Sources of Information and Explanation of Lake Trophic Data

Updated April 2018

A lake trophic survey evaluates physical, biological and chemical parameters in lakes or ponds greater than 10 acres, to assess a lake's overall productivity, a.k.a. trophic status. Oligotrophic, mesotrophic and eutrophic are the most common trophic classifications. Oligotrophic lakes are nutrient-poor, with few plants and very clear water. Eutrophic lakes are highly productive, with lots of plants and/or algae and less clear water. Mesotrophic lakes are in-between. Trophic surveys provide a record and catalog of water quality parameters, serve as a basis for understanding environmental impacts and help inform water quality management policies.

Historically, waterbodies were sampled once in the winter and once in the following summer. The data collected during the single summer visit would determine the waterbody's trophic status. Since 2013, the monitoring effort for lake trophic surveys was modified. Winter sampling was discarded and waterbodies are sampled once a summer over three progressive summers to better capture year-to-year variability.

The sources of the data and the methodologies for computing the data that are presented in the Lake Trophic Survey Reports are explained here in the order presented in the reports. Generalized explanations of the data are provided to assist the reader in understanding a particular lake of interest. This document applies to Lake Trophic Surveys written on or after 2013.

Page 1: Background information, trophic ratings, and physical characteristics

<u>Header</u>

The name of the lake, pond, or reservoir, as given in the New Hampshire State Planning Project publication (NHSPP, 1964), is located at the very top center of the page. It is followed by a town name, which is the municipality in which the largest part of the waterbody is located. The three-year timespan during which the waterbody was surveyed is presented immediately below the waterbody name and town. Waterbodies are sampled once a summer over three progressive summers. In Year 1, the waterbody is sampled in August or early September. The waterbody is sampled in July for Year 2 and in June for Year 3.

In the upper right corner, the waterbody identification number, also known as Waterbody ID, is presented. This number is unique to the waterbody. All data, current and historical, collected on an individual waterbody are associated with this Waterbody ID.

<u>Background information</u>

A brief historical summary is offered in the upper left text box of the first page of the Lake Trophic Survey report. Any alternate waterbody names will be documented in this section. The results of

previous surveys are presented, as well as any noteworthy changes in water quality parameters. Known cyanobacteria blooms or exotic species infestations will be described. Wildlife observed during monitoring may also be noted.

Trophic Rating

In the green oval to the right of the background information the current trophic rating is presented, which is the result of the current report's monitoring effort. The trophic rating from the previous trophic survey is also presented. If more than one trophic survey was conducted on the waterbody prior to the present report, the most recent historical record of trophic status is described. Immediately below the green oval is a gray text box that provides an explanation of what a lake trophic survey is and the three trophic categories that a waterbody can be classified as: oligotrophic, mesotrophic and eutrophic.

Site location map

In the bottom left of Page 1, a map of New Hampshire is presented with a large yellow star. The star indicates the location of the waterbody.

Physical characteristics

A table of the physical characteristics of the waterbody is presented at the bottom of Page 1. The data included in this table are as follows:

- Elevation: The elevation of the water body above sea level, to the nearest one foot, from the NHDES *Official List of Public Waters in New Hampshire* (NHDES 1994*)*. Elevation influences trophic state primarily by its association with temperature, precipitation, and the length of the growing season. Higher altitude lakes also tend to have smaller watersheds, resulting in a greater percentage of their water input coming from direct precipitation. They are, therefore, more susceptible to acid precipitation effects than low elevation lakes.

- Mean Depth: Determined by dividing the lake volume (m^3) by the lake surface area (m^2) and recorded to the nearest 0.1 meter. Rawson (1955) found that mean depth was the primary factor in separating oligotrophic and eutrophic lakes. It is the most significant feature affecting the summer thermal stratification, and thus the ability of nutrient rich bottom waters to reach the surface layers. It also affects the percentage of lake water in the photic zone for phytoplankton growth, and the amount of sediment in the photic zone for rooted macrophyte growth.

- Maximum Depth: The greatest depth, to the nearest 0.1 meter, found in the lake during the current survey and determined from a Lowrance GPS fathometer. During the first year of monitoring, staff navigate transects across the lake to continuously record depth and locate the deep spot.

- Relative Depth: A ratio of the maximum depth to the mean diameter of a lake, expressed as a percentage to the nearest 0.1%. It is calculated by: (maximum depth x 50 x $\sqrt{\pi}$) / $\sqrt{A}$, where A is the lake area. The value is a measure of the extent of shallow

water, which is important both for the likely abundance of rooted macrophytes, and for the potential of mixing sediment nutrients into the overlying water by wind, waves, and motor boat activity. The smaller the ratio the greater the extent of shallow water. This value is sometimes referred to as the "bottom slope".

- Shore Length: The length of the shoreline to the nearest 10 meters, as determined from NHDES ArcGIS lake polygon shapefiles. The value also includes the shoreline length of islands over five acres in area.

- Shore Configuration: A ratio of the length of the shoreline divided by the circumference of a circle having an area equal to the area of the lake, recorded to the nearest 0.01. It was called "development of shoreline" by Hutchinson (1957) and is defined as: shore length/$2\sqrt{\pi A}$. This is a measure of the irregularity of the shoreline. A value of one is a lake that is a perfect circle. As the ratio increases, there is an increase in contact between land and water, generally resulting in greater the potential for rooted macrophyte growth and for enrichment from nearshore development.

- Watershed Area: The area of the watershed, in square kilometers. The area is delineated in-house by NHDES staff using ArcGIS. The value includes the area of the lake. Generally, the size of the watershed determines the volume of runoff entering a lake, thereby affecting the flushing rate.

- % Watershed Ponded: The total area of all the lakes and ponds in the watershed above the lake being considered, divided by the area of the watershed (minus the area of the lake being considered). Lakes are generally considered to be phosphorus traps, where a percentage of the incoming phosphorus is retained by the lake via sedimentation. If a lake has one or more upstream lakes in its watershed, these upstream lakes will retain a portion of the phosphorus loading to the downstream lake. The greater the percent watershed ponded of a lake, the smaller the expected concentration of phosphorus from surface runoff, assuming all other factors are equal. Dillon (1975a) considers this parameter when calculating the phosphorus export from watersheds, although Kirchner (1975) found that this parameter accounted for only 1% of the variation in phosphorus export.

- Lake Area: The surface area of the lake in square kilometers, from NHDES ArcGIS lake polygon shapefiles.

- Volume: The volume of water in a lake, given to the nearest 500m^3. This information is collected with the Lowrance GPS fathometer. The fathometer records depth information associated with a GPS point. By navigating around the entire waterbody, a bathymetry profile of the waterbody is collected, from which the lake volume can be determined using ArcGIS. Volume affects the trophic status largely by determining the lake's ability to dilute incoming water, thereby reducing nutrient concentrations.

- Average Hypolimnion (or Metalimnion) Volume: Every year over the three-year sample effort, a dissolved oxygen and temperature profile is collected at the deep spot location. This profile determines the layers of stratification that are present, if any. If a bottom

layer, a.k.a. hypolimnion is present, a volume can be estimated using ArcGIS. The average of these hypolimnion volumes is presented here. If a waterbody is partially stratified, without a true hypolimnion, the average of the metalimnion volumes is presented here.

- Average Anoxic Volume: Every year over the three-year sample effort, a dissolved oxygen and temperature profile is collected at the deep spot location. If dissolved oxygen is below 1 mg/L, the water is considered anoxic. The average of these anoxic volumes is presented here. Anoxic water influences nutrient dynamics in a lake, where phosphorus can be loaded into the water column from the bottom lake sediment under anoxic conditions. Anoxia can be an indication of excessive nutrient loading to a lake.

- Flushing Rate: The number of times a lake flushes (i.e., a volume of water equal to the lake's volume passes through the lake) in one year, expressed to the nearest 0.1 times/year. It is calculated by dividing the total volume of water entering a lake in a year (as determined by areal water load) by the lake volume. The reciprocal of the flushing rate is called the "water renewal time" or the "hydraulic detention time", and is the number of years required to completely replace the water volume of a lake by incoming water, assuming complete mixing. Areal water load, flushing rate, and hydraulic detention time all influence the trophic state of a lake by determining the duration that incoming nutrients are available for algal growth under the quiescent conditions of a lake. The importance of flushing rate to trophic level was pointed out by Dillon (1975b) and was incorporated by Vollenweider (1975, 1976) in his revised model relating phosphorus loadings to trophic conditions. A rapid flushing rate is also advantageous in the recovery of a lake that has undergone nutrient diversion.

- Phosphorus Retention Coefficient: The fraction of the inflowing phosphorus that is not lost through the outflow, i.e., it is added to the sediment each year. It is recorded here to the nearest 0.01. It is determined empirically by its various relationships to the areal water load or the flushing rate (Larsen and Mercier, 1976). For this study, the relationship developed by Kirchner and Dillon (1975) was used:

$$R = .426e^{(-.271qs)} + .574e^{(-.00949qs)}$$

where q_s is the areal water load. The greater the R, the greater the amount of phosphorus retained by the lake, some of which may later be made available for plant growth.

- Areal Water Load: The total volume of water entering a lake in a year (m^3/yr), divided by the lake surface area (m^2), and expressed to the nearest 0.01 m/yr. The total water inflow was estimated by adding the annual runoff from the drainage area to the input directly to the lake from precipitation minus evaporation. In other words, the yearly water input was:

$$A_d \cdot r + A_o (P_r - E_v)$$

where A_d is the area of the drainage basin (minus the lake area) (m^2), r is the average annual areal runoff (m/yr), A_o is the lake area (m^2), P_r is the average annual precipitation

(m/yr), and E_v is the average annual evaporation (m/yr). The methodology for doing these calculations is described by Dillon (1975a), and the data for annual runoff, precipitation, and evaporation were obtained from Randall (1996). It is cautioned that this method is only an estimate, and that the actual measurement of the water budget is greatly preferred. This value is used in many phosphorus-loading models relating phosphorus inputs to in-lake phosphorus and algal concentrations.

- Lake Type: The type of water body is from NHDES 1991. Three types are listed: natural, natural raised by damming, and artificial.

Page 2: Trophic classification, Carlson Trophic State Index, and DO/temp profiles

Trophic classification background

NHDES uses summer bottom dissolved oxygen, Secchi disk transparency, aquatic vascular plant abundance and chlorophyll-*a* concentration to calculate a lake's trophic status (Table 1). Each criterion has a list of descriptions that span a range of conditions that may be present. Points are assigned under each of the four criteria (Table 1). The NHDES method is one of several ways trophic status can be calculated. Lakes with no hypolimnion are not rated under the bottom dissolved oxygen criterion. The protocol for rating lakes under Secchi disk transparency when the disk is visible on the bottom (V.O.B.) is to select the next higher rating unless field data sheet comments suggest otherwise. For example, a 2.2 V.O.B. reading would receive two trophic points under the 3 to 5 meter category (Table 1). Table 1 displays the trophic classification system for New Hampshire lakes and ponds.

This trophic rating system has been used by NHDES since 1989 and was intended to determine a lake's trophic status based off of one summer sample. However, since 2013, NHDES conducts three summer samples over three consecutive years to determine trophic status. While the new methodology better encapsulates year-to-year variation, the rating system needed to be updated. For lake trophic reports written on or after 2013, trophic points were assigned for each annual monitoring trip and summed at the end of the three sample seasons. In other words, each year of sampling received its own trophic points, and the total number of trophic points over three years now determines the final trophic rating. Some waterbodies were stratified in one sample season but not in another, and lakes with no hypolimnion are not rated under the bottom dissolved oxygen criterion. Because whether a waterbody is stratified influences the total number of points used to make a trophic assessment and there can be year-to-year differences in stratification patterns of a single waterbody, a secondary point system was developed to determine the final trophic classification of a waterbody (Table 2). This secondary point system allows waterbodies with every stratification scenario (e.g. stratified all three years, stratified two out of the three years, etc.) to be given a trophic status that is sensitive to individual stratification patterns (Table 2).

Table 1. Trophic classification system for New Hampshire lakes and ponds.

TROPHIC CLASSIFICATION SYSTEM FOR NEW HAMPSHIRE LAKES AND PONDS

Trophic Points

1. Summer Bottom Dissolved Oxygen:

a. D.O. >4mg/L 0
b. D.O. = 1 to 4 mg/L & hypolimnion volume ≤10% lake volume 1
c. D.O. = 1 to 4 mg/L & hypolimnion volume >10% lake volume 2
d. D.O. <1mg/L in <1/3 hypo. volume & hypo. volume ≤10% lake volume 3
e. D.O. <1mg/L in ≥1/3 hypo. volume & hypo. volume ≤10% lake volume 4
f. D.O. <1mg/L in <1/3 hypo. volume & hypo. volume >10% lake volume 5
g. D.O. <1mg/L in ≥1/3 hypo. volume & hypo. volume >10% lake volume 6

2. Summer Secchi Disk Transparency:

a. > 7m 0
b. > 5m – 7m 1
c. > 3m – 5m 2
d. >2m – 3m 3
e. >1m – 2m 4
f. >0.5 – 1m 5
g. ≤0.5m 6

3. Aquatic Vascular Plant Abundance:

a. Sparse 0
b. Scattered 1
c. Scattered/Common 2
d. Common 3
e. Common/Abundant 4
f. Abundant 5
g. Very Abundant 6

4. Summer Epilimnetic Chlorophyll-a (mg/m^3):

a. <4 0
b. 4 - <8 1
c. 8 - <12 2
d. 12 - <18 3
e. 18 - <24 4
f. 24 - <32 5
g. ≥32 6

Trophic Classification	Trophic Points Stratified	Trophic Points Unstratified*
Oligotrophic	0-6	0-4
Mesotrophic	7-12	5-9
Eutrophic	13-24	10-18

Table 2. Trophic rating system for New Hampshire lakes and ponds.

Stratification Scenario *Trophic Rating*	3X Stratified	2X Stratified	1X Stratified	0X Stratified
Oligotrophic	0-18	0-16	0-14	0-12
Mesotrophic	19-36	17-33	15-30	13-27
Eutrophic	37-72	34-66	31-60	28-54

Trophic classification information

At the top of Page 2, a brief explanation of the trophic classification process is offered. It is a condensed summary of the trophic classification described above.

A table outlining the trophic points assigned per category, with a final trophic rating, based on this most recent monitoring event. Each sample year is listed with the respective trophic points. The sum of those points is presented with the trophic rating.

At the center right side of Page 2, a graph presents the Carlson Trophic State Index (TSI). The Carlson TSI uses algal biomass as the basis for trophic state classification, and looks at three variables, chlorophyll pigments, Secchi depth, and total phosphorus, to independently estimate algal biomass. The range of the index is from approximately zero to 100, although the index theoretically has no lower or upper bounds. The logarithmic transformation of the data normalizes the skewed data distribution.

The index is relatively simple to calculate and to use and the simplified equations are below:

$$\mathbf{TSI(SD) = 60 - 14.41 \ln(SD)}$$

$$\mathbf{TSI(CHL) = 9.81 \ln(CHL) + 30.6}$$

$$\mathbf{TSI(TP) = 14.42 \ln(TP) + 4.15}$$

The TSI is calculated using data points collected from each of the three sampling seasons and then averaged for each category. A grand mean, or average, is calculated for the final TSI.

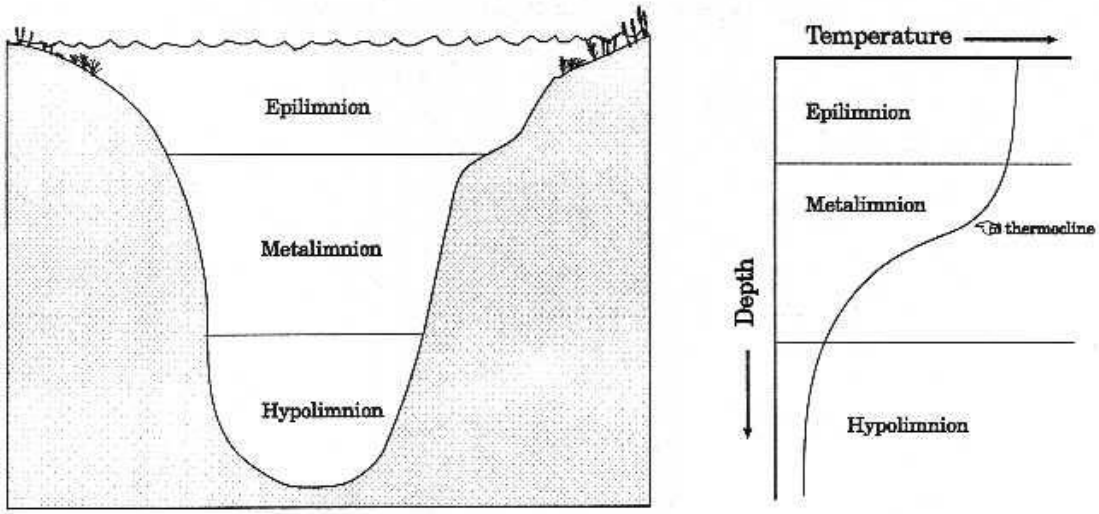
The Carlson TSI is presented in addition to the NHDES method to assist the reader in seeing how two different trophic rating methods may vary.

Dissolved oxygen and temperature profiles

At the bottom of Page 2, the dissolved oxygen and temperature profiles from the three summer monitoring events are graphically presented.

If a lake is sufficiently deep, it will thermally stratify during the summer, with a warm, well-mixed surface layer, a cold, undisturbed bottom layer, and a transitional layer in between, exhibiting a rapid decrease in temperature (thermocline) with depth. Figure 1 depicts these thermal layers.

Figure 1: Diagrammatic Sketch Depicting Thermal Stratification of Temperate Lakes in Summer



Although the term thermocline is often used interchangeably with metalimnion, it specifically refers to the plane of maximum temperature decrease. Diagrammatically, this is the point of inflection, or where the temperature profile curve goes from concave upward to concave downward (mathematically, it is where the second derivative is equal to zero).

For the purposes of this report, "stratified" means a thermocline is present (a hypolimnion may or may not be present); "weakly or partially stratified" means there is a several degree temperature difference (generally 5° C or more) between surface and bottom waters but there is no thermocline; and "not stratified" means that water temperatures are essentially the same from top to bottom. Stratified and weakly stratified waterbodies will be rated for dissolved oxygen in the trophic assessments.

Thermal stratification by itself is not a trophic state indicator. However, because it impedes mixing between the surface and bottom waters, it does not allow the hypolimnion to be replenished with dissolved oxygen from the surface. In general, given two hypolimnions of equal size, the one with the least dissolved oxygen is found in the more productive (more eutrophic) lake.

Page 3: Plankton

Page 3 begins with brief definitions of phytoplankton and zooplankton. Phytoplankton are microscopic algae that are found in the water column and includes cyanobacteria. Zooplankton are microscopic invertebrate animals that are found in the water column. Rotifers and microcrustacea (copepods and cladocerans) are the two most common groups of freshwater zooplankton, although ciliates and other protozoans are also counted. Both undergo natural succession throughout the summer due to changes in temperature, nutrient availability, light and predation. Phytoplankton and zooplankton are collected simultaneously during monitoring events with an 80-µm plankton net that is towed vertically through the water column in the photic zone of the lake. Presented in the center of Page 3 of the report are graphs of percentages of plankton groups (class or order) by month. Lastly, the most abundant plankton genera are displayed in pie graphs. Two to five genera may be listed depending on the sample diversity.

In general, the genera of dominant aquatic plants and animals observed in these surveys are found in a range of lake types, and are therefore poor indicators of trophic state as individuals. The number of zooplankton can be a trophic state indicator, but there is a wide range of numbers within each trophic category for New Hampshire lakes, as evidenced by the large overlap in the numbers defining the categories. The table below presents general classifications for some of the biological parameters.

Parameter	Oligotrophic	Mesotrophic	Eutrophic
Rotifers (cells/L)	0-100	25-250	>100
Microcrustacea (cells/L)	0-100	25-200	>50
Zooplankton (cells/L)	0-200	50-500	>250

Cyanobacteria, a.k.a. blue-green algae, are bacteria that can photosynthesize. While cyanobacteria occur naturally in all lakes and ponds, elevated nutrient levels may cause cyanobacteria to 'bloom', or grow out of control and cover the lake surface. The concern associated with cyanobacteria is that some species produce toxins that may affect domestic animals or humans through skin contact or ingestion. These toxins may cause a variety of symptoms, including nausea, vomiting, diarrhea, fever, skin rashes, eye and nose irritation and general malaise. If you see a cyanobacteria bloom, do not go in the water, do not drink the water and do not let pets or livestock go in or drink the water.

In addition to the above data, other biological data provide insights into trophic conditions. Cyanobacteria (blue-green algae), such as *Anabaena, Microcystis and Aphanizomenon*, as the dominant phytoplankton usually indicate high nutrient levels. Conversely, phytoplankton dominated by diatoms (e.g., *Asterionella, Tabellaria*) often indicate oligotrophic conditions. Dominant phytoplankton representing a large percentage of the total phytoplankton population indicates low species diversity. This generally means that conditions are not favorable for most algae growth, either because of extremely low (very oligotrophic) or extremely high (very eutrophic) nutrient levels.

To provide an understanding of how a particular lake compares to other New Hampshire lakes, the following table summarizes key biological parameters using summer data for all the state's lakes surveyed from 1975 to 2009.

Parameter	# of Lakes	Minimum	Maximum	Mean	Median
Rotifers (cells/L)	633	<1	13,516	-	78
Microcrustacea (cells/L)	633	<1	1584	-	65
Zooplankton (cells/L)	633	<1	13,807	-	182

Page 4: Chemical and Biological Parameters, Watershed Report Card

Chemical and Biological Parameters

At the top of Page 4, a table of the waterbody's chemical and biological parameters is presented. The table provides the mean, standard deviation and median of water quality parameters that were collected over the three summers of monitoring in the units in which the parameter is analyzed. If available, statewide medians for individual parameters are presented to provide a basis for comparison. Statewide medians were calculated from lakes sampled under the LTSP from 1990 to 2016. If a waterbody was sampled more than once in that timespan, the most recent data were used.

The majority of water quality parameters were collected every year over the course of the three consecutive years of monitoring. Several parameters, however, were only collected once, during the first year of sampling. Table 3 below describes the water quality parameters included in the report as well as how often and at what water depth the parameters are sampled.

Table 3. List of chemical and biological water quality parameters to be included in the Lake Trophic Survey Program.

Analyte	Sample location
Secchi Disk Depth*	Deep spot
Nitrate + Nitrite Nitrogen*	Mid-epilimnion deep spot
Total Kjeldahl Nitrogen*	Mid-epilimnion deep spot
Total Phosphorus*	Mid-epilimnion deep spot, possible mid-hypolimnion
Calcium**	Mid-epilimnion deep spot
Magnesium**	Mid-epilimnion deep spot
Sodium**	Mid-epilimnion deep spot
Potassium**	Mid-epilimnion deep spot
Organic carbon**	Mid-epilimnion deep spot
Sulfate**	Mid-epilimnion deep spot
pH*	Mid-epilimnion deep spot
Acid Neutralizing Capacity (ANC)*	Mid-epilimnion deep spot
Specific conductance*	Mid-epilimnion deep spot
Apparent Color*	Mid-epilimnion deep spot

Chloride*	Mid-epilimnion deep spot
Chlorophyll-a*	Mid-metalimnion deep spot

* Parameters sampled once annually over 3 year period; ** Parameters to be sampled only during first year.

This section provides descriptions of each water quality parameter included in the chemical and biological table:

- Depth: The depth at which the sample was collected, in meters. Epilimnetic, metalimnetic, and hypolimnetic zones are listed separately.

- pH: A measure of the hydrogen ions in the water or, in general terms, the acidity. pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). New Hampshire lakes generally have had pH values in the mid to upper sixes. As the pH decreases to between 5 and 6, many fish and other aquatic organisms become stressed, and some species disappear. Little or no fish life remains when the pH falls much below 5. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0.

- Acid neutralizing capacity (ANC), a.k.a. alkalinity: A measure of the buffering capacity of a lake, or the lake's ability to resist changes in pH by neutralizing acid inputs. Buffers are typically chemical compounds known as 'bases' such as bicarbonate and carbonate. The higher the ANC, the better a waterbody can resist a change in pH. New Hampshire has historically had low alkaline waters because of granite bedrock. If the buffering capacity of a lake is lost, conditions for aquatic life would be dramatically and adversely altered by acid rain inputs.

Sensivity Category	ANC (mg/L)
Acidified	<0
Critical	>0 – 2
Endangered	>2 – 5
Highly Sensitive	>5 – 10
Sensitive	>10 – 20
Not Sensitive	>20

- Apparent color: A visual measure of the color of water. This color is generally caused by decaying organic matter or by naturally occurring metals in the soils, such as iron and manganese. A highly colored lake generally has extensive wetlands along the shore or within the watershed and often a mucky bottom, conditions often associated with eutrophic waters.

Apparent Color	Units
Clear	0-25
Light Tea-colored	25-40
Tea-colored	40-75
Highly colored	>75

- Secchi depth: A Secchi disk is an eight-centimeter diameter black and white disk that is lowered into the water column. The depth is recorded just as the disk disappears from view. The greater the depth that the disk is lowered to, the more transparent the lake. A Secchi depth can be used with and without a Viewscope (a.k.a. Scope). A Viewscope is a device that blocks glare and wave action at the lake's surface, often allowing a deeper Secchi depth reading to be achieved.

Category	Transparency (M)
Eutrophic	<1.8 (<6 feet)
Mesotrophic	1.8 – 4 (6 – 13 feet)
Oligotrophic	>4 (>13 feet)

- Specific Conductance: A measure of the ability of water to conduct an electric current. It is determined primarily by the number of ionic particles present. The soft waters of New Hampshire have traditionally had low conductivity values. Although specific conductance is largely driven by the geology of a lake's watershed, it can be influenced by human factors such as road salt or septic systems. In general, a specific conductance of > 100 µS/cm is indicative of cultural (man-made) influences in New Hampshire waterbodies.

- Total Kjeldahl Nitrogen: A measure of inorganic ammonia nitrogen and total organic nitrogen. Higher values generally indicate more eutrophic conditions.

- Nitrate + Nitrite Nitrogen: A measure of the major inorganic species of nitrogen found in lake waters, and often used as a nitrogen source by algae. The detectable limit of the analytical method used is 0.05 mg/L, a level which can still support algal growth. The combined nitrite (NO_2) plus nitrate (NO_3) nitrogen are measured and reported as one value. In New Hampshire lakes, nitrite nitrogen is extremely low so that $NO_2 + NO_3$ is essentially the same as NO_3.

- Total Phosphorus: A measure of all the phosphorus forms present in the water, including both inorganic and organic forms. Along with nitrogen, it is a plant nutrient that determines the amount of algae growth that can occur. Phosphorus directly relates to trophic state and is a limiting nutrient in freshwater lakes. The New Hampshire Surface Water Quality Standards (Env-Wq 1700) has a narrative phosphorus standard, which NHDES has translated into numeric criteria for each trophic class.

Trophic Class	Total Phosphorus (TP) µg/L
Oligotrophic	< 8.0
Mesotrophic	≤ 12.0
Eutrophic	≤ 28

A total phosphorus sample is also collected in the hypolimnion when anoxic conditions are present. Anoxia in the hypolimnion can chemically 'release' phosphorus from the

bottom sediments, creating an area of the lake that is 'loaded' with phosphorus. While the waterbody is thermally stratified, this extra phosphorus remains separated in the hypolimnion; however, during fall and/or spring turn-over, the phosphorus is available throughout the entire water column, which can contribute to algal blooms.

- Chloride: The chloride ion (Cl^-) is found naturally in some surface ground waters and in high concentrations in seawater. The chloride content in New Hampshire lakes is naturally low, generally < 2 mg/L in lakes that are remote from habitation. Higher values are generally associated with salted highways and, to a lesser extent, with septic inputs. Elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state adopted acute and chronic chloride criteria of 860 and 230 mg/L respectively.

- Sulfate: Sulfate is generally not related to trophic status and is naturally low in New Hampshire lakes. Elevated sulfate in a pond that is otherwise undisturbed by man may be an indication of acid rain deposition.

- Calcium, Magnesium, Potassium, and Sodium: A measure of the four major cations present in water. Calcium levels are sometimes used to predict the sensitivity of waters to acid rain: Adirondack lakes containing less than 2.5 mg/L calcium are considered to be sensitive (Glass et. al., 1982).

- Organic carbon: Organic carbon occurs as a result of the decomposition of plant or animal material. Total Organic Carbon (TOC) is a measure of the total amount of carbon found in a waterbody, which is the sum of particulate and dissolved organic carbon. Dissolved Organic Carbon (DOC) is a measure of the dissolved portion of carbon in a waterbody and is the fraction of TOC that can pass through a 0.45-µm filter. Organic carbon influences light absorption, thermal structure, water clarity and pH, among other influences. It is only sampled once during the three-year monitoring period. For waterbodies selected for trophic assessments from 2013 to 2016, a measurement of TOC is provided. For waterbodies selected for trophic assessments from 2017 to current, a measurement of DOC is provided.

- Chlorophyll-a: A green pigment found in plants that is essential to photosynthesis. A measure of the total amount of planktonic algae, including cyanobacteria, in the water.

Trophic class	Chl-a (µg/L)
Oligotrophic	< 3.3
Mesotrophic	≤ 5.0
Eutrophic	≤ 11

Chlorophyll-a concentrations greater than or equal to 15 µg/L are considered nuisance levels.

Watershed Report Card

The bottom half of Page 4 presents the Watershed Report Card, which is generated from the New Hampshire Section 305(b) and 303(d) Surface Water Quality Report. The primary purpose of the Surface Water Quality Report is to report on the water quality status of New Hampshire's surface waters and groundwater in accordance with Section 305(b) and 303(d) of the Federal Water Pollution Control Act as last reauthorized by the Water Quality Act of 1987 [PL92-500, commonly called the Clean Water Act (CWA)], and New Hampshire Statutes Chapter 485-A:4.XIV. The Watershed Report Cards provide one-page summaries of the overall use support for Aquatic Life, Primary Contact (e.g. swimming), Secondary Contact (e.g. boating), and Fish Consumption Designated Uses on every Assessment Unit ID (AUID) within a HUC12 Watershed. For more information, please visit: https://www.des.nh.gov/organization/divisions/water/wmb/swqa/index.htm

Pages 5 & 6: Aquatic Plant Maps and Key

Aquatic Plant Species Map and Key

Pages 5 & 6 provide information on the type, location and abundance of the major growths of aquatic vascular plants in the lake. On page 5, a lake outline map with letter codes indicating the location of specific growths is given. On page 6, a key identifying the letter codes to the plants and an abundance rating for each of the plants observed is given, as well as a whole lake plant abundance rating. The abundance rating is a subjective evaluation of the abundance of the plants in the lake as a whole, using the terms and descriptions presented in Table 4.

Table 4. Aquatic vascular plant abundance ratings and the associated description.

Abundance	Description
Sparse	Few emergent plants observed; submerged plants not obvious
Scattered	Several small patches or one to two large patches or much of the shoreline with a sparsely growing plant; submerged plants not obvious
Scattered/Common	Intermediate between Scattered and Common
Common	Plants around most of the shoreline but not a problem to navigation or several large patches of plants
Common/Abundant	Intermediate between Common and Abundant
Abundant	Plants around the entire shoreline and with large patches in several areas; submerged plants generally visible wherever bottom is visible
Very Abundant	At least ½ of the surface with emergent or floating leaf plants or submerged plants thick throughout the pond; navigation and swimming is impaired in areas due to physical presence of plants

Plant growth is generally dependent on substrate type and water depth, and does not necessarily indicate water quality. However, an abundance of aquatic plants is generally associated with eutrophic conditions.

Aquatic Plant Biovolume Map

In addition to the Aquatic Plant Species Map on Page 5, an Aquatic Plant Biovolume Map, also known as a heat map, is displayed. It indicates the percentage of the water column occupied by aquatic plants. High percentages are indicated by the color red and low percentages are indicated by the color blue. The information is collected by the Lowrance GPS fathometer and quantifies submerged vegetation.

Page 7: Lake Bathymetry Map

Bathymetric charts indicate water depths in lakes by showing depth contour intervals. Depth soundings are electronically recorded by a Lowrance GPS fathometer that records locational information (latitude/longitude) as well as water depth. The data are downloaded and transferred to an ArcGIS-based program that calculates the depth contours. These data also inform lake volume calculations.

Page 8: Watershed Land Use Map

The watershed of a particular waterbody of interest is delineated in-house at NHDES using ArcGIS. The delineated watershed is overlaid on the 2011 National Land Cover Database for the conterminous United States. The National Land Cover Database (NLCD) provides nationwide data on land cover and land cover change at the native 30-m spatial resolution of the Landsat Thematic Mapper (TM). NLCD is produced by a Federal agency consortium called the Multi-Resolution Land Characteristics Consortium (MRLC). The consortium includes the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Forest Service (USFS), among others. The information is available for free at http://www.mrlc.gov.

Total watershed area and areas for each land use category are estimated within the delineated watershed. The percent of each land use category within the watershed is calculated from the estimated areas. The watershed land use map is displayed with a table of the percent cover of each land use category.

Land use categories are informative for pollution and nutrient loads to a waterbody. Different land uses can have different phosphorus export coefficients. For example, forested lands export less phosphorus than land that is considered residential or agricultural.

Final note

All lake trophic survey reports are available online at **http://tinyurl.com/NH-LakeMapper**