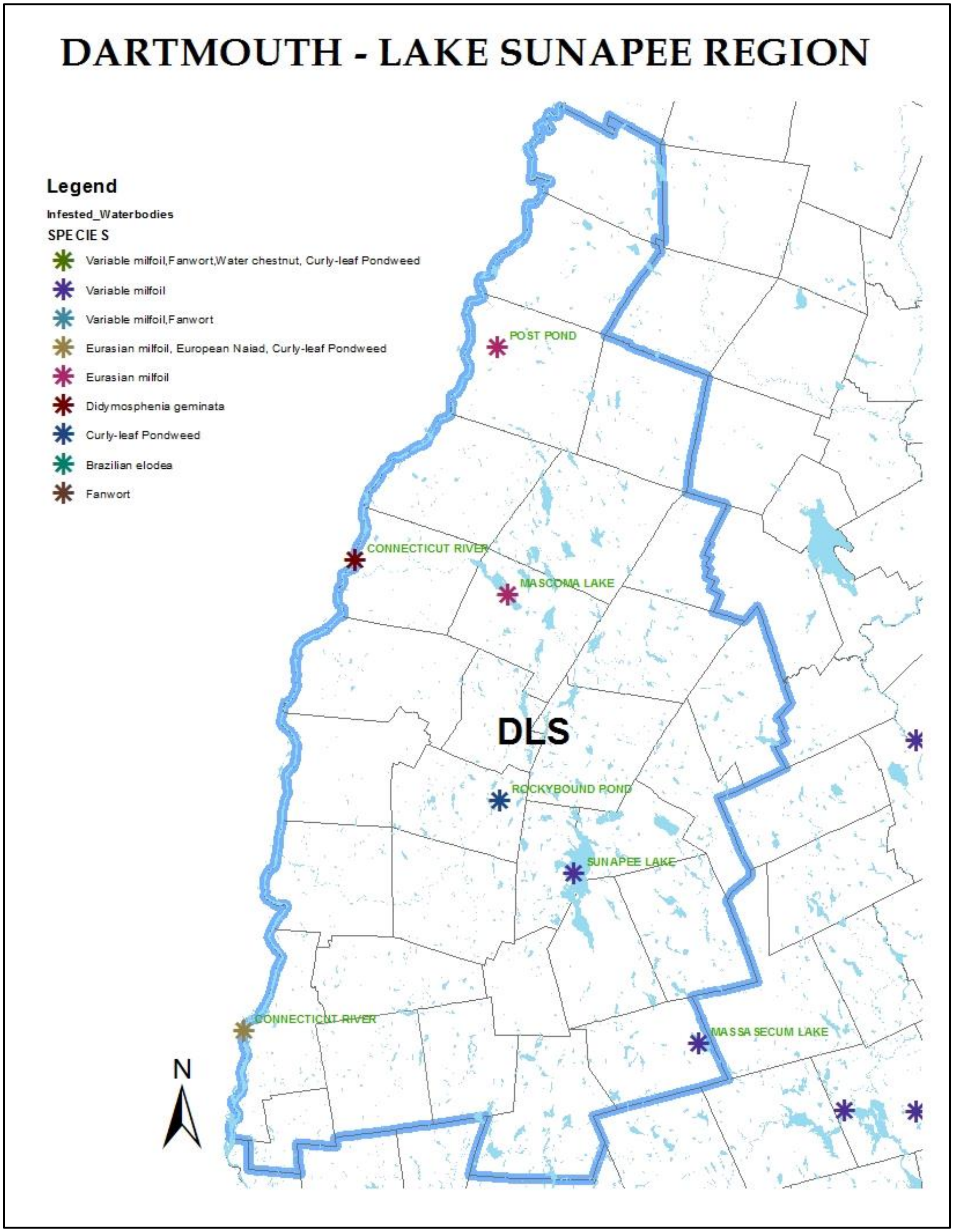
Exotic aquatic nuisance species are those plants and animals not native to New Hampshire's waterbodies, spread quickly through the aquatic environment, negatively affect economic and recreational activities, and can have a detrimental influence on natural habitats, the ecology of the system, and native species. They are a serious threat to the health of New Hampshire's aquatic ecosystems, recreation and tourism industries.

New Hampshire has 106 exotic plant infestations in 85 waterbodies. Those include Variable milfoil, Eurasian milfoil, Brazilian Elodea, Water Chestnut, Curly-Leaf Pondweed, Fanwort, European Naiad, and *Didymo* (Rock Snot). The majority of infested waterbodies contain Variable milfoil, and *Didymo*, an invasive alga, has now infested 54 river miles in the North Country. Currently, three lakes in the DLS region and the Connecticut River are infested with an exotic species. Post Pond in Lyme and Mascoma Lake in Enfield have Eurasian milfoil infestations. The Connecticut River in Charlestown is infested with Eurasian milfoil, European Naiad, Water Chestnut, and Curly-leaf Pondweed, and Rockybound Pond in Croydon is infested with Curly-leaf Pondweed. Lake Sunapee did support a small infestation of Variable milfoil in 2000, but due to early detection and rapid response actions, the lake is invasive plant species-free now. The DLS region experiences a range of exotics species that are rare elsewhere in New Hampshire. Both the European Naiad and Curly-leaf Pondweed infestations are unique to this region.

The unique nature and invasive tendencies of these exotic species heighten the need to prevent new infestations, manage current infestations and engage watershed residents. The newest infestation in the DLS region occurred in 2013, when a new Water Chestnut infestation was found in the Connecticut River. Public education is integral in preventing further infestations. One program that educates the public and engages watershed residents is the NHDES Weed Watchers Program. The Weed Watchers program has approximately 750 volunteers dedicated to monitoring lakes and ponds for the presence of exotic aquatic plants. Volunteers are trained to survey their lake or pond once a month from May through September. To survey, volunteers slowly boat, or sometimes snorkel, around the perimeter of the waterbody and its islands looking for suspicious aquatic plant species. If a suspicious plant is found, the volunteers send a specimen to NHDES for identification, either in the form of a live specimen, or as a photograph emailed to the Exotic Species Program Coordinator. Upon positive identification, a biologist visits the site to determine the extent of infestation, initiates a rapid response management technique where possible, and formulates a long-term management plan to control the nuisance infestation.

Another program dedicated to public education and engaging watershed residents regarding exotic plant species is the Lake Host™ program, which was developed in 2002 by the non-profit organization New Hampshire Lake Association (NHLA, a.k.a. NH LAKES) and NHDES. The Lake Host™ Program is funded through NHDES and federal grants and provides courtesy boat inspections at boat ramps to prevent invasive species introduction and spread. Since the program was implemented, the number of participating waterbodies, volunteers, and number of "saves" (exotic plants discovered) has consistently increased. The program is invaluable in educating boaters, preventing recreational hazards, avoiding property value and aquatic ecosystem decline, addressing aesthetic issues and saving costly remediation efforts.

Figure 4. DLS Region Exotic Plant Infestations



Geomorphology and Climate

Chemical, physical and biological properties of lakes often reflect how they were formed. Lake formation can occur in a variety of ways. In New Hampshire, most lakes were formed during the last ice age, as glaciers retreated approximately 12,000 years ago. Lakes are also formed from rivers (oxbow), as well as man- and animal-made (e.g., impoundments, dams and beavers). These formations create distinct lake morphology. Included in a lake's morphology are length, width, area, volume and shape. Lake morphology affects the lake's overall ability to adapt to shifts in climate and land use.

Along with the morphological characteristics of lakes, the bedrock and sediment geology are also important in understanding lake properties. Underlying geological properties can affect the pH and ANC of our surface and groundwater. New Hampshire is typically referred to as the "Granite State" because the bedrock geology consists of variations of igneous rock high in granite content that contributes to a lower capacity to buffer acidic inputs such as acid rain. Metamorphic rocks make up the remainder of bedrock geology and consist of slate, schist, quartzite, and carbonate rocks, which tend to contribute to a more neutral pH and better buffering capacity.

Climate also drives multiple processes in lake systems. Lakes respond to shifting weather conditions such as sunlight, rainfall, air temperature, wind and wave action in various ways. This variability is reflected in the types and number of biological communities present, as well as chemical and physical properties of the lake system. It is essential that we understand how these factors influence water quality data collected at individual lake systems. Therefore, volunteers record pertinent weather data, such as rain and storm event totals, on field data sheets while sampling.

To summarize DLS region climate conditions in 2013, the sampling season experienced average air temperatures (°F) and above average rainfall (in.) based on the weather conditions recorded in Lebanon (Table 1). Air temperatures were average in May and June, slightly above average in July, dipped in August, yet remained average in September, resulting in the 2013 average summer air temperature being approximately equal to the historical regional average. Average air temperatures resulted in average surface water temperatures. However, the 2013 monthly summer rainfall amounts were well above average from May through September, making the 2013 average summer precipitation 2.75 inches greater than the historical average.

In contrast, the 2014 sampling season was slightly cooler and drier. Average air temperatures were below normal May through August, resulting in the 2014 seasonal average being 0.5 degrees cooler than the historical average. However, surface water temperatures were slightly warmer than normal with above average temperature in June and July and the annual average surface water temperature 1.2 degrees above average. The 2014 rainfall was average in May and June, above average in July, and well below average in August and September. This resulted in the annual average summer precipitation being 0.2 inches below normal. Annual air and precipitation averages were provided by the National Climatic Data Center and historic averages were provided by the Weather Channel.

Table 1. 2013, 2014 and Historical Average Temperature and Precipitation Data for DLS Region

	May	June	July	August	September	Summer
2013 Average Air Temperature (°F)	57.4	65.5	73.6	67.6	60.1	64.8
2014 Average Air Temperature (ºF)	56.7	65.8	70.2	66.6	60.1	63.9
Average Annual Air Temperature (°F)	**57.0**	**66.0**	**71.0**	**69.0**	**60.0**	**64.6**
2013 Average Surface Water Temperature (°F)	-------	66.3	76.1	72.4	--------	71.6
2014 Average Surface Water Temperature (°F)	-------	69.7	76.0	73.3	--------	73.0
Regional Average Surface Water Temperature (ºF)	**-------**	**68.0**	**73.8**	**73.6**	**--------**	**71.8**
2013 Precipitation (in.)	5.50	6.11	8.89	7.31	3.02	6.17
2014 Precipitation (in.)	3.53	3.89	5.09	2.50	1.03	3.21
Average Annual Precipitation (in.)	**3.35**	**3.34**	**3.53**	**3.48**	**3.42**	**3.42**

MONITORING AND ASSESSMENT

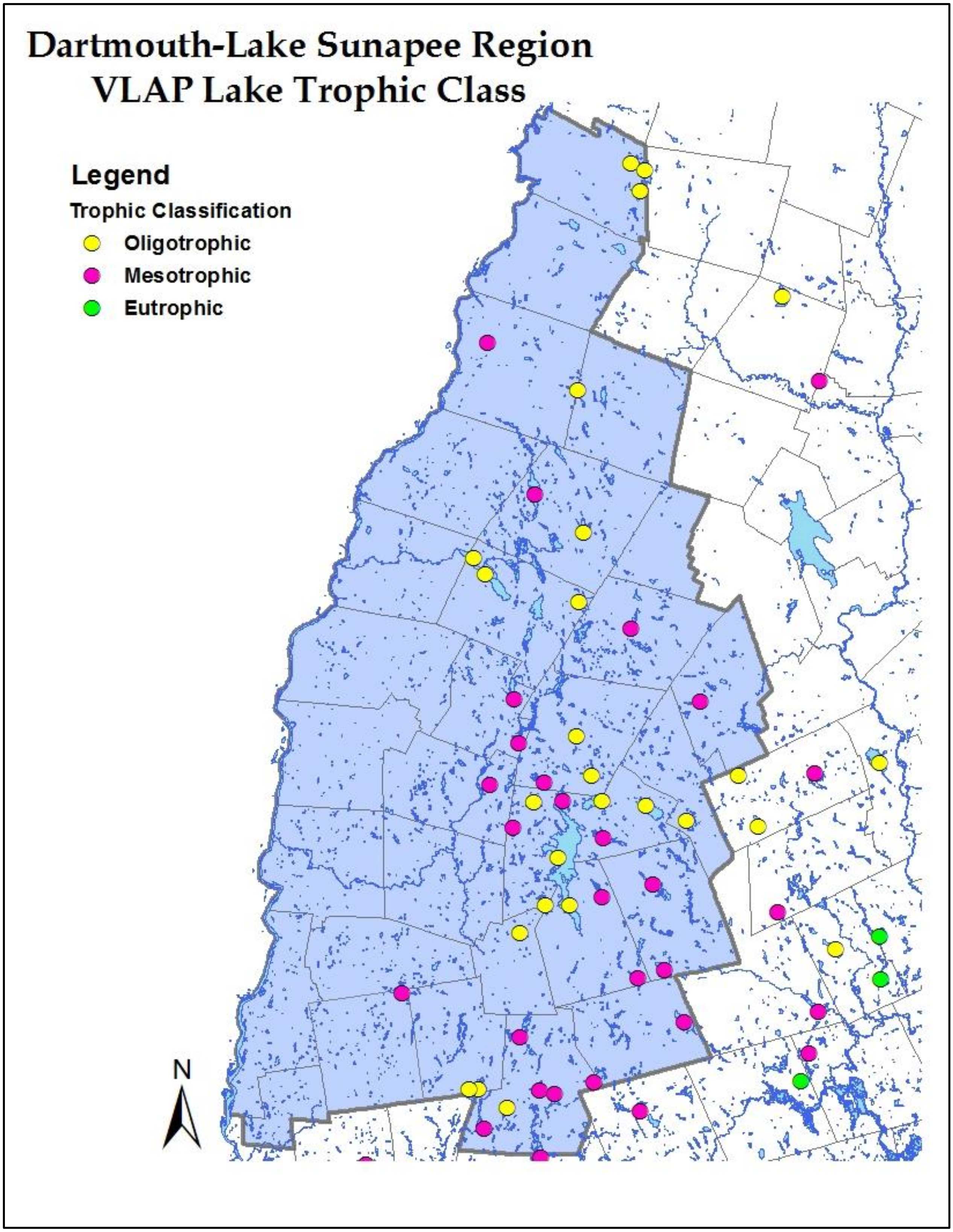
New Hampshire considers public waters to be great ponds or artificial impoundments greater than 10 acres in size, rivers, streams and tidal waters. The DLS region consists of 136 lakes, or great ponds, and 40 of those lakes participate in VLAP. These data are critical for informing the local public of lake conditions, but also in making formal national water quality assessments reported to EPA. Data on the remaining 70% of lakes are sparse, being only occasionally sampled through the NHDES Lake Trophic Survey Program.

The NHDES Lake Trophic Survey Program monitors New Hampshire's lakes on a rotating basis, with the goal of conducting a comprehensive lake survey every 10 to 15 years. The surveys compile chemical, biological and morphological data. The data are used to assign a lake trophic class to each waterbody. The trophic class provides an assessment of lake productivity and can provide information on how population growth and human activities may be accelerating the lake-aging process, also known as lake eutrophication.

Three trophic classes are used to assess a lake's overall health as oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes have high dissolved oxygen levels (> 5 mg/L), high transparency (> 12 ft. or 3.65 m), low chlorophyll-a concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen (< 2 mg/L), low transparency (< 6 ft. or 1.8 m), high chlorophyll-*a* concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of oligotrophic and eutrophic lakes for the parameters listed.

The trophic class breakdown of the DLS region lakes is as follows: 35 are oligotrophic, 56 are mesotrophic, 14 are eutrophic and 31 are un-assessed for trophic classification due to lack of data. Eighteen oligotrophic and 22 mesotrophic lakes participate in VLAP (Figure 5). Approximately 70% of the DLS lakes are classified as oligotrophic and mesotrophic; however, nearly half of those lakes do not participate in VLAP or a similar monitoring program. As human activities in watersheds accelerate lake-aging, it is imperative to keep a close eye on the health of those lakes. Efforts should also be made to gather data on the un-assessed waterbodies. Protecting a lake and preventing lake aging is much more cost-effective than restoring a damaged lake.

Figure 5. DLS Region VLAP Lake Trophic Classification



VLAP Water Quality Data Interpretation

The DLS Region is home to 40 lakes and ponds that participate in VLAP. Volunteer monitors at each lake collect comprehensive data sets at the deepest spot of the lake and from streams entering or exiting the lake. Deep spot sample collection is representative of overall lake quality and data are used to establish long-term water quality trends and to provide information on the overall health of the waterbody. Stream sample collection is representative of what flows into the lake from the surrounding watershed. Stream data are used to identify potential watershed pollution problems, such as stormwater inputs, so that remediation actions occur before they negatively impact the overall health of the waterbody.

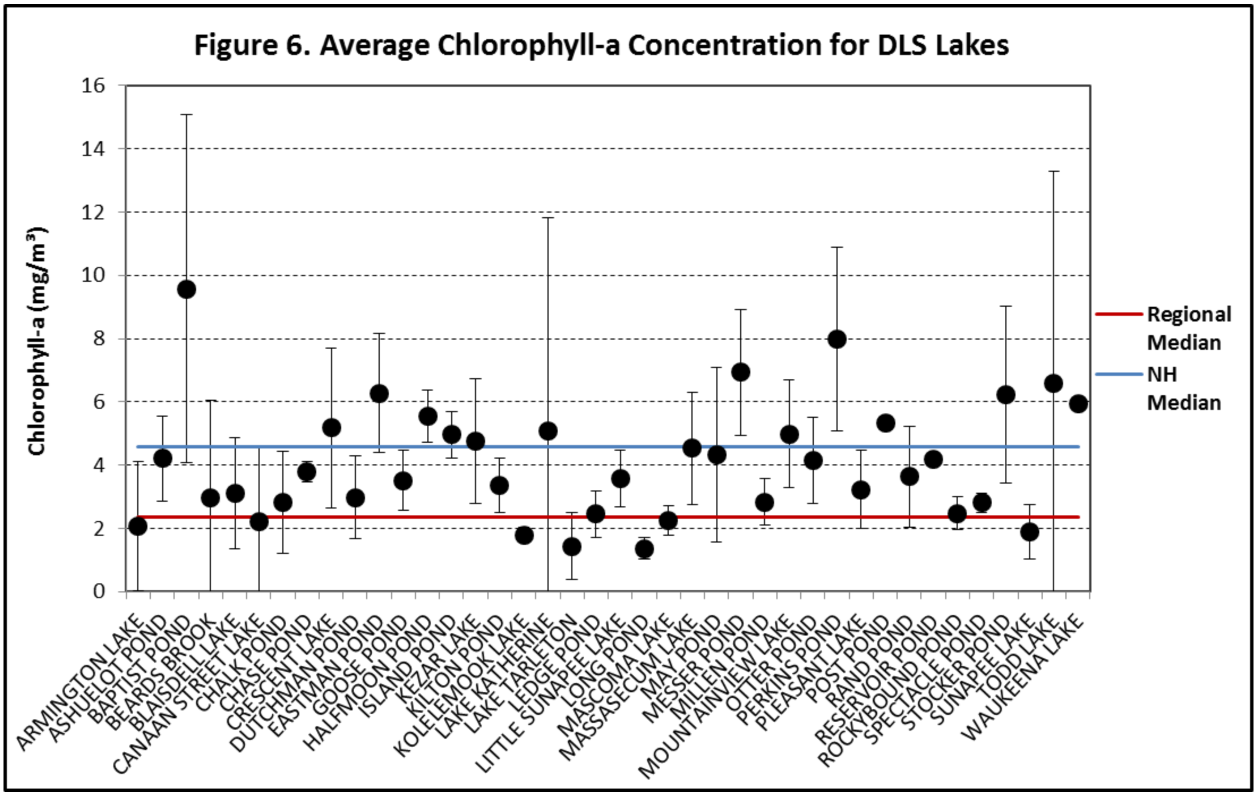
The following section provides a summary of the VLAP monitoring parameters, long-term water quality trends, and an analysis of the current year and historical data for the VLAP lakes and ponds in the DLS region compared with regional and state medians. The deep spot data for the epilimnion, or surface water layer, is compared to the New Hampshire median to provide an understanding of how the quality of a lake deep spot compares to other New Hampshire lake deep spots. Similarly, the epilimnion data are compared to the regional median to provide an understanding of how the quality of your lake deep spot compares with other local lakes. Median values were utilized to represent historical state and regional conditions as the value tends to better represent “typical” conditions while minimizing the effects of “extreme” (i.e. outlier) values. Average annual lake and regional values are then compared to the historical medians.

A complete list of monitoring parameters and how to interpret data are included in Appendix A.

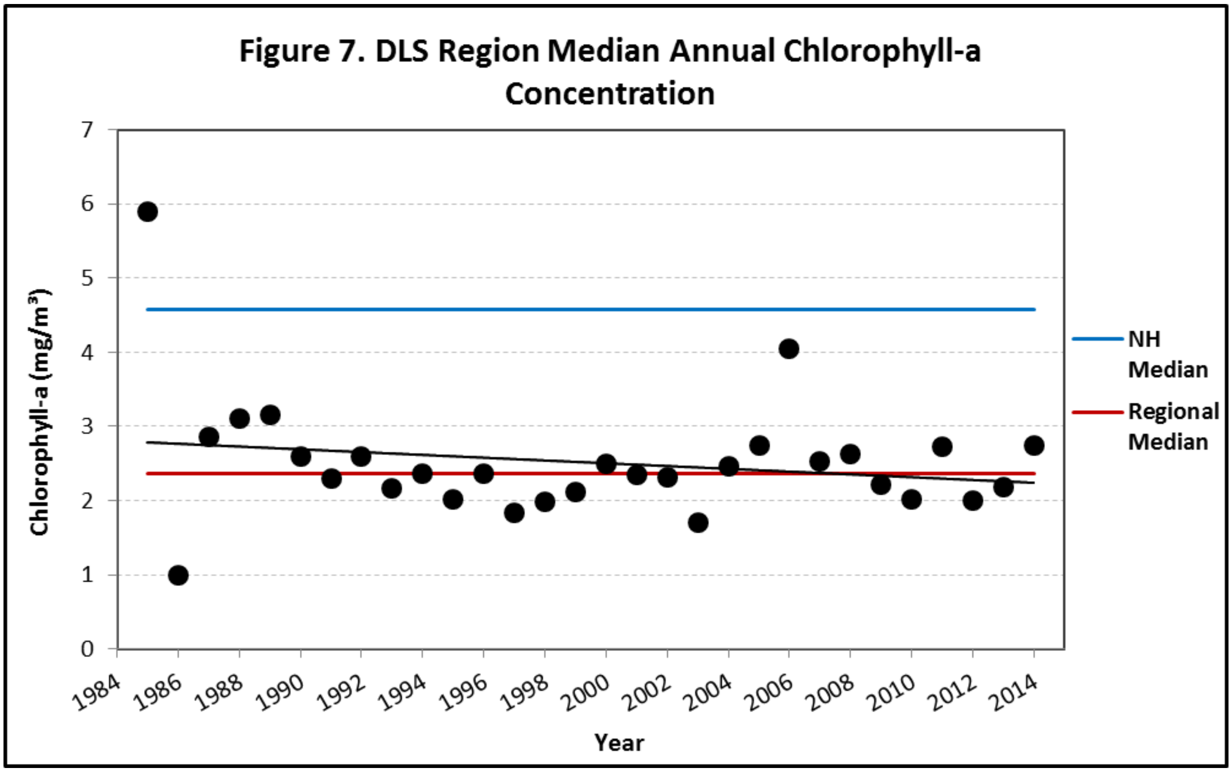
Annual and Historical Chlorophyll-*a* Data Analysis

Algae are microscopic plants that are naturally found in the lake ecosystem. Algae, including cyanobacteria, contain chlorophyll-*a*, a pigment used for photosynthesis. The measurement of chlorophyll-*a* in the water provides an estimation of algal abundance or lake productivity. **The median summer chlorophyll-a concentration for New Hampshire's lakes and ponds is 4.58 mg/m3. The median chlorophyll-a concentration for the DLS region is 2.37 mg/m^3.**

Figure 6 represents the combined 2013 and 2014 average chlorophyll-*a* concentrations for each lake in the DLS Region compared with state and regional medians. The average chlorophyll-*a* concentration at 26 DLS lake deep spot stations are equal to or below the state and regional medians and are typically representative of good water quality. Fourteen lakes have average chlorophyll-*a* concentrations above the state median. Typically, chlorophyll-*a* concentrations that exceed 5.0 mg/m^3 are considered higher than desirable. Ten lakes have average chlorophyll-*a* concentrations greater than 5.0 mg/m^3. In summary, approximately 75% of the sampled deep spots experienced chlorophyll-*a* concentrations representative of oligotrophic and mesotrophic classifications.



The annual median chlorophyll-*a* concentrations for the DLS region are represented in Figure 7 compared with state and regional medians. The median chlorophyll-*a* concentration for the region has generally remained between 1.5 and 3.0 mg/m^3 since monitoring began. The 2013 and 2014 median chlorophyll-*a* concentration remained between 2.0 and 3.0 mg/m^3 and was approximately equal to the regional median.



Chlorophyll-*a* Trend Analysis

The regional median chlorophyll-*a* level was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the region (Appendix D: Table D-1), which was consistent with the majority of regional trends.

In addition to the regional trend analysis, DLS region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Chlorophyll-*a* trends were assessed for approximately 39 deep spots at 36 lakes in the region, representing 90% of the region's VLAP lakes. Table 2 represents the DLS lakes with significant trends in chlorophyll-*a* concentration. For the full list of DLS trend results by individual lake, see Appendix D: Table D-2. Lakes with an increasing chlorophyll-*a* trend means that chlorophyll-*a* concentration has significantly increased over time, which indicates potential worsening water quality; while a decreasing chlorophyll-*a* trend indicates potentially improving water quality.

Chlorophyll-*a* concentrations have significantly improved (decreased) at six lake deep spots, remained relatively stable at 32 lake deep spots, and worsened (increased) at only one lake deep spot in the region. Approximately 97% of DLS lake deep spots have stable or improving chlorophyll-*a* concentrations. Chlorophyll-*a* concentrations are typically related to phosphorus concentrations. Phosphorus is a nutrient that promotes plant and algal growth in New Hampshire lakes. As phosphorus levels increase in lakes, it will normally cause an increase in algal growth or chlorophyll-*a* concentrations. The stable and improving chlorophyll-*a* concentrations are a positive sign for the region.

Table 2. Significant Chlorophyll-*a* Trends for DLS Region Lakes

Lake Name	Chlorophyll-*a*	
	Increasing Trend	Decreasing Trend
	p	p
Otter Pond	0.01	
Ashuelot Pond		< 0.01
Chase Pond		< 0.01
Eastman Pond		0.04
Kezar Lake		< 0.01
Kolelemook Lake		0.02
Mascoma Lake		0.04

Annual and Historical Transparency Data Analysis

Volunteers use the Secchi disk, a 20 cm disk with alternating black and white quadrants, to measure transparency. Transparency, a measure of water clarity, can be affected by algae and suspended sediments, as well as the natural water color. Transparency may also be measured using a viewscope, a cylindrical tube, designed to decrease surface water properties that may make Secchi disk viewing difficult. A comparison of data collected with and without the viewscope shows that the viewscope typically increases the observed Secchi disk depth, particularly on sunny and windy days. **The median summer transparency for New Hampshire's lakes and ponds is 3.20 meters. The median transparency for the DLS region is 4.00 meters.**

Figure 8 represents the combined 2013 and 2014 average transparency for each lake in the DLS Region compared with state and regional medians. The average transparencies at 15 DLS lake deep spots are below both the regional and state medians and are typically representative of good water clarity. Thirteen lakes fall between the regional and state medians, and 12 are above the regional median. It is important to note that data from Lake Sunapee are collected using only a viewscope, which tends to increase transparency depths. Overall lake depth plays an important role when interpreting transparency data. Shallow lakes will typically report lower transparencies than deeper lakes, yet these waterbodies may be quite clear. A better representation would be to look at how transparency changes over time.

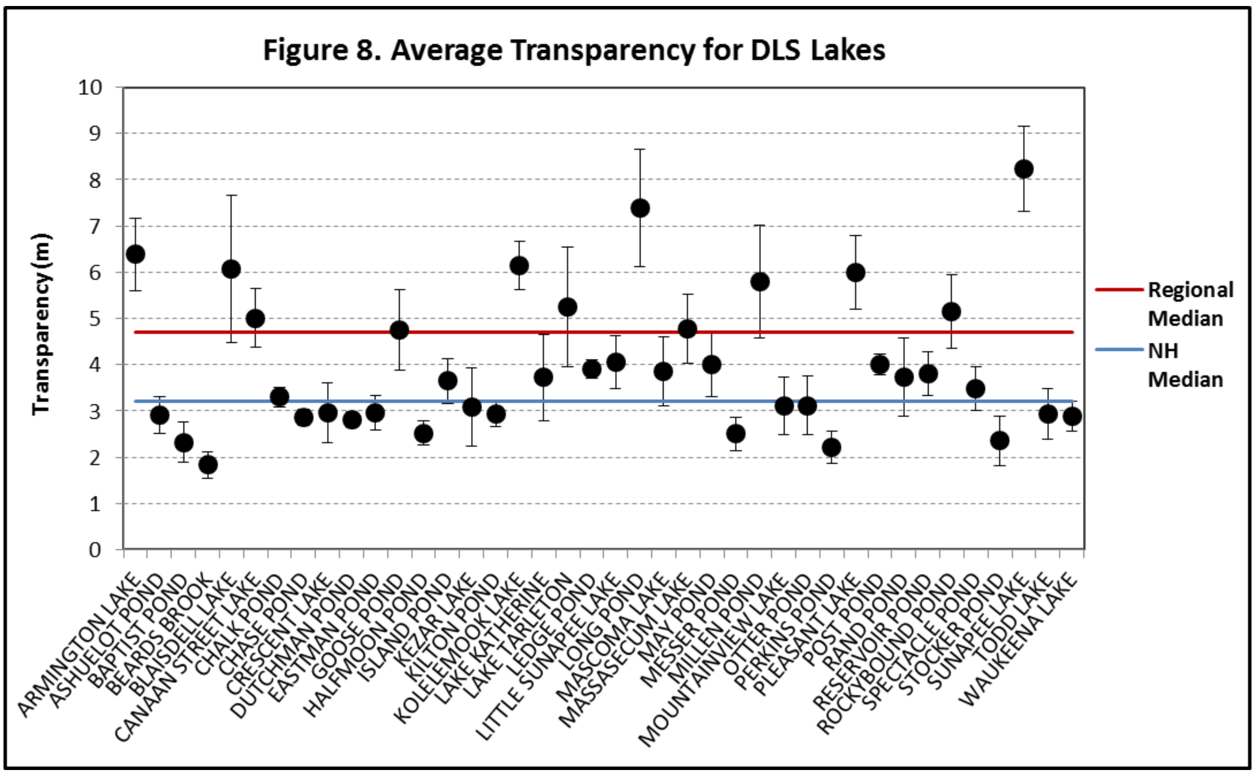
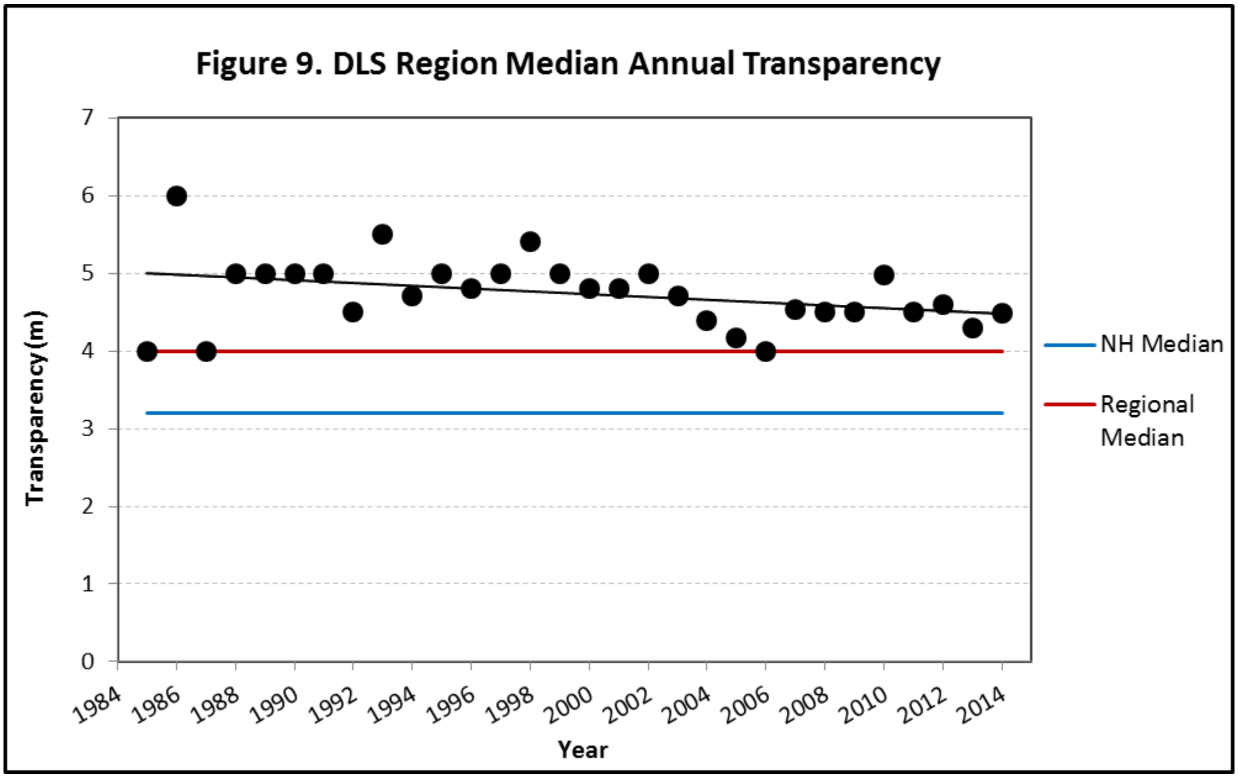


Figure 9 represents the annual median transparency for the DLS region compared with state and regional medians. Median transparencies for the region have remained at or above the regional median and well above the state median since 1985. Specifically, median transparency has generally remained between approximately 4.0 and 5.0 meters. The 2013 and 2014 median values were less than those measured since 2007. Above average rainfall in 2013 may have resulted in decreased transparencies, as well as the above average algal growth in 2014.



Transparency Trend Analyses

The regional median transparency was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significant decreasing (worsening) trend was detected for the region consistent with all other regional trends except the Lakes Region (Appendix D: Table D-1).

DLS region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Transparency trends were assessed for approximately 39 deep spots at 36 lakes in the region, representing 90% of the region's VLAP lakes. Table 3 represents the DLS lakes with significant trends in transparency. Increasing transparency trends mean that water clarity has become significantly deeper over time, which indicates potential improving water quality, while decreasing transparency trends mean water clarity has become shallower, indicating potentially worsening water quality.

Trend analysis revealed two lake deep spots with increasing (improving) transparency, representing five percent of lakes, 11 lake deep spots with decreasing (worsening) transparency representing 30% of lakes, and 26 lake deep spots with relatively stable transparency trends representing 67% of lakes. While the majority of regional lakes have not experienced significant decreases in lake transparency, the data, when combined, indicate that regional transparency has significantly decreased (Figure 9; Appendix D: Table D-2).

Table 3. Significant Transparency Trends for DLS Region Lakes

Lake Name	Transparency	
	Increasing Trend	Decreasing Trend
	p	p
Blaisdell Lake	0.04	
Kilton Pond	< 0.01	
Chalk Pond		< 0.01
Crescent Lake		< 0.01
Halfmoon Pond		0.03
Island Pond		< 0.01
Kolelemook Lake		< 0.01
Messer Pond		0.01
Millen Pond		0.04
Mountainview Lake		< 0.01
Otter Pond		< 0.01
Pleasant Lake		< 0.01
Stocker Pond		0.01

Transparency, or water clarity, is typically affected by the amount of algae, color and particulate matter within the water column. The increased frequency and intensity of storm events, as well as higher than average precipitation, has resulted in an increase in stormwater runoff as well as increased flushing of wetland systems. Stormwater runoff can transport exposed and unstable sediments and other debris to lake systems, thus resulting in decreased transparency. Wetland systems are rich in organic acids that add color to the water, making it appear dark. Lake watersheds with extensive wetland systems may also experience decreased transparency due to the influx of dark water during storm events. Transparency impacts due to wetland flushing is a natural occurrence, however erosion due to stormwater runoff can be mitigated to reduce sediments and particulate entering lake systems. Refer to Appendix B for more information on how to manage stormwater runoff.

Annual and Historical Total Phosphorus Data Analysis

Phosphorus is typically the limiting nutrient for vascular plant and algal growth in New Hampshire's lakes and ponds. Excessive phosphorus in a pond can lead to increased plant and algal growth over time. **The median summer epilimnetic (upper layer) total phosphorus concentration of New Hampshire's lakes and ponds is 12 ug/L. The median epilimnetic total phosphorus concentration of the DLS region is 8 ug/L.**

Figure 10 represents the combined 2013 and 2014 average epilimnetic total phosphorus concentration for DLS region lakes compared with state and regional medians. The regional median is considerably lower than the state median, and is considered to be representative of oligotrophic conditions. Twenty DLS lakes have average phosphorus concentrations equal to or below the regional median. Fifteen DLS lakes have average phosphorus concentrations between the regional and state medians, and only five lakes have average phosphorus concentrations greater than the state median. Overall, regional lake epilimnetic phosphorus concentrations are relatively low and representative of oligotrophic and mesotrophic conditions.

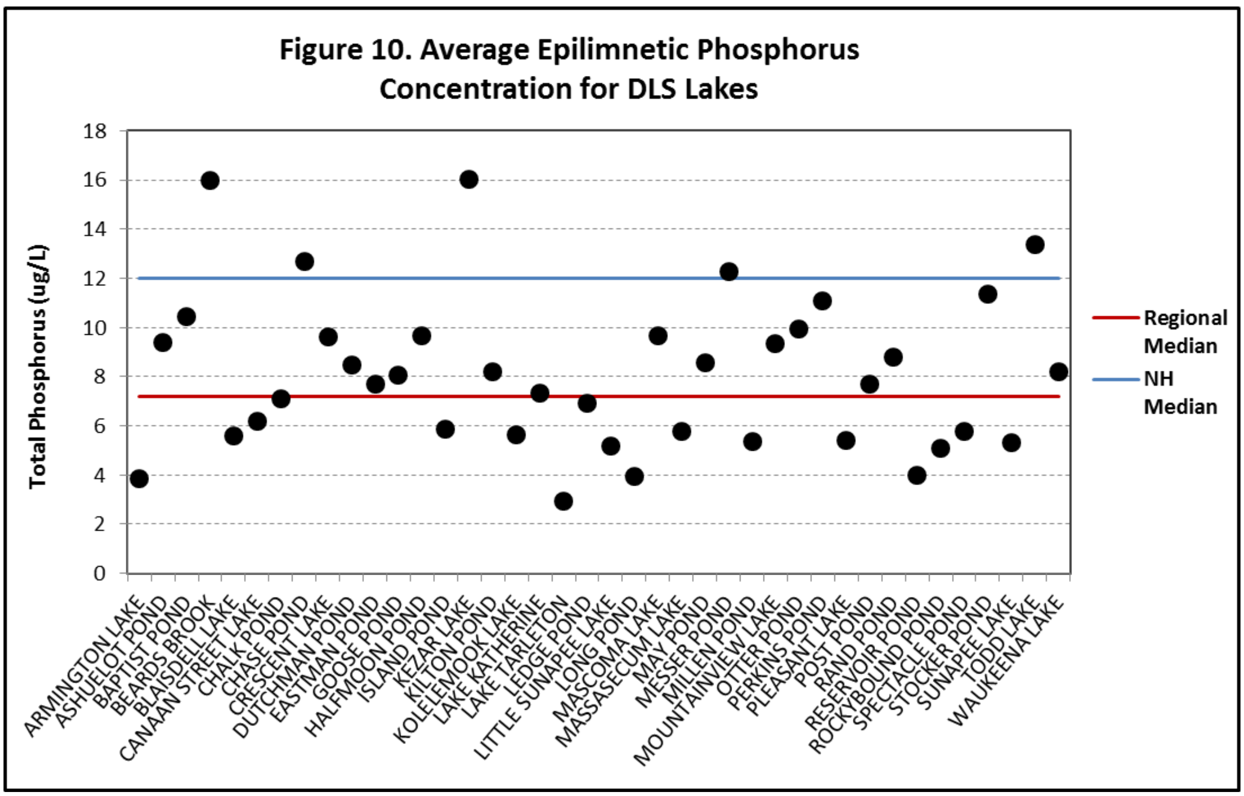
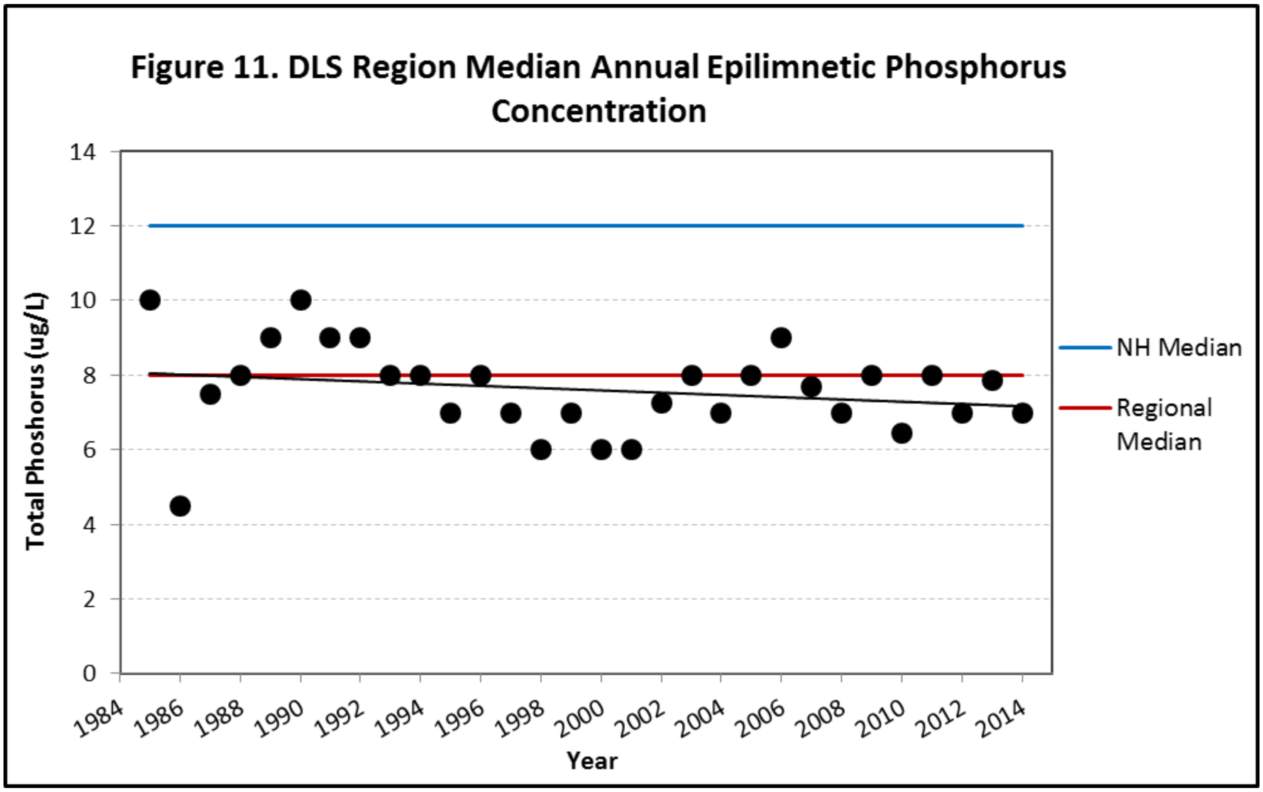


Figure 11 represents the median annual epilimnetic phosphorus concentration for the DLS Region. Regional median phosphorus concentrations are well below the New Hampshire median and have generally remained below the regional median since 1995. Specifically, the regional median has remained at or below 8 ug/L since 1995 (excluding 2006).



Epilimnetic Phosphorus Trend Analyses

The regional median epilimnetic phosphorus was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the region (Appendix D: Table D-1) consistent with all other regional trends except the Lakes and Seacoast Regions.

In addition to the regional trend analysis, DLS region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Epilimnetic phosphorus trends were assessed for approximately 39 deep spots at 36 lakes in the region representing 90% of the region's VLAP lakes. Table 4 represents the DLS lakes with significant trends in epilimnetic phosphorus levels. For the full list of DLS trend results by individual lake, see Appendix D: Table D-2. Trend analysis revealed six lake deep spots with significantly decreasing (improving) phosphorus levels, representing 15 percent of regional lakes. The remaining 33 lake deep spots experienced relatively stable phosphorus levels, representing 85% of regional lakes.

Epilimnetic phosphorus trends that increase over time can be the result of phosphorus-enriched stormwater runoff related to increased watershed development. An increase in watershed development often results in an increase in impervious surfaces and unstable sediments. This contributes to an increase in stormwater runoff and sedimentation to rivers and lakes. Efforts should be made to adopt watershed ordinances to limit stormwater runoff and other phosphorus contributions. Watershed residents should be educated on utilizing and installing stormwater management controls on their properties. For more information and resources to control stormwater and phosphorus loading refer to Appendix B.

Table 4. Significant Epilimnetic Total Phosphorus Trends for DLS Region Lakes

Lake Name	Total Phosphorus
	Decreasing Trend
	p
Armington Lake	< 0.01
Ashuelot Pond	0.02
Kolelemook Lake	0.04
Long Pond	0.01
Millen Pond	0.04
Tarleton Lake	0.03

Dissolved Oxygen Data Analysis

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant (i.e., sensitive) to this situation, such as trout, will be forced to migrate closer to the surface where there is more dissolved oxygen but the water is generally warmer, and the species may not survive. Temperature and time of day also play a role in the amount of dissolved oxygen in the water column. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring and fall than during the summer. Oxygen concentrations are typically lower overnight than during the day. Plants and algae respire (use oxygen) at night and photosynthesize (produce oxygen) during the day. Dissolved oxygen levels may shift depending on the abundance of aquatic plants and algae in the littoral (near shore) and pelagic (deep water) zones.

Dissolved oxygen and temperature profiles are collected at VLAP lakes on an annual or biennial basis. The average whole-column dissolved oxygen level for the DLS region is 6.85 mg/L, which is sufficient to support a wide range of aquatic life. For additional information regarding dissolved oxygen, please refer to Appendix A.

Annual and Historical pH Data Analysis

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 typically limits the growth and reproduction of fish. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0. **The median epilimnetic pH value for New Hampshire's lakes is 6.6, which indicates that the state surface waters are slightly acidic. The median epilimnetic pH value of the DLS region is 6.71.**

Figure 12 represents the combined 2013 and 2014 average epilimnetic pH for each lake in the DLS region compared with the state and regional medians. Twenty-five DLS lakes have average epilimnetic pH values greater than the state and regional medians and are sufficient to support aquatic life. Fifteen lakes have average epilimnetic pH less than the state median and potentially critical to aquatic life. Typically a pH between 6.5 and 8.0 is ideal for a healthy environment; additionally, pH values below 6.5 or above 8.0 are harmful to most aquatic organisms. The lowest, most acidic, average epilimnetic pH value was 5.50 measured at Ashuelot Pond in Washington, whereas the highest, most basic, epilimnetic pH value was 7.32 measured at Post Pond in Lyme.

Figure 12. Average Epilimnetic pH for DLS Lakes

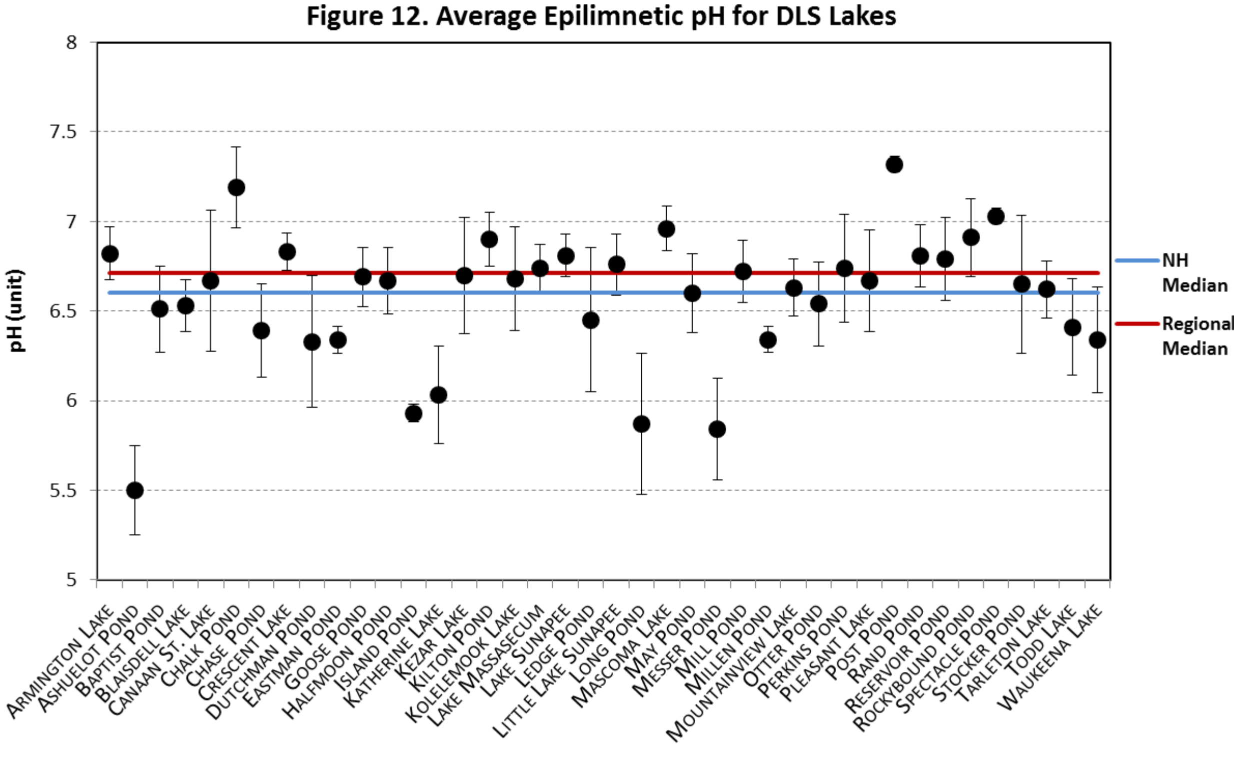
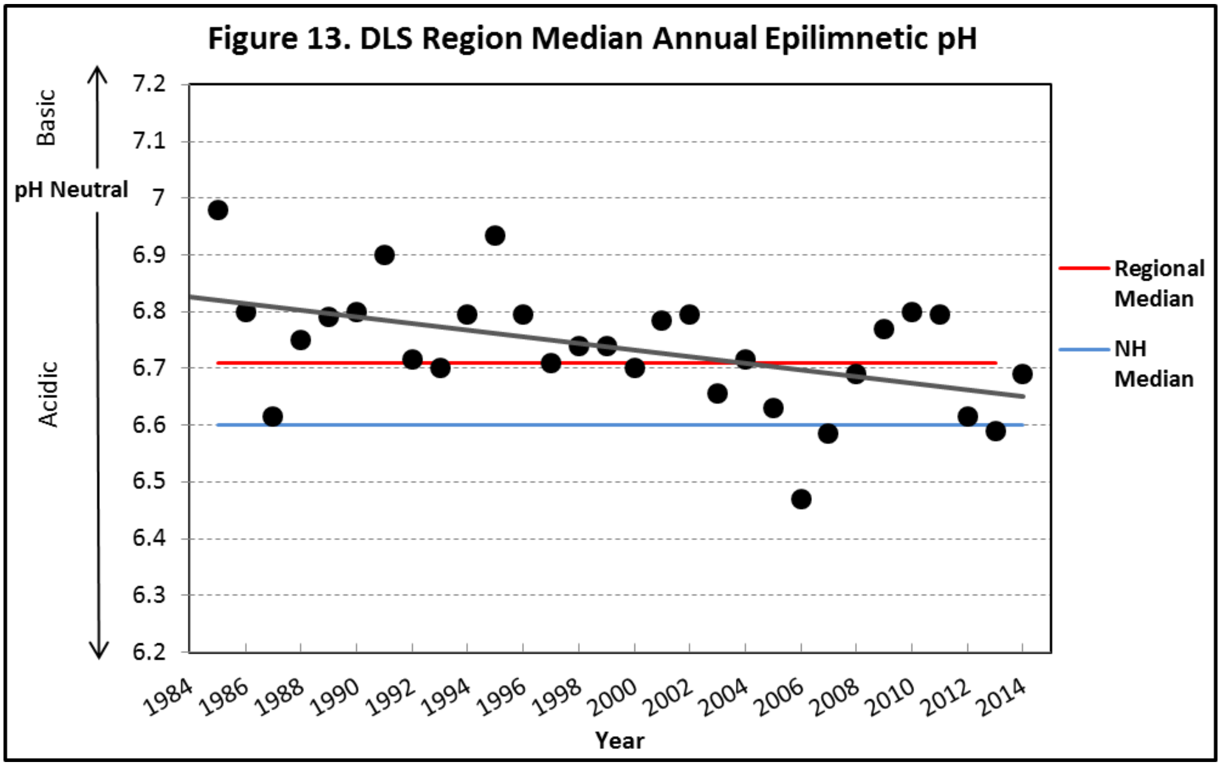


Figure 13 represents the median annual epilimnetic pH value for DLS lakes compared with the regional and state medians. The median epilimnetic pH generally remained between 6.7 and 6.9 from 1985 to 2002 and then decreased, or became more acidic, and has generally remained between 6.6 and 6.7 from 2003 to 2014.



pH Trend Analysis

The regional median epilimnetic pH was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly decreasing (worsening) trend was detected for the region (Appendix D: Table D-1). This trend was also detected in the Merrimack Valley (MV) region, however all other regions of the state experienced increasing (improving) or stable trends (Appendix D: Table D-1).

In addition to the regional trend analysis, DLS region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Epilimnetic pH trends were assessed for approximately 39 deep spots at 36 lakes in the region, representing 90% of DLS lakes. Table 5 represents the DLS lakes with significant trends in epilimnetic pH. For the full list of DLS trend results by individual lake, see Appendix D: Table D-2. Trend analysis revealed nine lakes with significantly decreasing (worsening) epilimnetic pH, representing 23% of regional lakes, five lakes with significantly increasing (improving) epilimnetic pH, representing 13% of regional lakes and 25 lakes with relatively stable epilimnetic pH levels, representing 84% of regional lakes.

Table 5. Significant Epilimnetic pH Trends at DLS Region Lakes

Lake Name	pH (Epilimnion)	
	Increasing Trend	Decreasing Trend
	p	p
Little Lake Sunapee	0.04	
Messer Pond	0.03	
Millen Pond	0.03	
Reservoir Pond	0.04	
Tarleton Lake	< 0.01	
Blaisdell Lake		< 0.01
Kezar Lake		< 0.01
Kolelemook Lake		0.01
Mountainview Lake		< 0.01
Otter Pond		0.01
Perkins Pond		0.05
Post Pond		0.02
Stocker Pond		< 0.01
Todd Lake		< 0.01

Variations in pH values between lakes and between different geographical regions may depend on the composition and weathering of underlying bedrock and the lake water chemistry. Another contributing factor to pH is acid deposition received as a result of emissions from power plants and vehicles. This increases levels of atmospheric carbon, nitrogen and sulfur, which fall back to the earth in the form of acidic precipitation.

A recent report published by NHDES, "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" analyzed trends in historical pH, ANC, conductivity, sulfate and nitrate concentrations from three state-wide monitoring programs to determine if the state's lakes and ponds are recovering from the effects of acid rain. The Acid Outlet, Remote Pond and Rooftop Rain programs have been collecting data since the early 1970s and 1980s. Analysis of sulfate, nitrate and pH concentrations of precipitation indicate that pH levels have significantly increased (become less acidic), and sulfate and nitrate concentrations have significantly decreased (improved) since 1972. Analysis of sulfate, nitrate, pH and ANC concentrations of lake water indicate that the majority of lakes sampled have experienced a stable trend or increase (improvement) in pH and ANC as well as a 90% reduction in sulfate and nitrate concentration. This supports significant improvements in local and national air quality as regulations have improved acid rain; however our surface waters reflect a slower rate of recovery.

Annual and Historical ANC Data Analysis

ANC measures the buffering capacity of a water body, or its ability to resist changes in pH by neutralizing acidic inputs. These buffers are typically chemical compounds known as 'bases' such as bicarbonate and carbonate. Geology can play an important part in a water body's buffering capacity. Lakes located in areas with predominantly limestone (calcium carbonate), sedimentary rocks and carbonate-rich soils often have a higher ANC, while lakes located in areas with predominantly granite and carbon-poor soils often have a lower ANC. The higher the ANC, the more readily a waterbody can resist change in pH. **The median ANC value for New Hampshire's lakes and ponds is 4.8 mg/L, and the median ANC value for the DLS Region is 4.6 mg/L, which indicates that many lakes and ponds in the state are at least *moderately vulnerable* to acidic inputs.**

Figure 14 represents the combined 2013 and 2014 average ANC for DLS region lakes compared with the state and regional medians. Four lakes have average ANC values much greater than the state and regional medians and greater than the 10 mg/L and considered to have a *low vulnerability* to acidic inputs. Thirty lakes have average ANC values that fall between 2.1 and 10.0 mg/L and considered to be *moderately vulnerable* to acidic inputs. Six lakes have average ANC values less than 2.0 mg/L and considered to be *extremely vulnerable* to acidic inputs. A wide range of buffering capacity exists for the region. The lowest ANC measured was 0.49 mg/L at Ashuelot Pond in Washington and the highest ANC measured was 20.2 mg/L measured at Post Pond in Lyme.

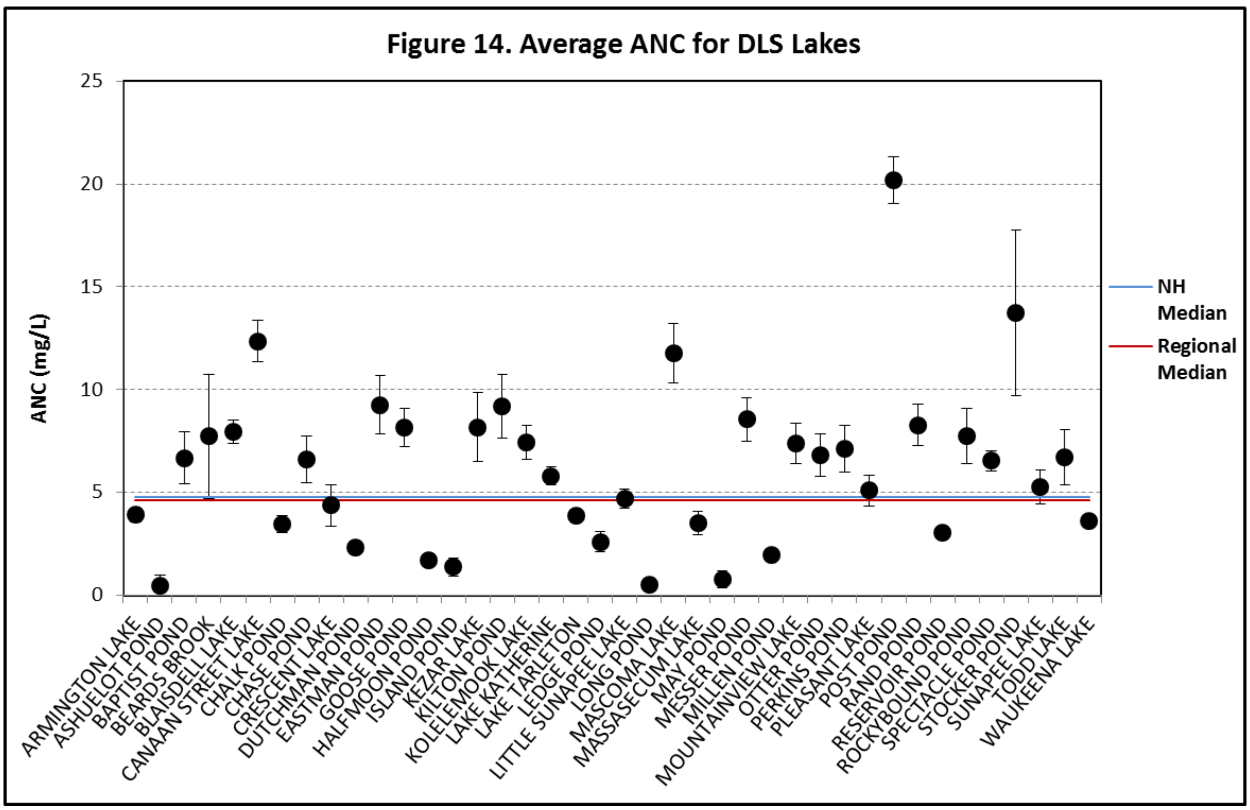
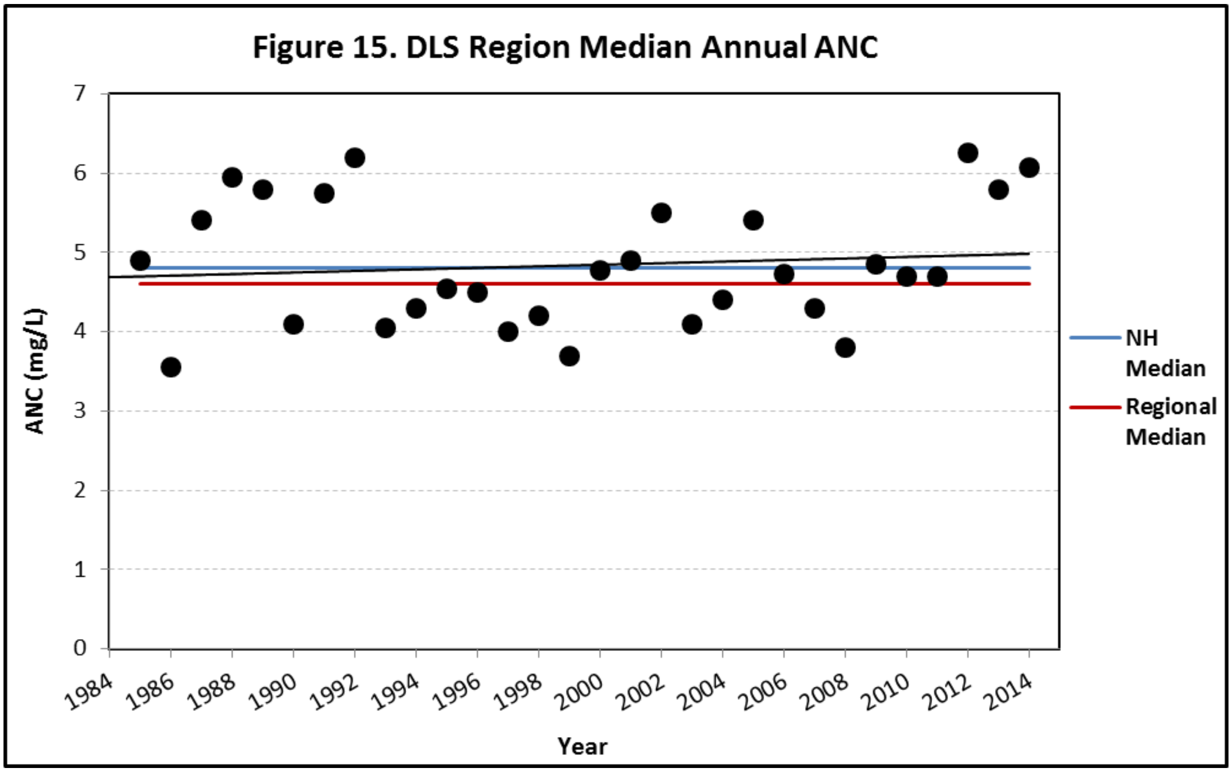


Figure 15 represents the median annual ANC for the DLS region compared with state and regional medians. The median annual ANC has generally remained between 4.0 and 6.0 mg/L since 1985, however, since 2012, the median ANC has remained approximately 6.0 mg/L. In 2012, many lakes in this region reported the phenomena of an increase in ANC but a decreased pH which has continued to an extent through 2014. Typically, when the buffering capacity increases, the pH also increases, however the opposite has generally occurred here. Additional monitoring is necessary to identify an exact cause.



Acid Neutralizing Capacity Trend Analysis

The regional median ANC was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the DLS Region (Appendix D: Table D-1; Figure 15); however, a significantly increasing ANC trend was detected for five of the seven regions, indicating that New Hampshire lakes' buffering capacity is improving. This further supports the NHDES "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" report.

Annual and Historical Conductivity Data Analysis

Conductivity is the numerical expression of the ability of water to carry an electric current, which is determined by the number of negatively charged ions from metals, salts and minerals in the water column. The soft waters of New Hampshire have traditionally low conductivity values, generally less than 50 uMhos/cm. **The median conductivity value for New Hampshire's lakes and ponds is 40.0 uMhos/cm. The median epilimnetic conductivity value for the DLS region is 64.3 uMhos/cm.**

Figure 16 represents the combined 2013 and 2014 average epilimnetic conductivity for DLS region lakes compared with the state and regional medians. Fourteen lakes have average epilimnetic conductivity less than the state median and generally representative of good water quality. Ten lakes have average epilimnetic conductivity between the state and regional medians and representative of good to average water quality. Eight lakes have average epilimnetic conductivity greater than the regional median but less than 100.0 uMhos/cm and still representative of average conditions. Seven lakes have average epilimnetic conductivity greater than 100.0 uMhos/cm and are typically representative of a more urbanized landscape or receive runoff from urbanized areas.

Conductivity values fluctuate widely among the region's lakes. The lowest value of 11.0 uMhos/cm was measured at May Pond in Washington whereas the highest value of 176.9 uMhos/cm was measured at Stocker Pond in Grantham. A wide range of watershed types and degrees of development exists in the region. May Pond experiences very little developmental pressures located inside the heavily forested area of Pillsbury State Park. Although development is not heavy around Stocker Pond in Grantham, stormwater runoff from I-89 influences conductivity levels in the pond.

Figure 16. Average Conductivity for DLS Lakes

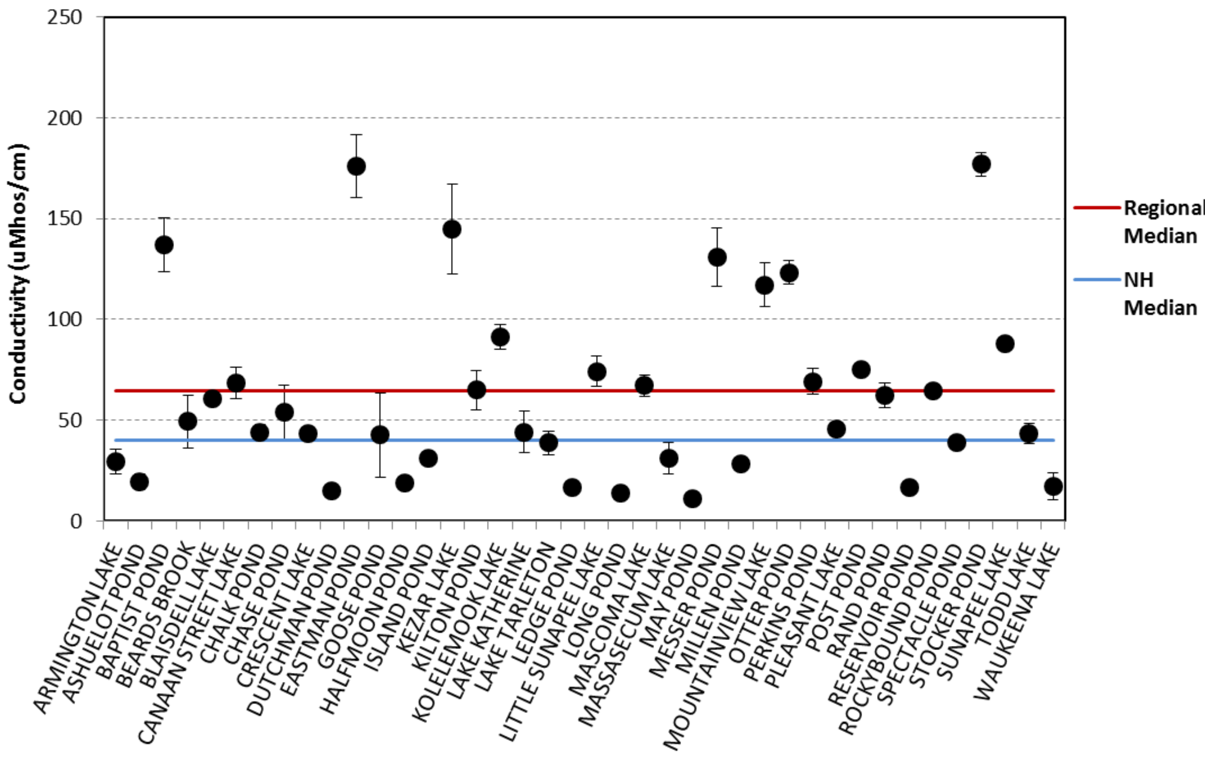
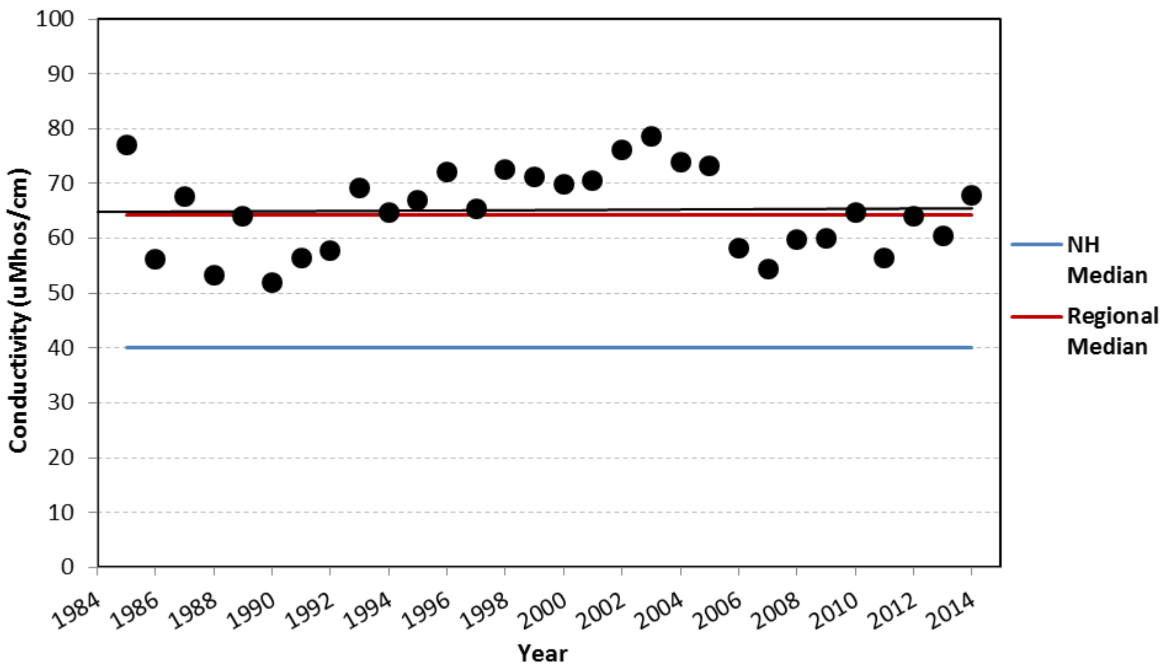


Figure 17 represents the median annual epilimnetic conductivity value at DLS lakes compared with the regional and state medians. Median epilimnetic conductivity generally increased from 1985 to 2005 from between 50.0 and 60.0 uMhos/cm to between 70.0 and 80.0 uMhos/cm. However, since then conductivity has decreased back to levels measured between 1984 and 1992. This is a positive sign and may indicate reduction of pollutants associated with winter road maintenance and reduction of stormwater runoff.

Figure 17. DLS Region Median Annual Epilimnetic Conductivity



Historical Conductivity Trend Analysis

The regional median epilimnetic conductivity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the DLS Region (Appendix D: Table D-1 and Figure 17). This is a positive sign as all other regions of the state have experienced significant increasing (worsening) epilimnetic conductivity levels (Appendix D: Table D-1).

In addition to the regional trend analysis, DLS region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Epilimnetic conductivity trends were assessed for approximately 39 deep spots at 36 lakes in the region representing 90% of the region's VLAP lakes. Table 6 represents the DLS lakes with significant trends in epilimnetic conductivity. For the full list of DLS trend results by individual lake, see Appendix D: Table D-2. Trend analysis revealed eight lakes with significantly decreasing (improving) epilimnetic conductivity, representing 21% of regional lakes, 11 lakes with significantly increasing (worsening) epilimnetic conductivity, representing 28% of regional lakes, and 20 lakes with relatively stable epilimnetic conductivity, representing 51% of regional lakes.

Table 6. Significant Epilimnetic Conductivity Trends for DLS Region Lakes

Lake Name	Conductivity	
	Increasing Trend	Decreasing Trend
	p	p
Canaan St. Lake	< 0.01	
Chalk Pond	0.01	
Eastman Pond	< 0.01	
Kolelemook Lake	0.01	
Otter Pond	< 0.01	
Perkins Pond	< 0.01	
Rockybound Pond	< 0.01	
Stocker Pond	< 0.01	
Lake Sunapee, 200	< 0.01	
Lake Sunapee, 210	< 0.01	
Lake Sunapee, 230	< 0.01	
Ashuelot Pond		< 0.01
Dutchman Pond		0.04
Halfmoon Pond		0.01
Island Pond		< 0.01
Ledge Pond		0.04
Long Pond		0.01
Millen Pond		0.02
Rand Pond		0.02

Generally, conductivity values in New Hampshire lakes exceeding **100 uMhos/cm** indicate cultural, meaning human, disturbances. An elevated conductivity trend typically indicates point sources and/or non-point sources of pollution are occurring within the watershed. These sources include failed or marginally functioning septic systems, agricultural runoff, road runoff and groundwater inputs. New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could also contribute to increasing conductivity. In addition, natural sources, such as the mineral composition of bedrock, can influence conductivity. Seven DLS region lakes had conductivity values above 100 uMhos/cm.

Annual and Historical Chloride Data Analysis

High conductivity values are often due to elevated chloride levels, which are generally associated with road salt and/or septic inputs. The chloride ion (Cl^-) is found naturally in some surface and ground waters and in high concentrations in seawater. The chloride content in New Hampshire lakes is naturally low in surface waters located in remote areas away from habitation. Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state has adopted acute and chronic chloride criteria of 860 and 230 mg/L respectively. **The median chloride value for New Hampshire's lakes is 4 mg/L. The median epilimnetic chloride value for the DLS region is 9 mg/L.**

Figure 18 represents the combined 2013 and 2014 average chloride for DLS region lakes compared with the state and regional medians. Three lakes have chloride levels less than the state median and are considered very low. Seven lakes have chloride levels between the state and regional medians and also considered low. Ten lakes have chloride levels greater than the regional median and are greater than what would be measured in undisturbed surface waters, however are much less than state acute and chronic chloride criteria. The chloride measurement is relatively new for VLAP and is an optional analyte for participating lakes. Lakes that serve as water supplies or where conductivity levels may be influenced by chloride are analyzed annually.

Figure 18. Average Epilimnetic Chloride for DLS lakes

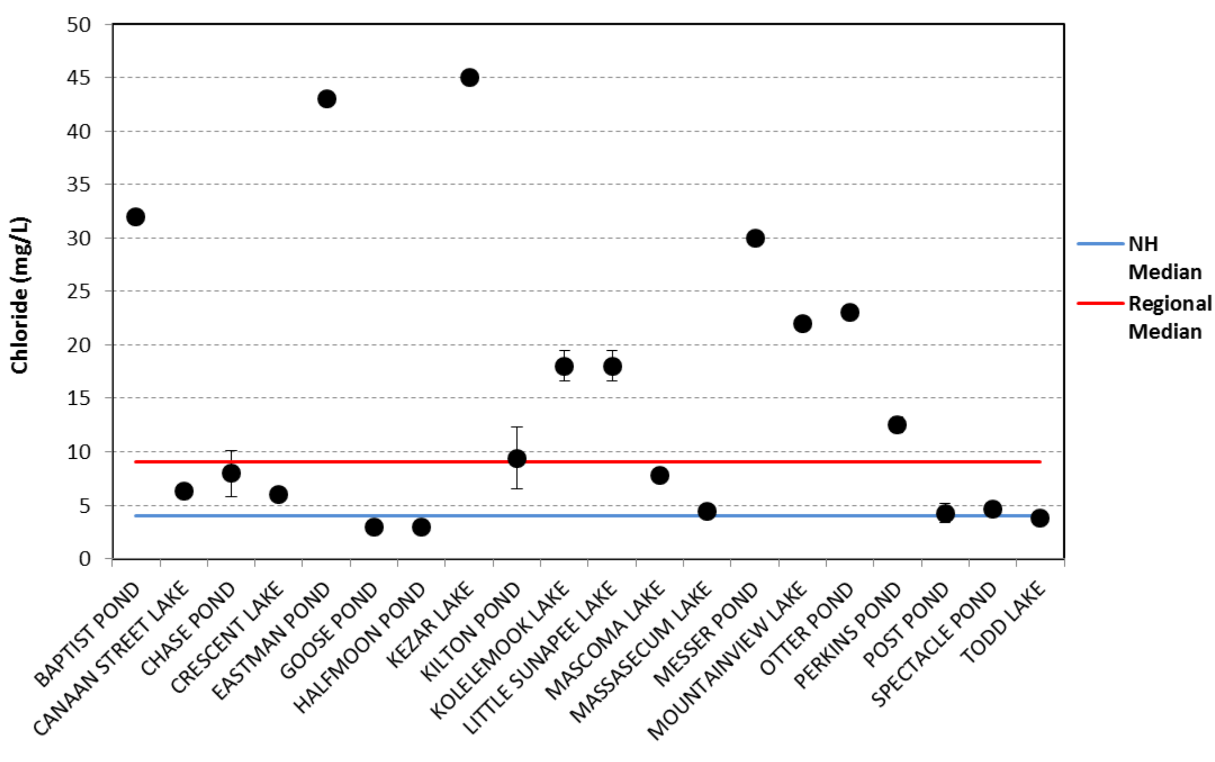
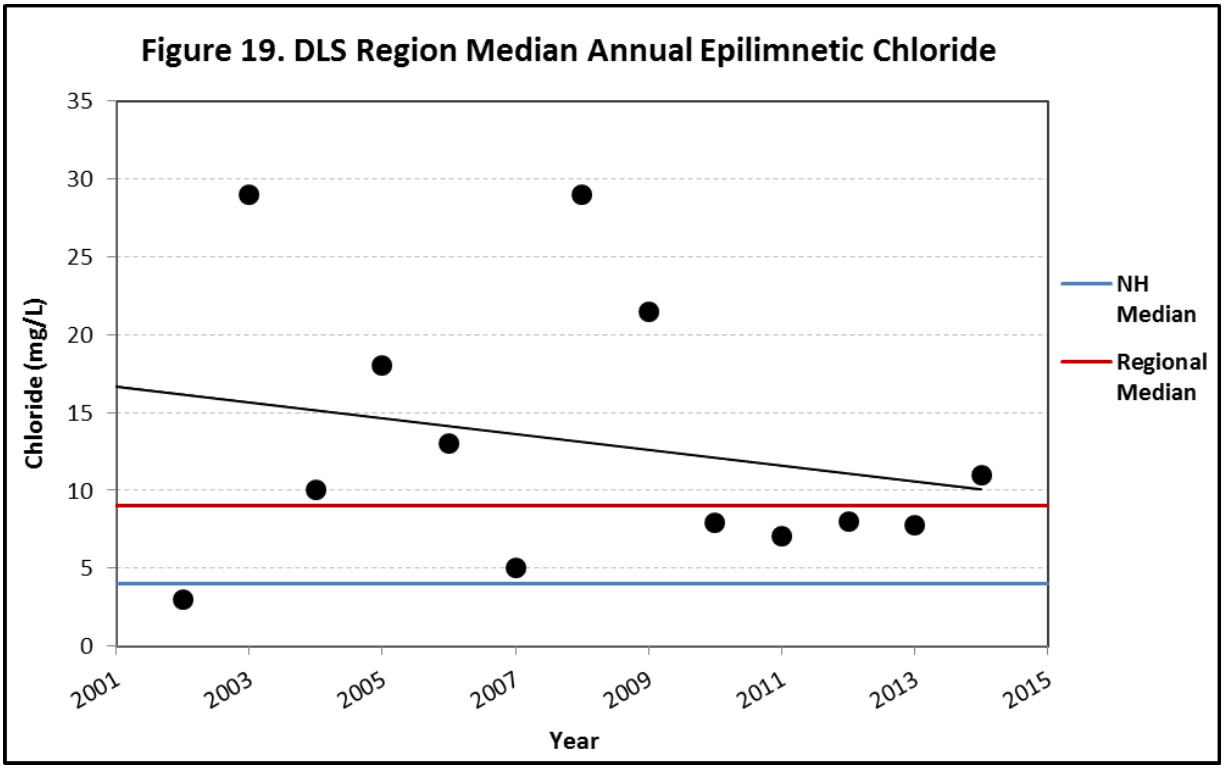


Figure 19 depicts median annual epilimnetic chloride levels for select regional lakes. Median epilimnetic chloride levels generally range between 7 and 30 mg/L, with the exception being 2002 and 2007, where only three lakes with relatively low road salt impacts were sampled for chloride. Regional chloride levels are much less than the acute and chronic chloride criteria; and since 2010 are generally consistent with what is typically measured in undisturbed New Hampshire surface waters and is consistent with the lower regional epilimnetic conductivity in recent years (Figure 17).



Historical Chloride Trend Analysis

The regional median epilimnetic chloride was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the DLS Region (Appendix D: Table D-1, Figure 19). This trend is consistent with all regions of the state.

Watershed management efforts to control unnatural sources of conductivity and chloride in waterbodies should employ a combination of best management practices in regards to winter salting practices. State and local governments and private homeowners should evaluate the use of road salt and alternatives to reduce the amount of material applied while maintaining public safety. *For additional information on the relationship between conductivity and chloride, please refer to Appendix A. For additional information on best management practices please refer to Appendix B.*

Annual and Historical Turbidity Data Analysis

Turbidity in the water is caused by suspended matter (such as clay, silt and algae) that causes light to be scattered and absorbed, not transmitted in straight lines through water. Water clarity is strongly influenced by turbidity. **The Class B surface water quality standard for turbidity is no greater than 10 NTUs over the lake background turbidity level. The median epilimnetic turbidity for the DLS region is 0.78 NTU.**

Figure 20 represents the combined 2013 and 2014 average epilimnetic turbidity values for DLS region lakes compared with the regional median. Fifteen lakes have average epilimnetic turbidities less than or equal to the regional median and considered to be within a low range. Fourteen lakes have average epilimentic turbidity greater than the regional median but less than 1.2 NTU and considered to be within an average range. Eleven lakes have average epilimentic turbidities greater than 1.2 NTU and are higher than desirable.

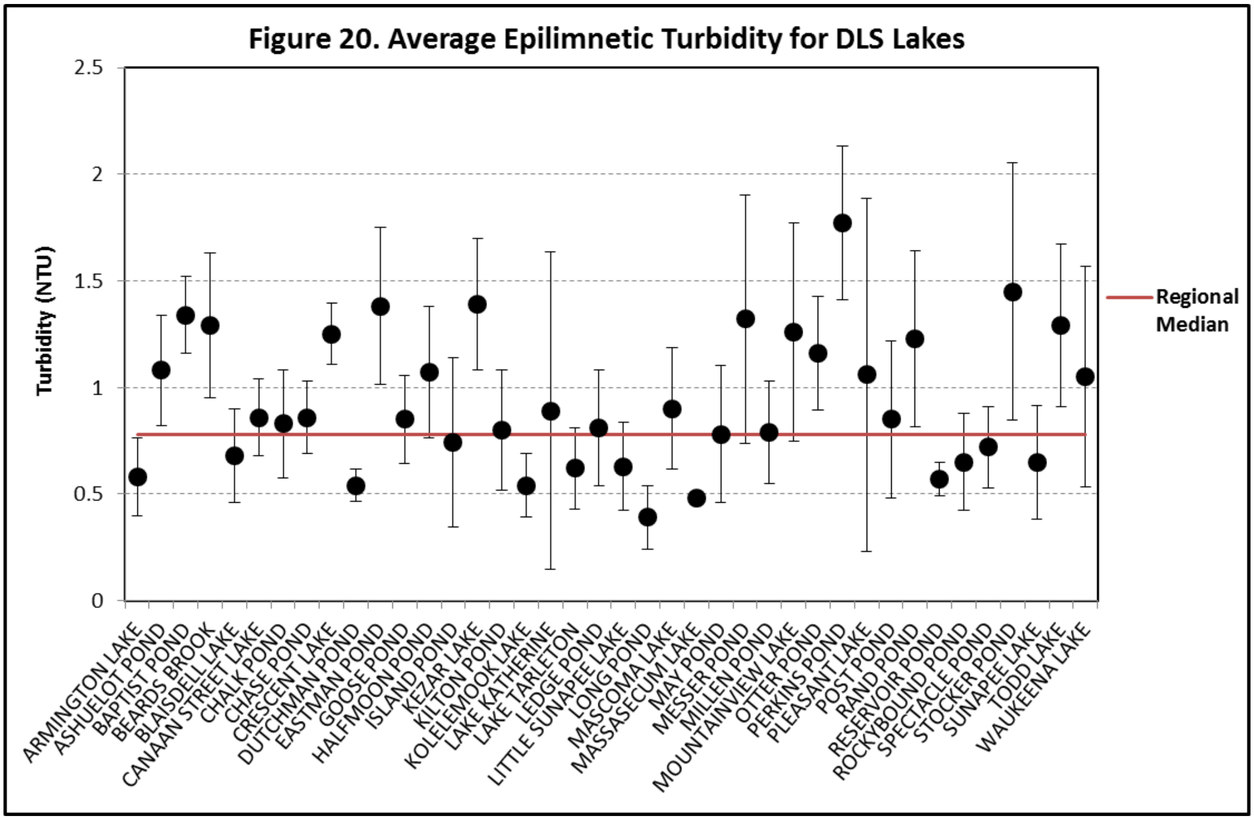
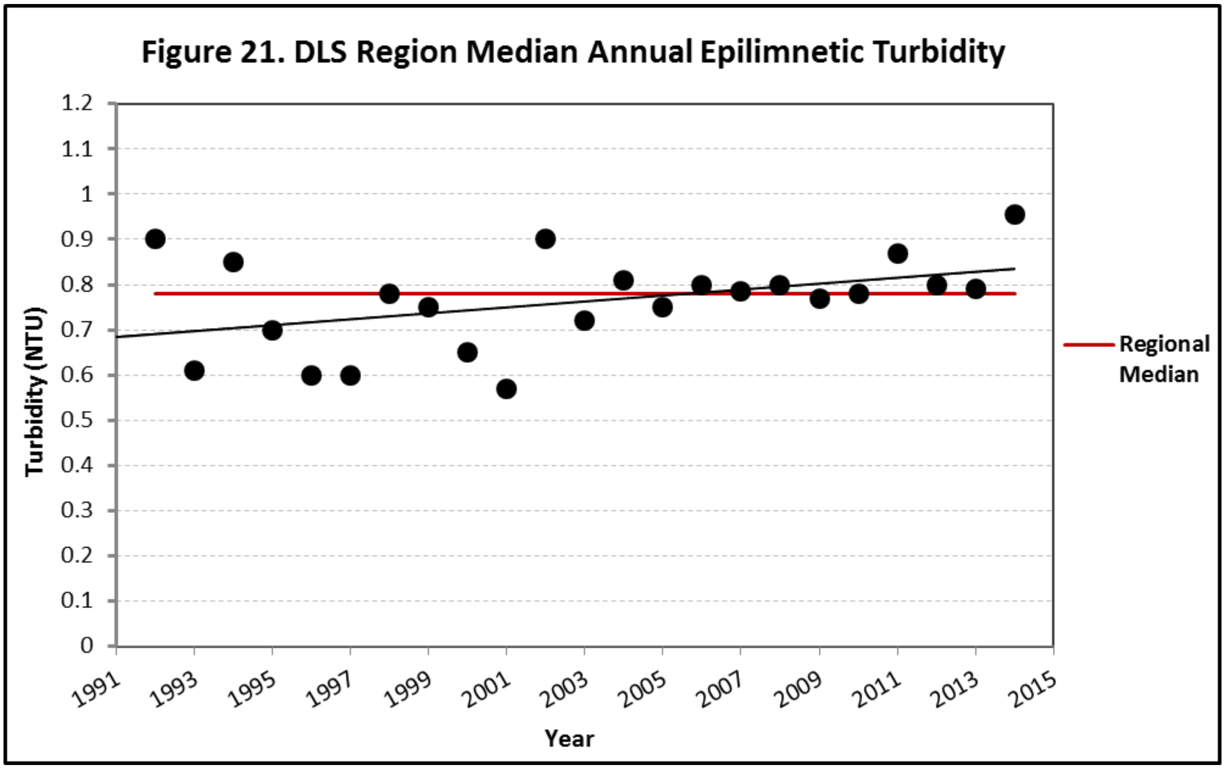


Figure 21 depicts the median annual epilimnetic turbidity for the DLS Region compared with the regional median. The 2014 median epilimnetic turbidity at DLS lakes was 0.96 NTU, which is slightly greater than the regional median and the highest median turbidity since monitoring began. This may be attributed to higher levels of algal growth in 2014 as indicated by the median chlorophyll-a concentration (Figure 7). Median epilimnetic turbidity remains below 1.0 NTU and is average for most New Hampshire lakes.



Historical Turbidity Trend Analysis

The regional median epilimnetic turbidity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (worsening) trend was detected for the DLS Region (Appendix D: Table D-1, Figure 21). This trend is consistent with all regions of the state.

Elevated deep spot turbidity levels are typically the result of stormwater runoff, algal or cyanobacteria blooms, and/or disturbance of lake bottom sediments. Stormwater BMPs should be implemented when possible to reduce the amount of suspended sediments and debris transported to surface water. Boating activity in shallow areas should adhere to rules specified by the New Hampshire Marine Patrol in regards to speed and no wake zones. If an algal or cyanobacteria bloom is observed, please contact NHDES immediately. *For additional information on stormwater BMPs, boating, algae and cyanobacteria please refer to Appendices A and B.*

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