1.0 INTRODUCTION

The New England Nutrient Database ("Nutrient Database") was developed by ENSR for NEIWPCC in support of EPA Region 1 in its effort to develop nutrient criteria for New England lakes, ponds and reservoirs. Following EPA guidance, ENSR performed statistical analysis of the historical data contained in the database to identify target nutrient ranges for reference waterbodies, and general population (see Data Synthesis Report, ENSR, 2000). The analysis presented herein is an effort to ground-truth the statistical indicators of water quality to the 305(b) assessment of whether waterbodies support designated uses, and thus determine nutrient levels that are supportive of the various water uses.

Pursuant to Section 305(b) of the Clean Water Act (CWA), states are required to biennially assess water quality of their waterbodies for attainment of fishable/swimmable goals of the Act and to report their findings in 305(b) Reports. The attainment of the CWA goals is measured by determining how well waters support their designated uses, defined as the most sensitive and therefore governing water use that the waterbody class is intended to protect. The waters are classified as "fully", "partially", "threatened" or "not" supporting the specific designated use.

Although the EPA provides guidance on assessing surface water quality through its document entitled *Guidelines for Preparation of Comprehensive State Water Quality Assessment (305(b) Report) and Electronic Update (Sept.1997)*, there are no specific criteria for determining attainment of individual designated uses. Therefore, the methods followed by the New England states vary in their approach, details and implementation.

The current evaluation compares 1998 305(b) assessments made by the New England states with water quality data included in the New England Nutrient Database to assess nutrient levels associated with various impairment categories.

2.0 METHODOLOGY

For this evaluation data from recent available 305(b) reports was obtained. An electronic version of the 1998 305(b) list was obtained from the EPA (1998 305(b) NATIONAL ASSESSMENT DATABASE SYSTEM (NAD1998)). The database contains the 1998 assessment of waterbodies from all six New England states, except New Hampshire. New Hampshire assessments were obtained separately from the NHDES 2000 305(b) report available on NHDES website (http://www.des.state.nh.us) and added to the 305(b) database.

The 1998 305(b) database contained 8,458 waterbodies that were cross-referenced to those also present in the Nutrient Database, using the waterbody identifier used by the States (i.e., the name of the waterbody, town, and county). A total of 851 lakes and ponds were present in both the 305(b) database and the Nutrient Database for comparison.

2.1 General Description of the 305b Database

Figure 1 shows the distribution of the 851 lakes and ponds according to the states. The majority (76%) of the 851 assessed lakes and ponds are located in Maine. This is reflective of the fact that more than 73% of assessed lakes and reservoirs contained in the 1998 305(b) database are located in Maine, and that the Nutrient Database also includes a large population of Maine waterbodies. Previous work has shown that the number of assessed waterbodies in the Nutrient Database reflects a fairly even representation of lakes and reservoirs on an areal basis.

For each waterbody listed and designated water use considered, the 305(b) database provides the waterbody area for which the use is considered to be “totally supported”, “threatened”, “partially supported”, and “not supported”. The impaired area is defined as the sum of areas where the use is considered either “partially supported” or “not supported”.

Additionally, for each assessment record the database provides the assumed cause of the impairment, and source of pollution.

Figure 2 presents the distribution of assessment records by water use, while Figures 3 and 4 present the distribution by cause of impairment and source of pollution, respectively. The most numerous water uses assessed included aquatic life support, derived overall use support, primary and secondary contact recreation, fish consumption, and drinking water supply.

For the purpose of comparing the 305(b) assessments with nutrient levels found in the Nutrient Database, only assessment records that were based on what was assumed to be nutrient-related

causes were used, namely “Nutrients”, “Organic Enrichment/Low DO/TOC”, “Phosphorus”, “Excess Algal Growth/Chl-a”, and “Noxious Aquatic Plants, Native”. These are shown in red in Figure 3.

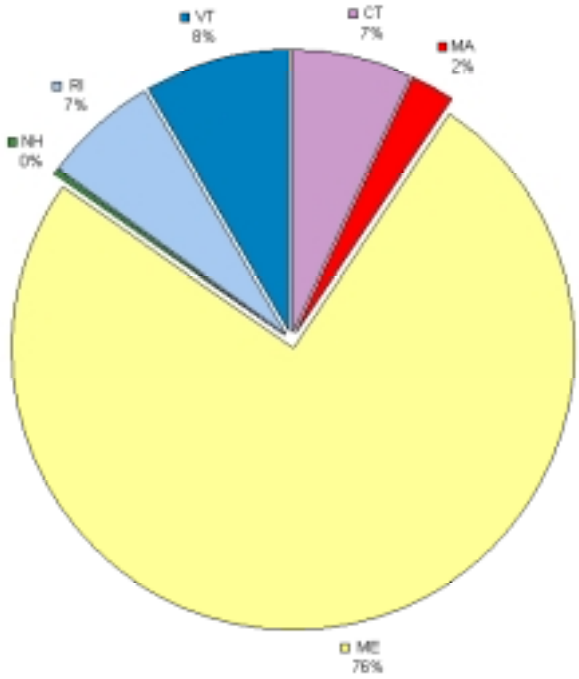

Figure 1: Distribution by state of New England lakes, ponds and reservoirs used for evaluation of designated use impairment and nutrient levels.

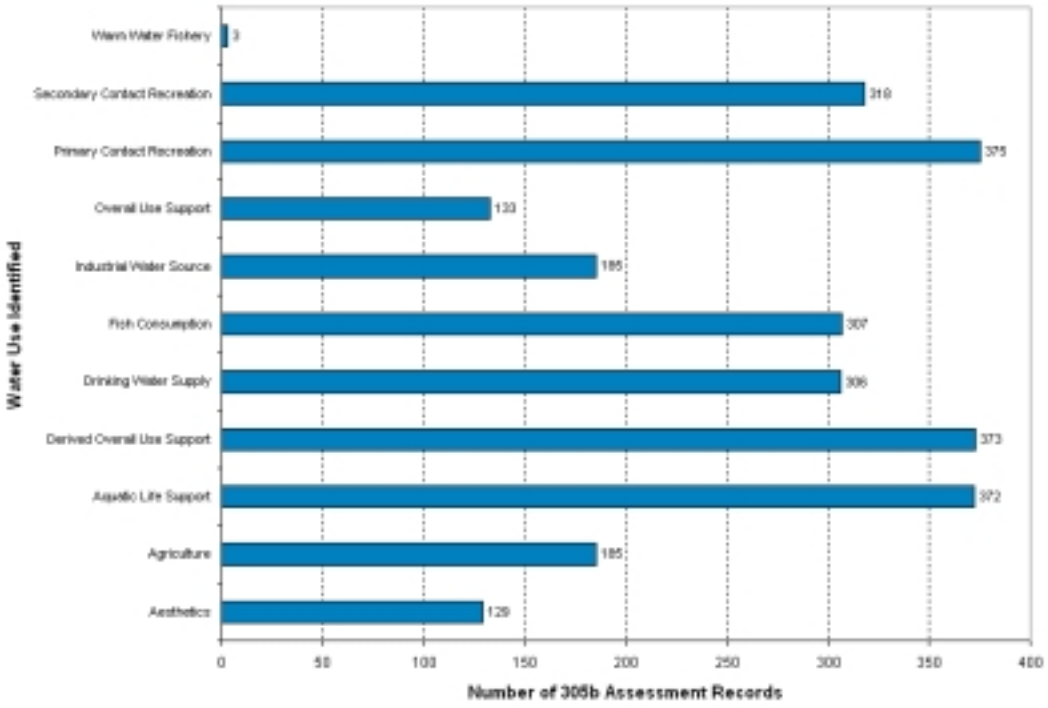

Figure 2: Distribution of 305(b) assessment records by designated water use considered.

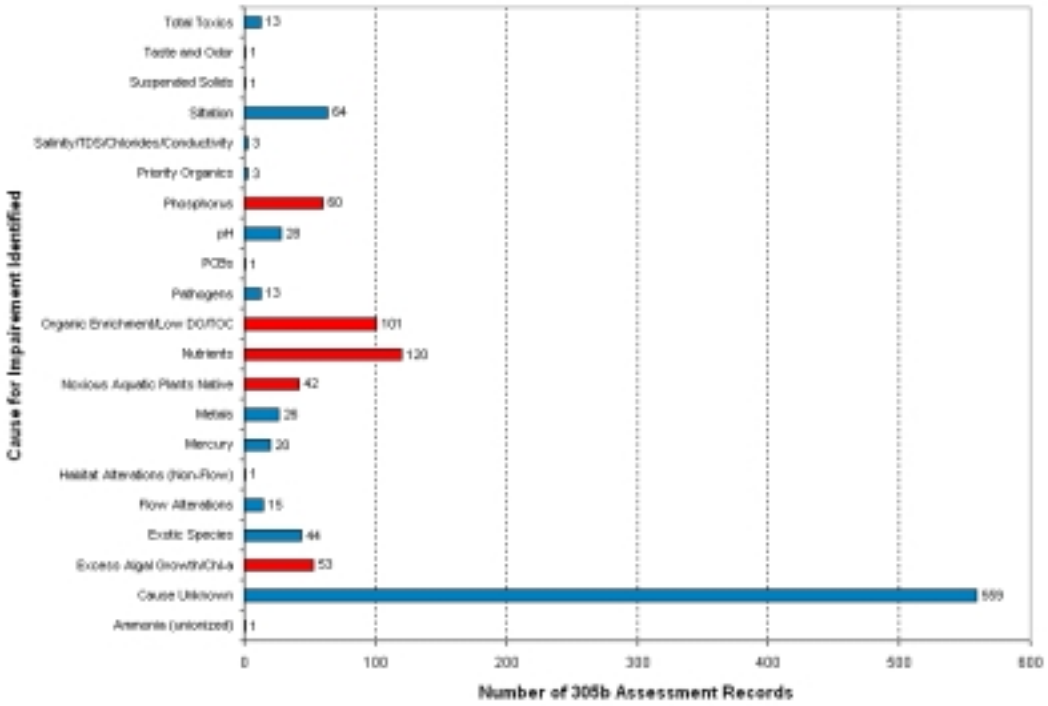

Figure 3: Distribution of 305(b) by cause of impairment provided (nutrient-related causes are shown in red).

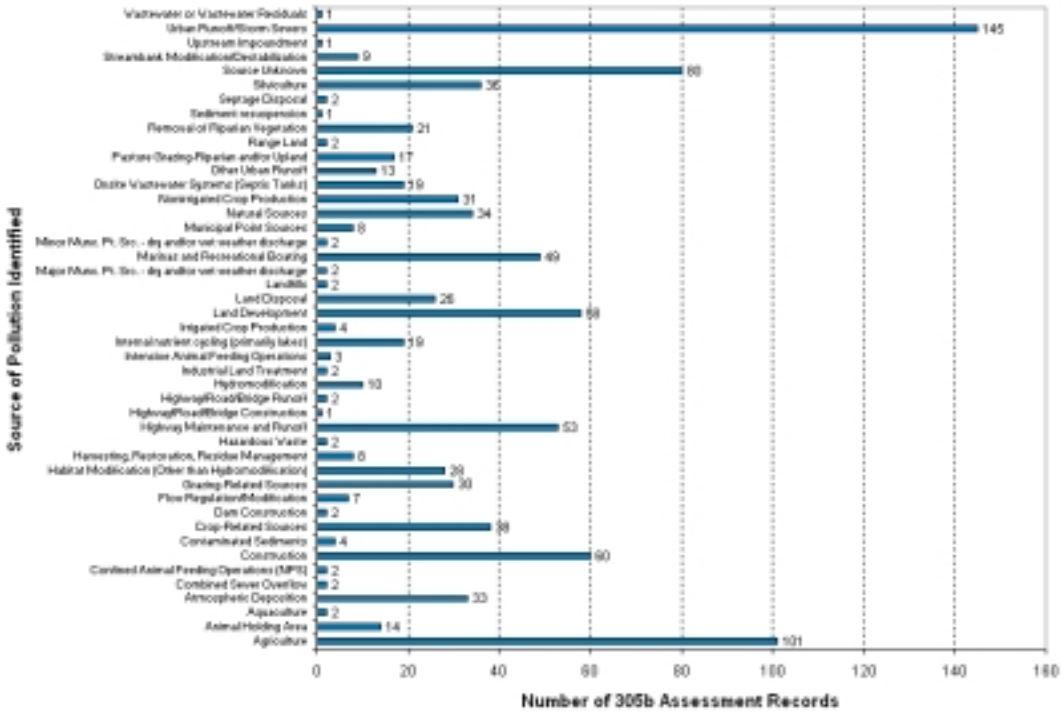

Figure 4: Distribution of 305(b) assessment records by source of pollution identified.

Figure 4 illustrates the extremely wide diversity of pollution sources identified in the 305(b) database. The three most widely identified sources were urban runoff/storm sewers, agriculture, and unknown sources.

Appendix A presents a summary table of the 305(b) and nutrient data used in the analyses discussed below for each lake. The table includes for each lake (sorted alphabetically by state), the cause of impairment, the water use assessed, the trophic state, waterbody size, the area of the lake for each "support" categories, the percentage of the lake area that is impacted (see definitions below), and the mean geometric mean of chlorophyll-*a* (CHLA), total nitrogen (TN), total phosphorus (TP) and Secchi disk transparency (SDT) measurements from the Nutrient Database.

2.2 Link between 305(b) Assessment and Nutrient Database

The analysis of the correlation between water use support and water quality was conducted using the summarized water quality for each of the waterbody. The water quality measurements found in the Nutrient Database were summarized by taking the geometric mean of the measurements taken in the upper 5-meters of the water column, during the summer index period (refer to Data Synthesis Report,

ENSR, 2000 for details). The geometric mean provides a unique value for each parameter measured and represents a measure of the central tendency for the given waterbody.

3.0 RESULTS

3.1 "Impacted" Lake Definition

In constructing a population of so-called "impacted" lakes, different levels of impairment were considered, based on the fraction of the lake's area that is only partially supporting or not supporting a specific designated use. The fraction impacted (FI) is defined as:

$$Fraction\ Impacted = (Area_{partially\ supporting} + Area_{not\ supporting})/(Total\ Area)$$

For each lake, the fraction of the lake area impacted for a specific designated use was calculated using the equation above. As part of the evaluation, different criteria were used to define the level of impairment required for an entire lake to be considered "impacted": FI ≥ 25%, FI ≥ 50%, FI ≥ 75%, and FI = 100%. This allowed evaluation of potential ranges in the degree of water use impairment before a lake was judged to be "impacted".

However, as shown in

Figure 5, the impacted percentile criteria used for calling a given lake "impacted" had a relatively minimal impact on the overall distribution of the lake population against the geometric mean of total phosphorus (TP) concentration. This is attributable to the fact that, in most cases, the 305(b) assessments are written such that a lake is either considered fully supportive of a designated water use or not. Cases where the results of the assessment are mixed (i.e., where a fraction of the lake's area is impacted while the remainder supports the use) are relatively rare. In the analysis presented below, a criterion of 50% of the lake area impacted was arbitrarily selected to define a lake as "impacted". This assumption was considered appropriate by the authors given the lack of sensitivity of the analyses to the FI criterion.

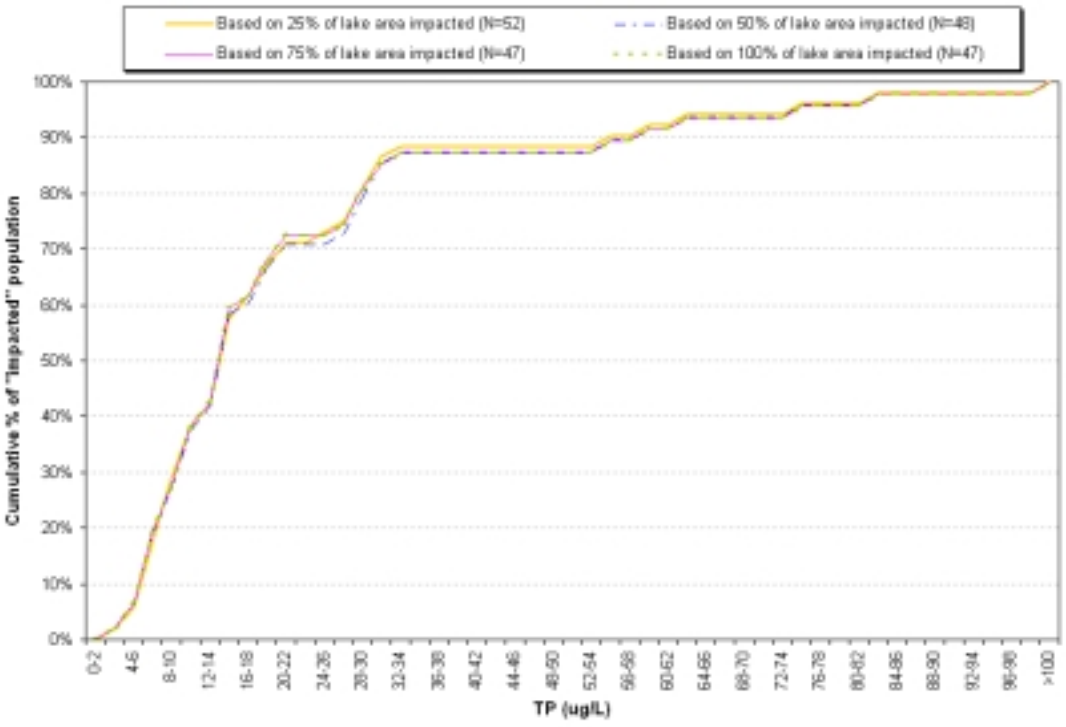

Figure 5: Cumulative distribution of Total Phosphorus (TP) versus % of lake population impacted for Aquatic Life Support for various definitions of "impacted" lakes (FI ≥ 25%, FI ≥ 50%, FI ≥ 75% and FI = 100%).

3.2 Target Levels of Protection for Designated Uses

Cumulative distribution plots, such as the one shown in

Figure 5 are useful graphical tools in illustrating how the population of lakes becomes increasingly impacted with increasing nutrient levels such as TP concentration. The nutrient concentration shown on the X-axis corresponds to the average concentration that corresponds to that associated with a certain fraction of impacted lakes. The corresponding target nutrient level will vary depending on the level of lake population protection desired (i.e., the fraction of the lake population that is tolerated as impacted for a given use). The target percentage of impacted lakes tolerated may be set to accommodate natural variability in lakes or as a state lake management policy.

The cumulative distribution plots are generated within the Nutrient Database using the Total Access Statistics add-in (from FMS Software). The add-in package allows the database user to summarize large data sets and perform parametric and non-parametric statistical analyses. Cumulative distribution plots are generated by counting the number of records with values between set intervals of nutrient

concentration. The output table provides the %count for each concentration interval and the cumulative sum of records. The results can then be plotted in Excel using the lower limit of the interval range for the X-axis, and the reported cumulative % count on the Y-axis. Note that unless otherwise noted, the cumulative distributions presented in this document were calculated using the subset of the lakes and ponds that were impacted for the designated use considered. Other plots were also developed based on the whole population of lakes and ponds.

3.3 Levels of Protection and Corresponding Nutrient Levels for Selected Designated Uses

To illustrate the potential effect of setting different target levels of protection for lake population on the "acceptable" levels of nutrient or trophic indicator levels was further investigated for a number of designated uses. In the analyses presented in sections 3.3.1 through 3.3.3, the criterion FI was kept constant at 50% for evaluation of the effect of varying TP, chl-*a*, and SDT.

3.3.1 Total Phosphorus (TP)

Figure 6 shows the fraction of "impacted" lakes and ponds corresponding to a given range of mean TP concentration, and for several important designated uses: Aquatic Life, Primary Contact Recreation (swimming), Secondary Contact Recreation, and Overall Use support. The plot shows a general increase in the fraction of lakes impacted as the TP level increases. This information is presented again in Figure 7 but in this case with the cumulative percentage of impacted lakes shown on the y-axis. Overall use and primary contact recreation are the most restrictive of the four waterbody uses presented with approximately 33% and 30% of lakes and ponds impacted for TP concentration in the 24-26 ug/L range, respectively. These plots allow to evaluate the relationship that exists between nutrient levels and use impairment and may be used in further defining a lake protection policy for nutrients. Under a very protective lake protection policy, for example by keeping the TP value at 8 ug/L or less, less than 10% of the total lake population is impacted (Figure 7). Alternatively, if the TP level is set to 30 ug/L, the data shows more than 40% of the lake population being impacted for overall use and about 30% impacted for primary contact recreation (swimming).

Figure 8 shows the frequency distribution of TP for the subset of the lake population composed of the impacted lakes only for several important designated uses: Aquatic Life, Primary Contact Recreation (swimming), Secondary Contact Recreation, and Overall Use support. Comparison of the cumulative distributions among the designated uses indicates several important differences. Aquatic Life Support is generally the most stringent use (i.e., it is the designated use for which the TP concentration is lowest for a given "protection level"). For a protection level of 75% of the impacted waterbody population, corresponding TP concentrations as determined from following the arrows shown on the figure are approximately 28, 30, 30, and 32 ug/L for Aquatic Life, Overall Use, Secondary Contact Recreation, and Primary Contact Recreation, respectively. Table 1 provides TP concentration ranges corresponding to levels of potential impairment of 10%, 25%, 50%, 75% and 90% of the "impacted"

lake population. The corresponding fraction of the total population of lakes and ponds that is impacted (see Figure 6) is also provided between parenthesis next to each TP concentration range.

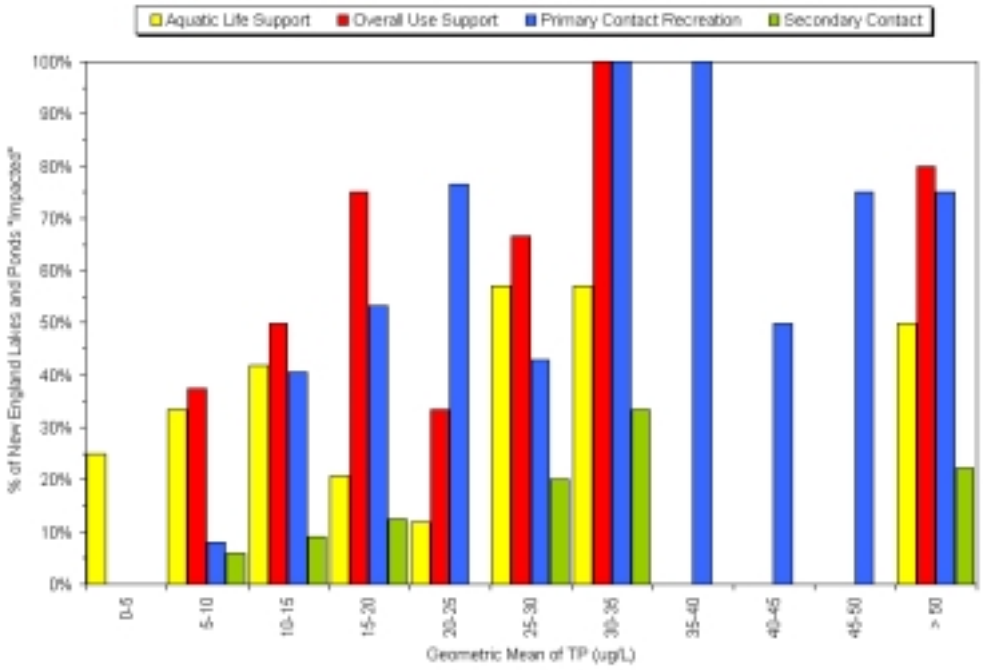

Figure 6 Percentage of New England lakes and ponds "impacted" for various designated uses as a function of Total Phosphorus concentration.

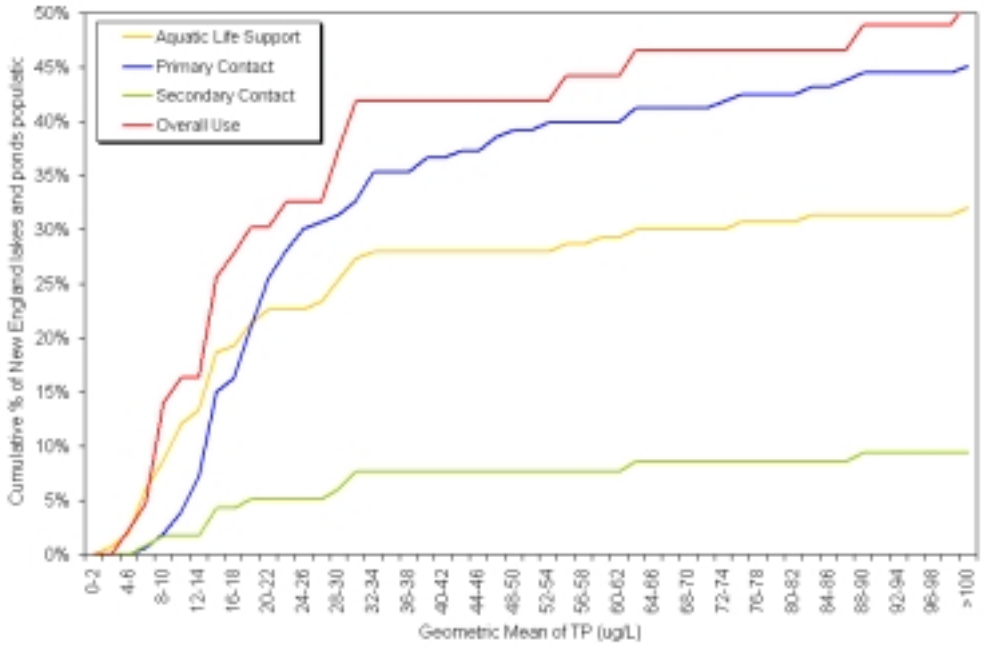

Figure 7: Cumulative fraction of New England lakes, ponds and reservoirs that are "impacted" for various designated uses as a function of Total Phosphorus concentration.

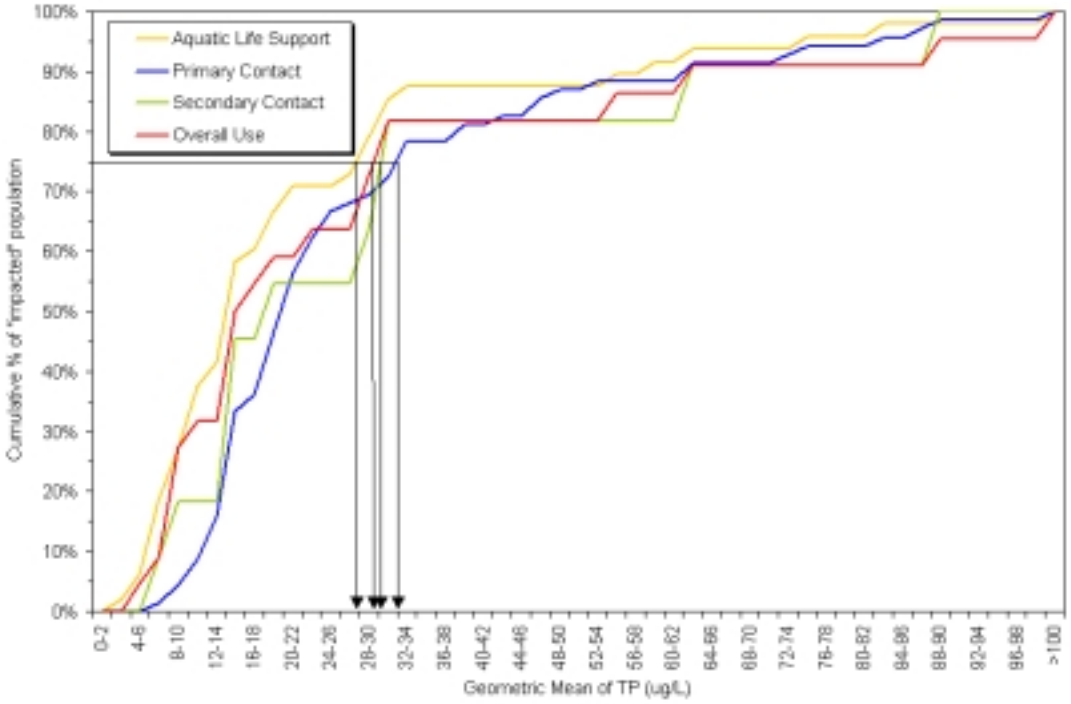

Figure 8: Cumulative distribution of % of lakes impacted as a function of the geometric mean of Total Phosphorus ("impacted" lake defined as 50% or more of lake area impacted).

Table 1: Range of total phosphorus concentration for different levels of impacted waterbodies. Corresponding % of total population impacted is given in paranthesis.

Target Level of Protection (fraction of impacted lakes)	Geometric Mean of TP (ug/L)			
	Aquatic Life	Overall Use	Primary Contact Recreation	Secondary Contact Recreation
10%	4-6 (2%)	6-8 (6%)	10-12 (12%)	6-8 (1%)
25%	8-10 (9%)	12-14 (16%)	12-14 (13%)	12-14 (2%)
50%	12-14 (13%)	14-16 (26%)	18-20 (21%)	16-18 (4%)
75%	26-28 (23%)	28-30 (33%)	30-32 (27%)	28-30 (6%)
90%	56-58 (29%)	62-64 (47%)	62-64 (30%)	62-64 (9%)

3.3.2 Chlorophyll-*a* (CHLA)

Figure 9 shows the fraction of “impacted” lakes and ponds corresponding to a given range of mean chlorophyll-*a* concentration, and for several important designated uses: Aquatic Life, Primary Contact

Recreation (swimming), Secondary Contact Recreation, and Overall Use support. As was also the case for Total Phosphorus, the plot shows a general increase in the fraction of lakes impacted as the mean chlorophyll-*a* concentration increases. Figure 10 presents the cumulative fraction of lakes and ponds as a function of chlorophyll-*a* concentration. Overall use support and primary contract recreation are the most stringent uses, as they correspond to the highest fraction of impacted lakes for given chlorophyll-*a* concentration. For example, mean chlorophyll-*a* concentrations in the 14-15 ug/L range correspond to levels of impairment of 38%, 35%, 27% and 7% for overall, primary contact, aquatic life and secondary contact use supports, respectively.

Figure 11 shows the cumulative distribution of chlorophyll-*a* for selected designated uses when considering only the subset of the lakes and ponds population that is "impacted". As with total phosphorus, Aquatic Life Support is generally the most stringent use, although overall use support is also associated with low CHLA concentration. For a protection level of 75% of the waterbody population impacted, corresponding CHLA concentration are 6 ug/L, 8 ug/L, 13.5 ug/L, and 15 ug/L for Aquatic Life, Overall Use, Primary Contact Recreation and Secondary Contact Recreation, respectively. Table 2 provides TP concentration corresponding to levels of protection of 10%, 25%, 50%, 75% and 90%. The corresponding fraction of the total population of lakes and ponds that is impacted (see Figure 10) is also provided between parenthesis next to each CHLA concentration range.

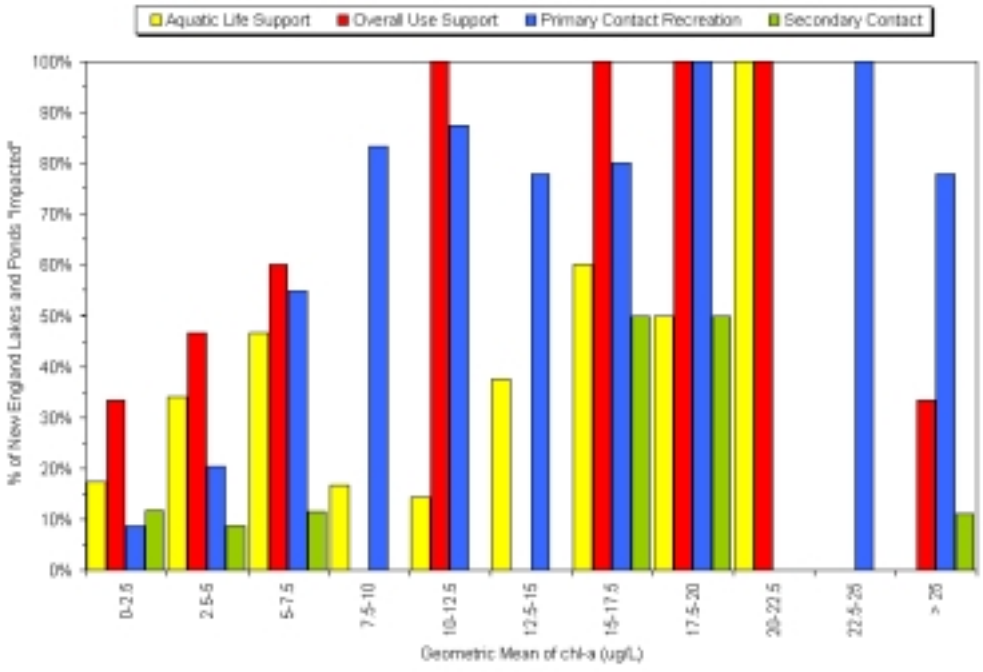

Figure 9: Percentage of New England lakes and ponds "impacted" for various designated uses as a function of chlorophyll-a concentration.

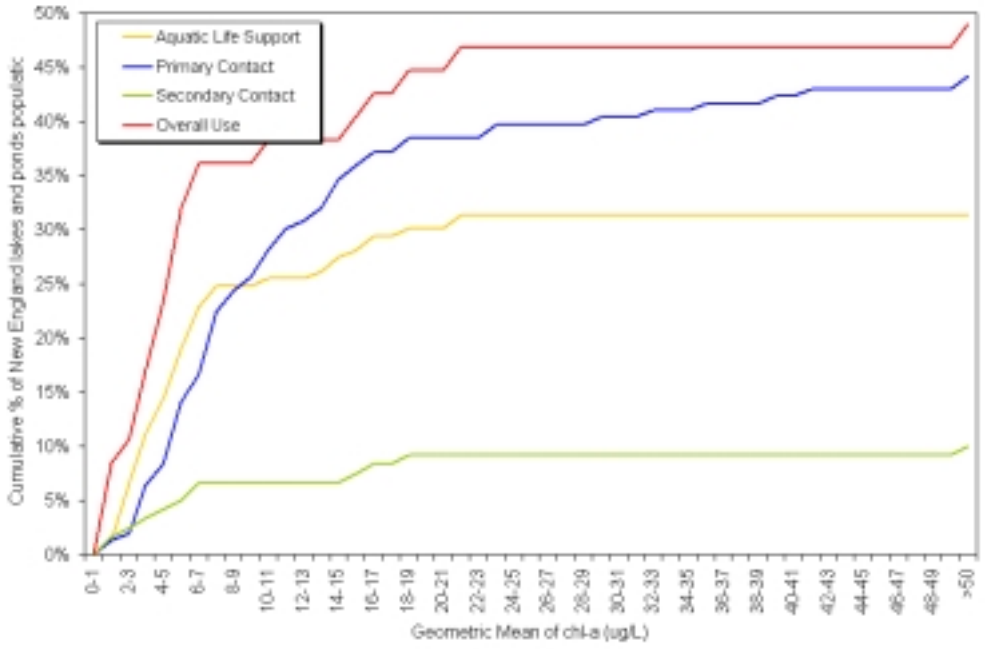

Figure 10: Cumulative fraction of New England lakes, ponds and reservoirs that are "impacted" for various designated uses as a function of chlorophyll-a concentration.

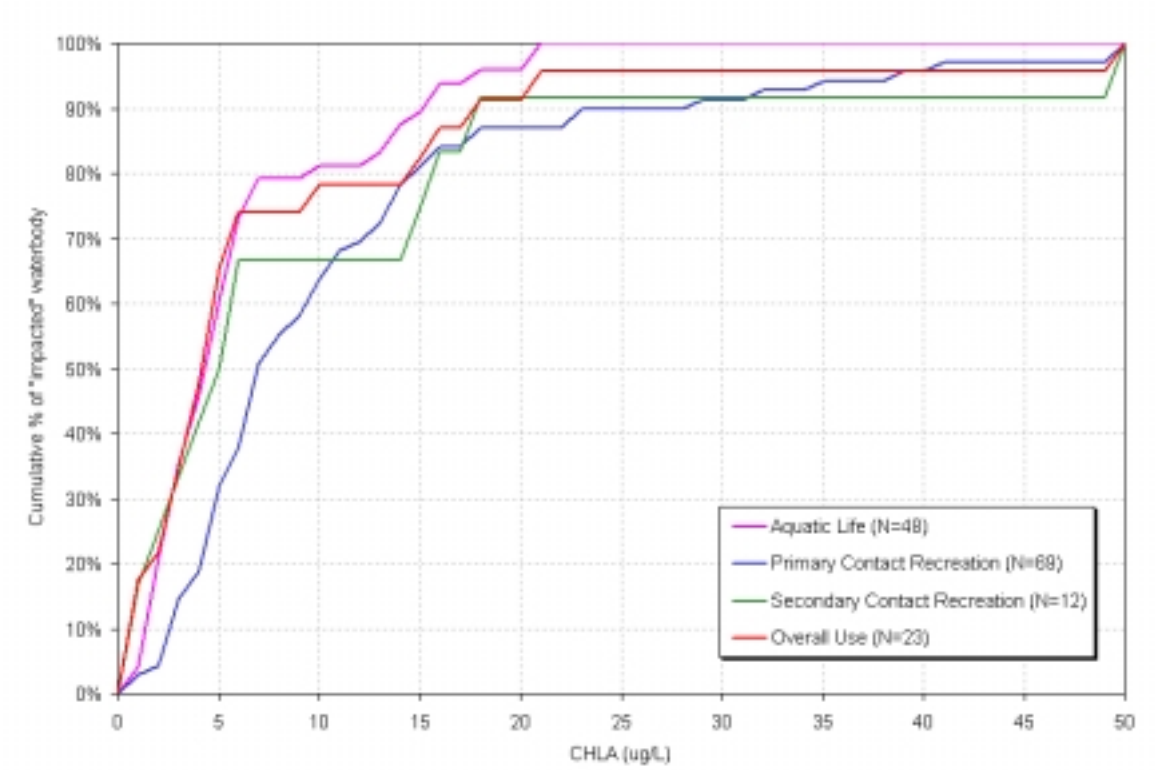

Figure 11: Cumulative distribution of % of lakes impacted as a function of the geometric mean of Chlorophyll-a ("impacted" lake defined as 50% or more of lake area impacted).

Table 2: Chlorophyll-a concentration for different levels of impacted waterbodies.

Target Level of Protection (fraction of impacted lakes)	Geometric Mean of CHLA (ug/L)			
	Aquatic Life	Overall Use	Primary Contact Recreation	Secondary Contact Recreation
10%	1-2 (2%)	1-2 (9%)	2-3 (2%)	0-1 (0%)
25%	2-3 (7%)	2-3 (11%)	4-5 (8%)	2-3 (7%)
50%	4-5 (14%)	4-5 (23%)	7-8 (22%)	5-6 (19%)
75%	6-7 (23%)	8-9 (36%)	13-14 (32%)	15-16 (28%)
90%	15-16 (28%)	18-19 (45%)	28-29 (40%)	18-19 (30%)

3.3.3 Secchi Depth Transparency (SDT)

Figure 12 shows the fraction of “impacted” lakes and ponds corresponding to a given range of mean Secchi disk transparency depth, and for several important designated uses: Aquatic Life, Primary Contact Recreation (swimming), Secondary Contact Recreation, and Overall Use support. The plot does not reveal a strong trend towards a higher fraction of impacted lakes and ponds with lower Secchi

disk transparency depth measured. Such a trend is however slightly noticeable in the case of primary contact recreation (swimming) water use whereby, as could be expected, smaller Secchi disk transparency depths are associated with a larger fraction of lakes being impacted for swimming. Figure 13 presents the cumulative fraction of lakes and ponds as a function of Secchi depth transparency depth. Overall use support, aquatic life support and primary contract recreation are the most stringent uses. For example, mean SDT depths in the 2.0-2.2 ug/L range correspond to levels of impairment of 34%, 24%, 21% and 6% for overall, primary contact, aquatic life and secondary contact use supports, respectively.

Figure 14 shows the cumulative distribution of Secchi Depth Transparency (SDT) for selected designated uses: Aquatic Life, Primary Contact Recreation (swimming), Secondary Contact Recreation, and Overall Use support. Note that the distributions are inversely related compared to TP and CHLA, as higher values of SDT are associated with better water quality, and therefore with a lower fraction of lakes considered impacted. Where SDT is concerned, Primary Contact Recreation is the most stringent use, with about 50% of the lake population impacted when SDT is around 3 meters. For a target protection level of 75% of the waterbody population impacted, corresponding SDT values are 1.6 m, 1.6 m, 1.4 m, and 1.4 m for Aquatic Life, Overall Use, Primary Contact Recreation and Secondary Contact Recreation, respectively. Table 3 provides SDT depth corresponding to levels of impacted lakes of 10%, 25%, 50%, 75% and 90% of the lakes. The corresponding fraction of the total population of lakes and ponds that is impacted (see Figure 13) is also provided between parenthesis next to each SDT depth range.

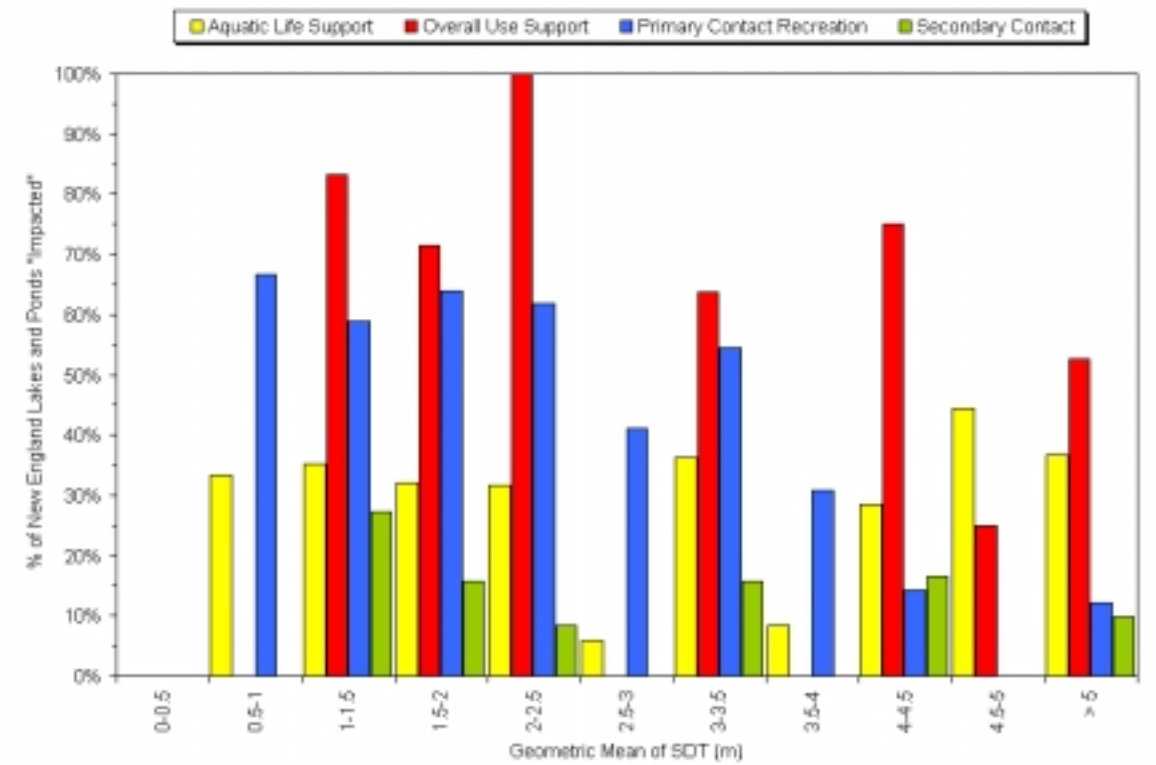

Figure 12: Percentage of New England lakes and ponds "impacted" for various designated uses as a function of Secchi disk transparency depth.

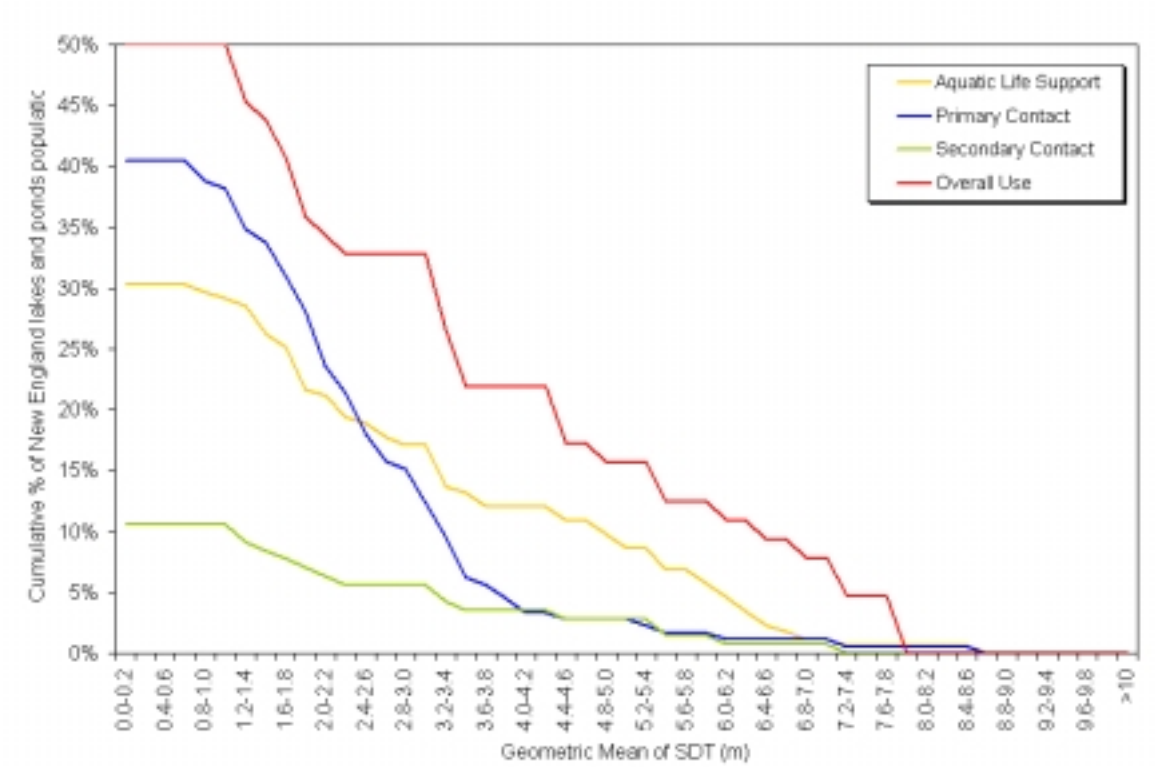

Figure 13: Cumulative fraction of New England lakes, ponds and reservoirs that are "impacted" for various designated uses as a function of Secchi disk transparency depth.

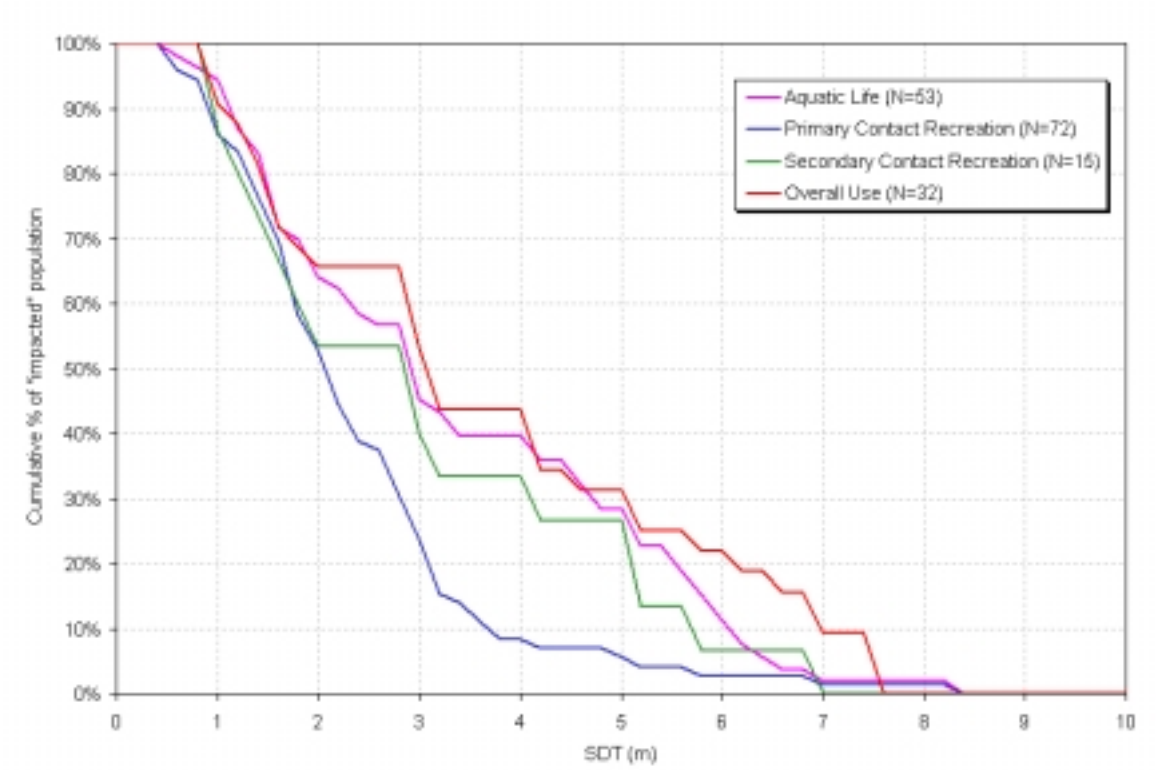

Figure 14: Cumulative distribution of % of lakes impacted as a function of the geometric mean of Secchi Depth Transparency ("impacted" lake defined as 50% or more of lake area impacted).

Table 3: Secchi depth transparency for different levels of impacted waterbodies.

Target Level of Protection (fraction of impacted lakes)	Geometric Mean of SDT (m)			
	Aquatic Life	Overall Use	Primary Contact Recreation	Secondary Contact Recreation
10%	6.0-6.2 (5%)	7.0-7.2 (8%)	3.6-3.8 (6%)	5.6-5.8 (1%)
25%	5.0-5.2 (9%)	5.2-5.4 (17%)	3.0-3.2 (12%)	5.0-5.2 (3%)
50%	2.8-3.0 (17%)	3.0-3.2 (33%)	2.0-2.2 (24%)	2.8-3.0 (6%)
75%	1.6-1.8 (25%)	1.6-1.8 (41%)	1.4-1.6 (34%)	1.4-1.6 (8%)
90%	1.0-1.2 (29%)	1.0-1.2 (50%)	0.8-1.0 (39%)	1.0-1.2 (11%)

3.4 Levels of Protection and Corresponding Total Phosphorus Concentration for Ecoregions of New England

The population of lakes and ponds was further sub-divided into the three main ecoregions of New England: the New England Coastal Zone (NECZ), New England Highlands (NEH), and Laurentian Plains and Hills (LPH). This was done to evaluate whether the protective level for a designated use differed among geographic locations in New England.

Figure 15 shows the cumulative distribution of geometric mean of TP against the fraction of impacted waterbodies, for the protection of Aquatic Life. While the lines representing the NEH and LPH ecoregions are very similar, the distribution in the NECZ ecoregion is shifted towards higher mean TP concentrations. This seems to indicate that a higher TP concentration is required to classify a lake or pond as "impacted" within the NECZ region. This difference could be ascribed to variation in methods used to assess the lakes, or to a difference in regional expectations of "desirable" or acceptable lake characteristics. Similar observations can be made on the cumulative distributions of CHLA and Secchi Depth Transparency presented in Figure 16 and Figure 17, respectively.

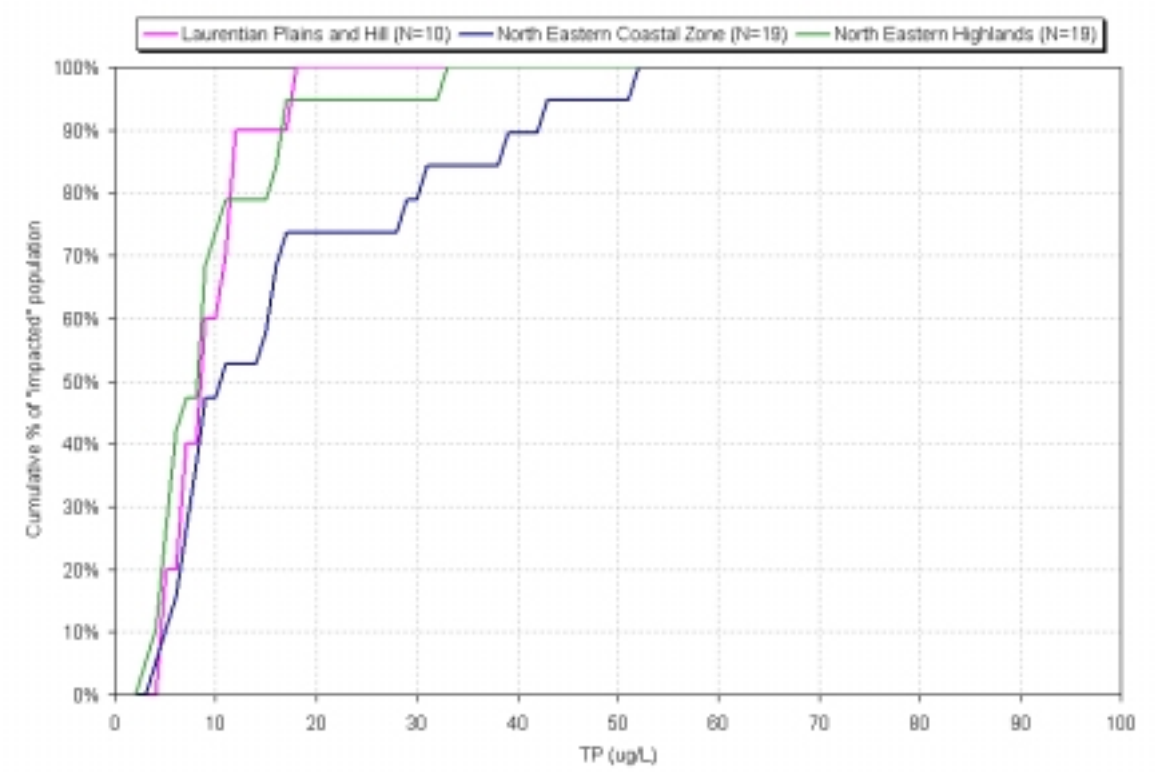

Figure 15: Cumulative distribution of the fraction of lakes impacted as a function of the geometric mean of Total Phosphorus (TP) for the ecoregions of New England (based on Aquatic Life use support).

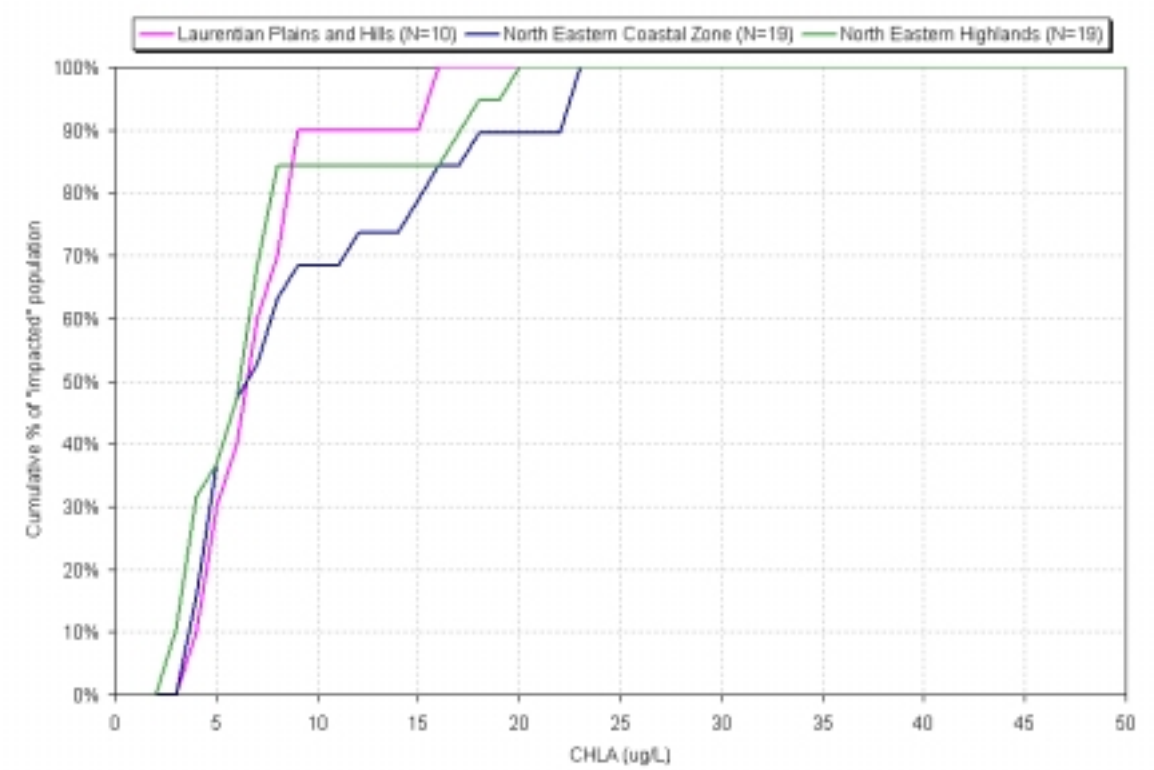

Figure 16: Cumulative distribution of the fraction of lakes impacted as a function of the geometric mean of chlorophyll-a (CHLA) for the ecoregions of New England (based on Aquatic Life use support).

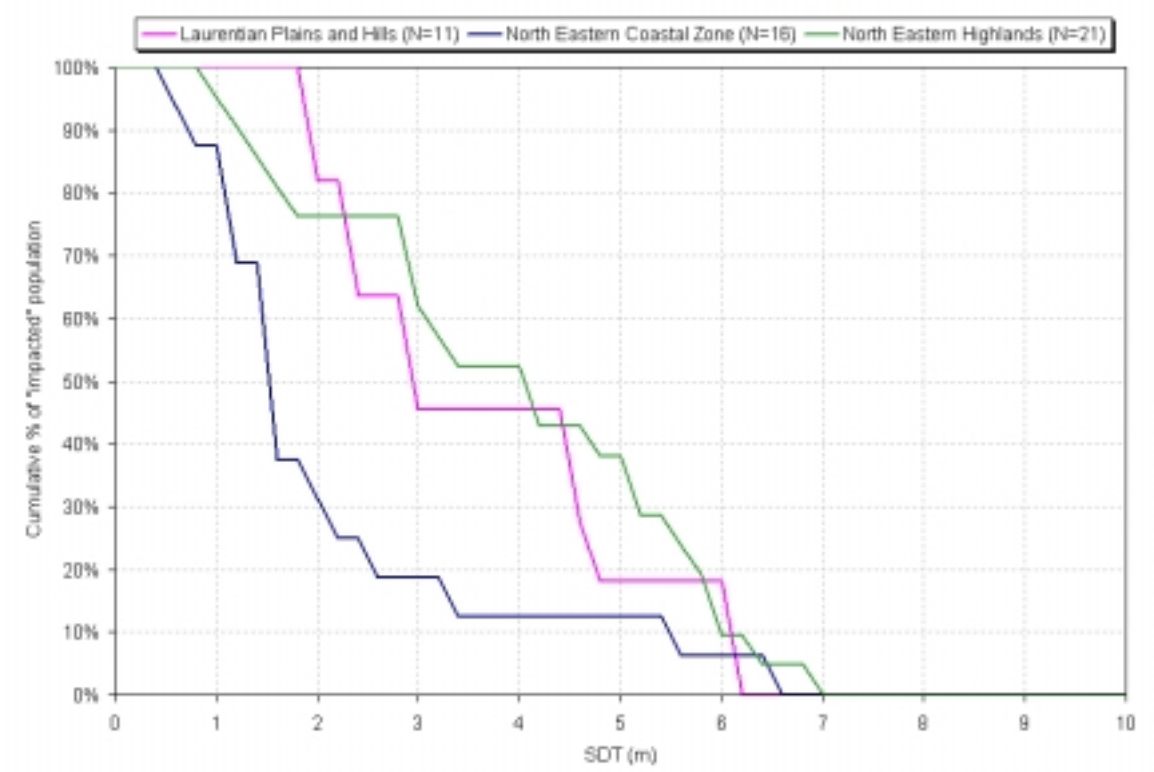

Figure 17: Cumulative distribution of the fraction of lakes impacted as a function of the geometric mean of Secchi Depth Transparency (SDT) for the ecoregions of New England (based on Aquatic Life use support.

3.5 Nutrient Levels Associated with Target Protection Levels and Selected Designated Water Uses

The analyses above provide a range of nutrient levels associated with the various water uses and depending on the desired level of protection. The range of lakes' geometric mean can be defined for levels of lake population protection of 10%, 25%, 50%, 75%, and 90%. These values were compared to other values generated as alternative approaches to ecoregional nutrient criteria (ENSR, 2000), including those obtained when following the "percentile" method presented in the EPA guidance document and those typically associated with oligotrophic, mesotrophic and eutrophic conditions, as described in limnology literature.

Using the quartile range approach described in the EPA Nutrient Criteria Technical Guidance Manual Lakes and Ponds (EPA, 2000), we obtained the values for TP, Chl-a, and SDT for New England lakes and ponds shown in Table 4. Table 5 displays the typical ranges of nutrient associated with the three commonly used trophic conditions of a lake or pond.

Table 4: Range of Nutrient levels as defined using "percentile" method from EPA guidance manual (range of 75th percentile of reference population and 25th percentile of all lakes, ponds and reservoirs in New England, and as reported by ENSR, 2000).

Ecoregion	TP (ug/L)	CHLA (ug/L)	SDT (m)
New England Coastal Zone	8.6 - 11.2	2.5 – 2.7	2.7 - 3.5
New England Highlands	6.5 - 10.0	2.3 – 3.8	3.7 - 5.5
Laurentian Plains and Hills	7.9 - 11.7	2.6 – 4.8	4.0 - 5.7
New England-wide	7.2 - 11.0	2.5 – 4.2	3.8 – 5.8

Table 5: Nutrient levels associated with trophic conditions, based on trophic status classification presented in EPA Guidance Manual (Table 7-2, U.S. EPA, 1999).

Trophic Status	TP (ug/L)	CHLA (ug/L)	SDT (m)
Oligotrophic	< 10	< 1.5	> 6
Mesotrophic	10 - 24	1.5 – 7.2	2 - 6
Eutrophic	> 24	> 7.2	< 2

The range of nutrient levels obtained using the percentile approach (EPA, 2000), found in the literature, were compared to those obtained from the 305(b) assessments for target population protection levels of 25%, 50% and 75%. Summarized results of those comparisons are presented and described below for TP, CHLA and SDT.

3.5.1 Total Phosphorus

Figures 19, 20 and 21 present the range of TP associated with selected water uses for levels of protection of 25%, 50%, and 75%, respectively. As expected, the allowable total phosphorus concentration decreases with more stringent protection. At a level of protection of 75% (Figure 20), the TP levels correspond to those typically associated with eutrophic conditions, while for levels of protection of 25% and 50%, the TP levels are within the low to mid mesotrophic range.

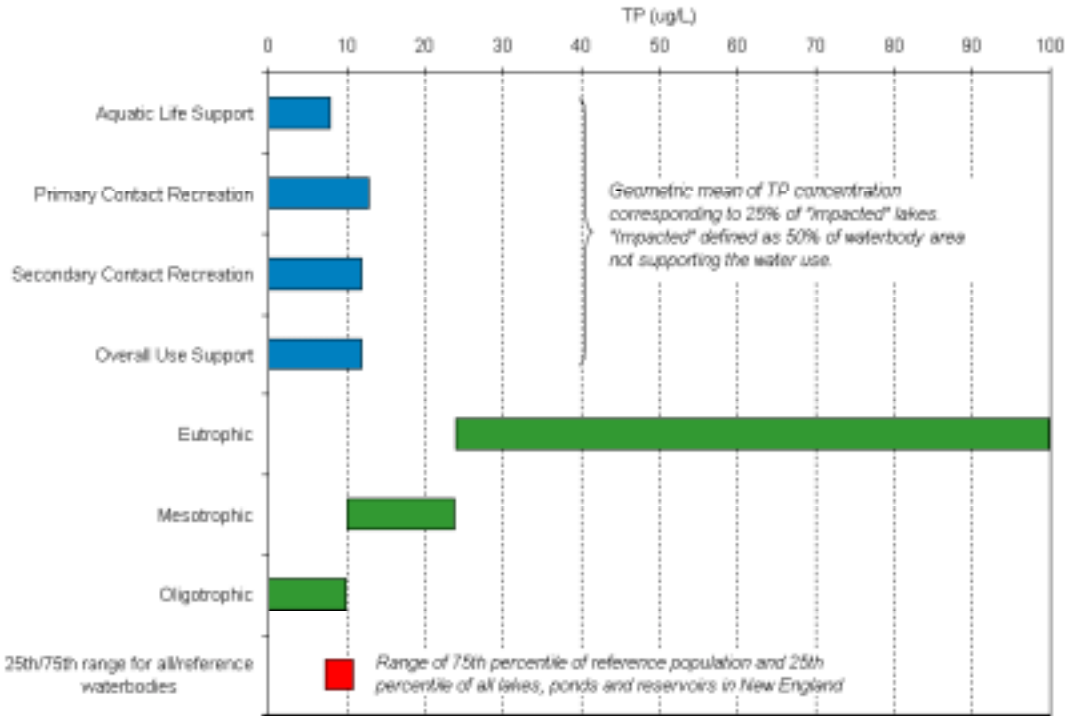

Figure 18: Comparison of Total Phosphorus range associated with selected water uses for target level of protection of 25% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

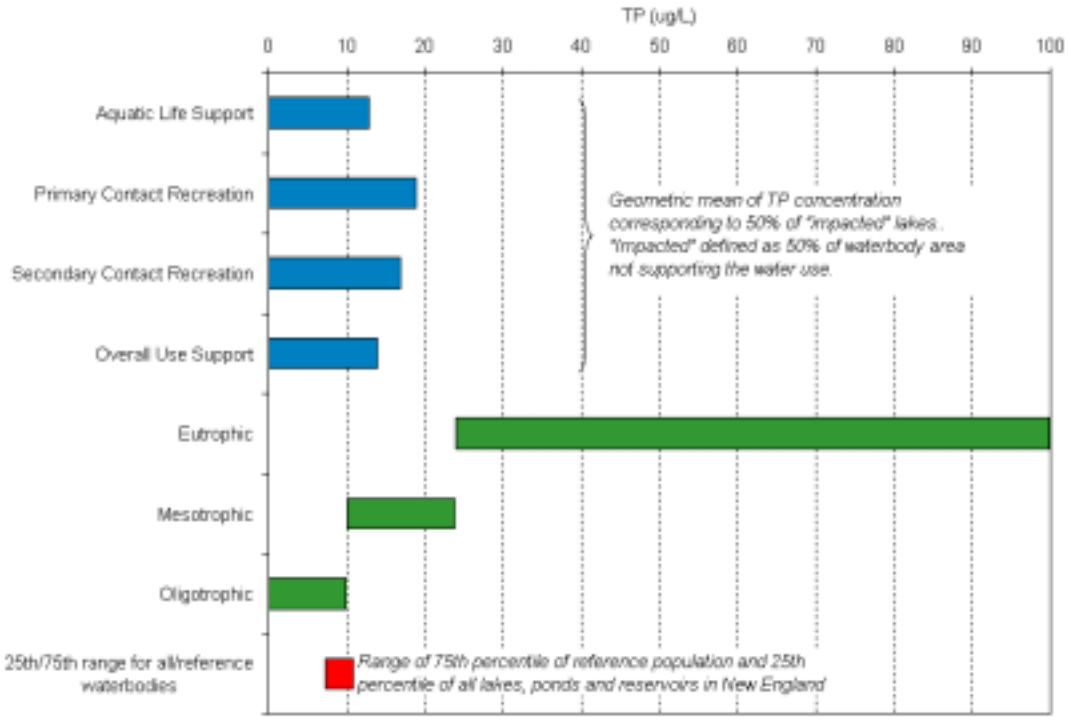

Figure 19: Comparison of Total Phosphorus range associated with selected water uses for target level of protection of 50% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

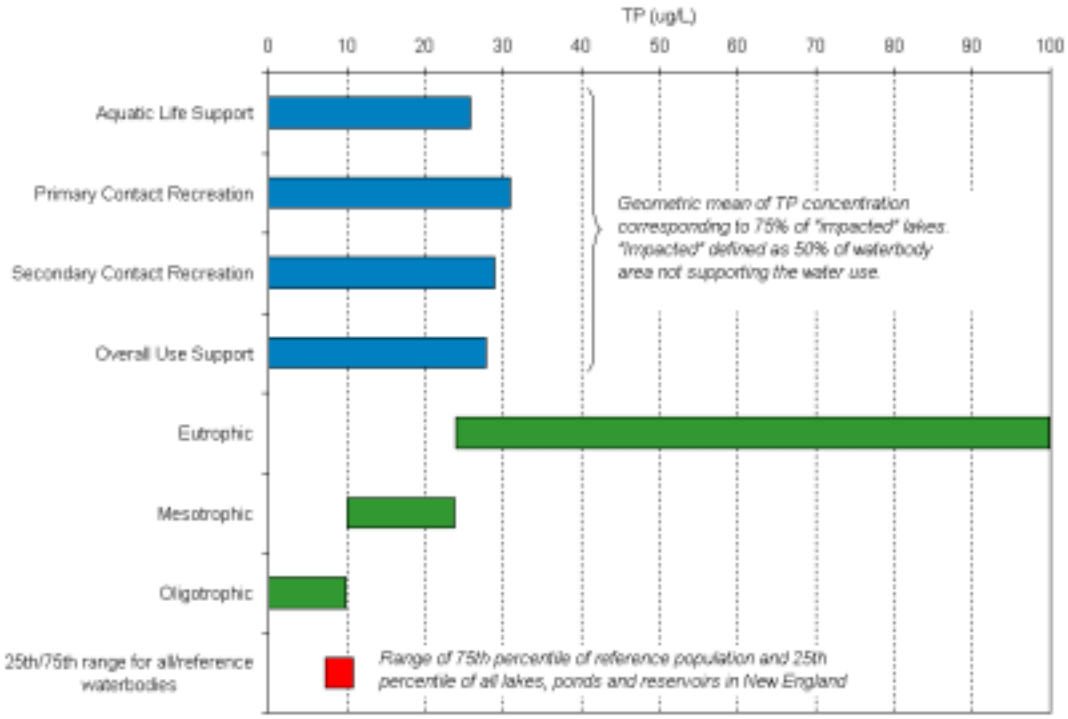

Figure 20: Comparison of Total Phosphorus range associated with selected water uses for target level of protection of 75% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

3.5.2 Chlorophyll-a (CHLA)

Figures 22, 23 and 24 present the range of CHLA associated with selected water uses for levels of protection of 25%, 50%, and 75%, respectively. Again, the allowable chlorophyll-a concentration decreases with more stringent protection level (i.e., 25% impacted lake allowed). For most uses, the chlorophyll-a associated with a 75% level of protection corresponds to eutrophic conditions, while for more protective targets of 25% and 50%, the trophic conditions are within the mesotrophic range.

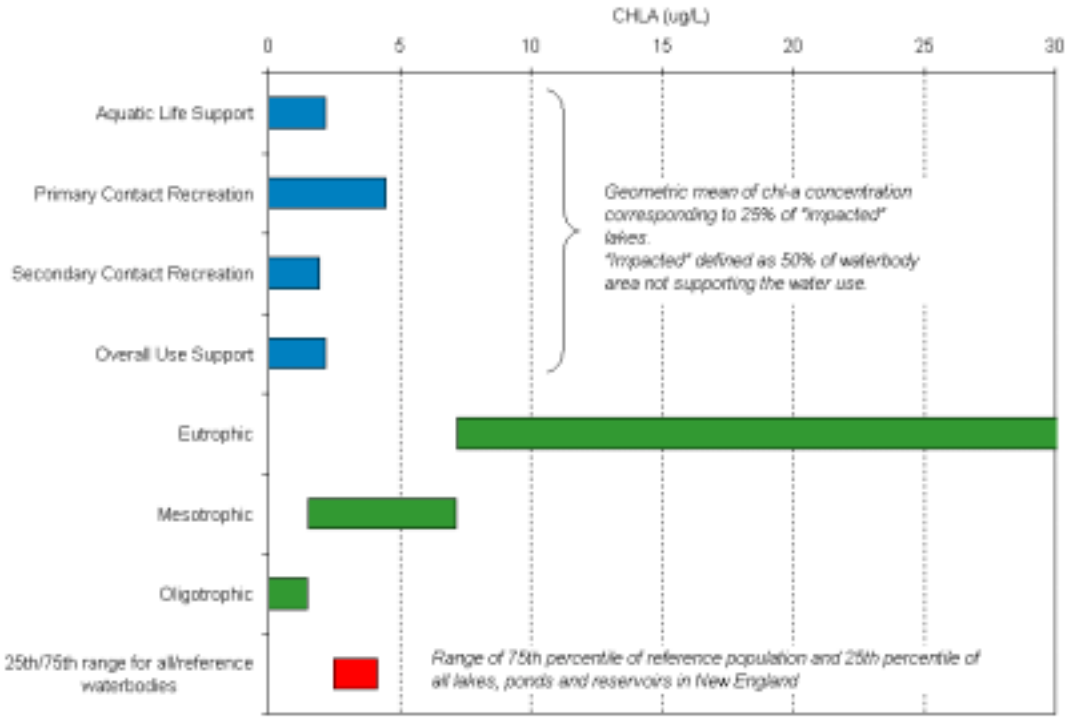

Figure 21: Comparison of Chlorophyll-a range associated with selected water uses for target level of protection of 25% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

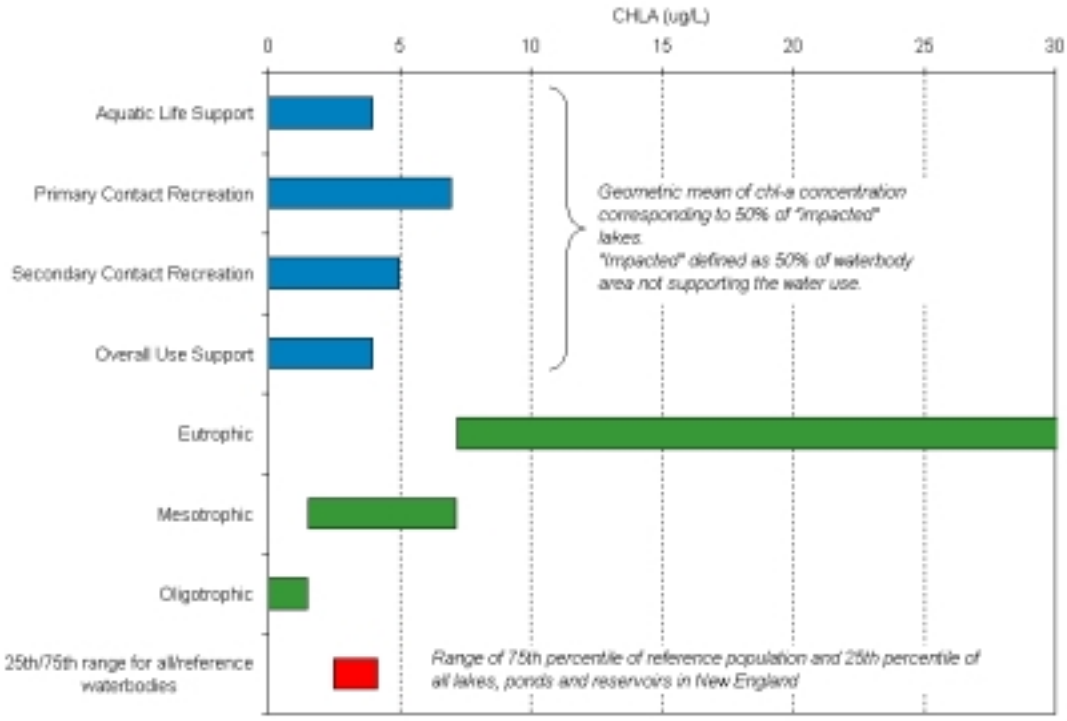

Figure 22: Comparison of Chlorophyll-a range associated with selected water uses for target level of protection of 50% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

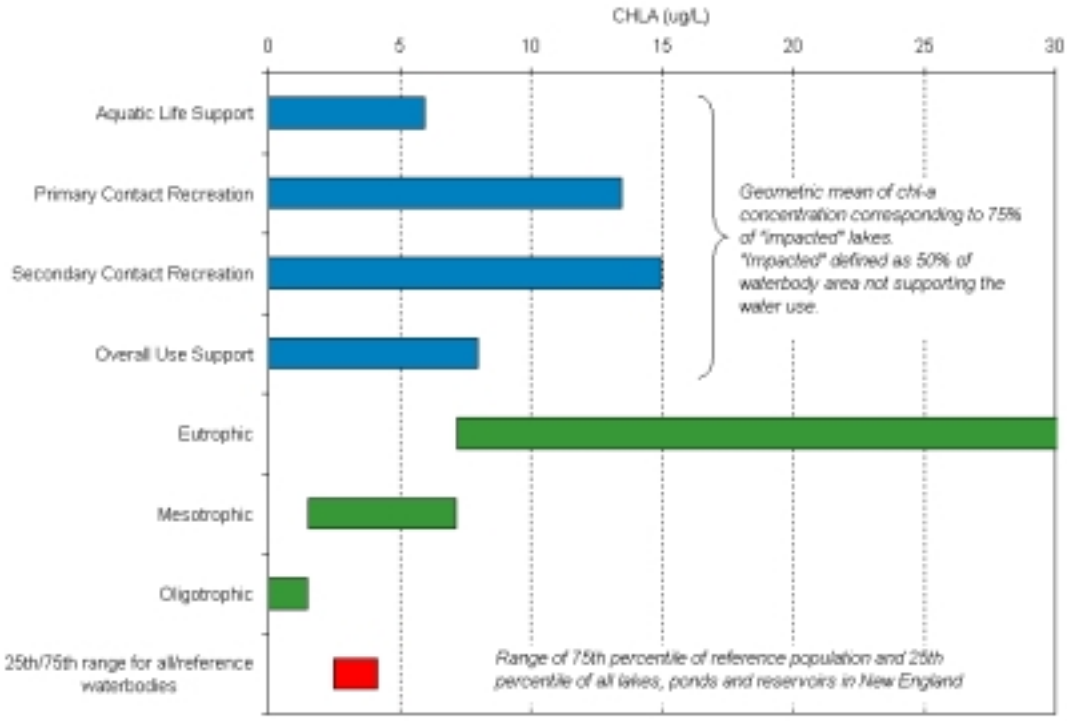

Figure 23: Comparison of Chlorophyll-a range associated with selected water uses for target level of protection of 75% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

3.5.3 Secchi Depth Transparency (SDT)

Figures 25, 26 and 27 present the range of SDT associated with selected water uses for levels of protection of 25%, 50%, and 75%, respectively. Note that in this case, the scale is inverted, as higher values are associated with better water quality. Again, the least restrictive level of protection of 75% of lakes impacted corresponds to SDT that are within the eutrophic conditions range, while more restrictive protection of 25% and 50% are within the mesotrophic range.

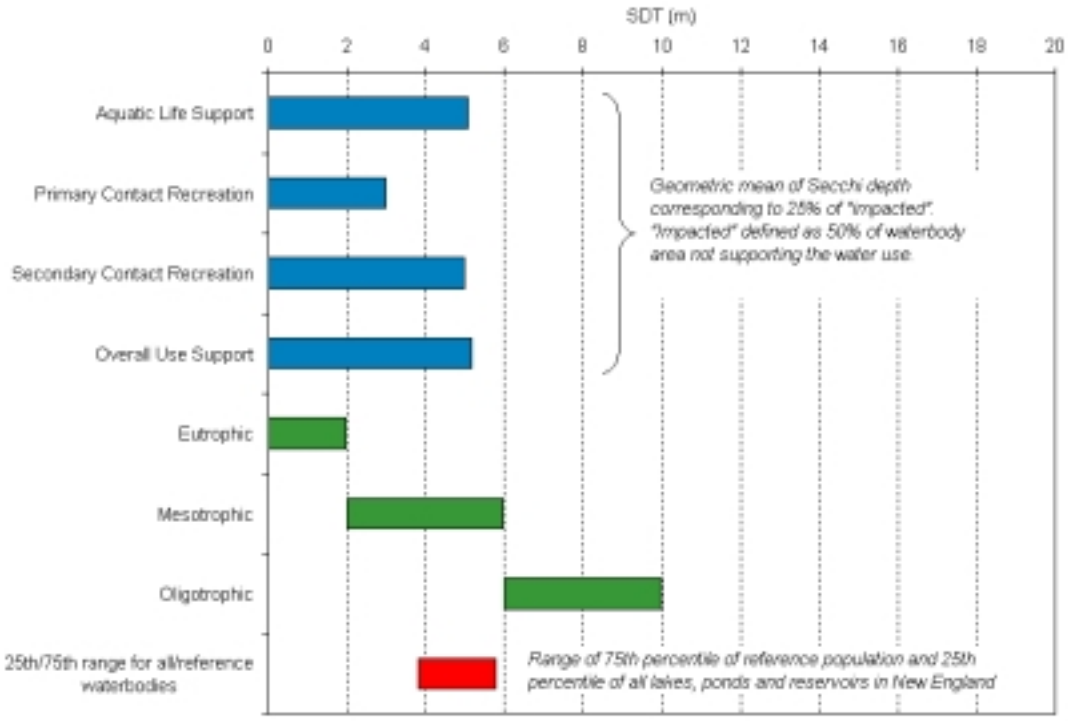

Figure 24: Comparison of Secchi Depth Transparency (SDT) range associated with selected water uses for target level of protection of 25% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

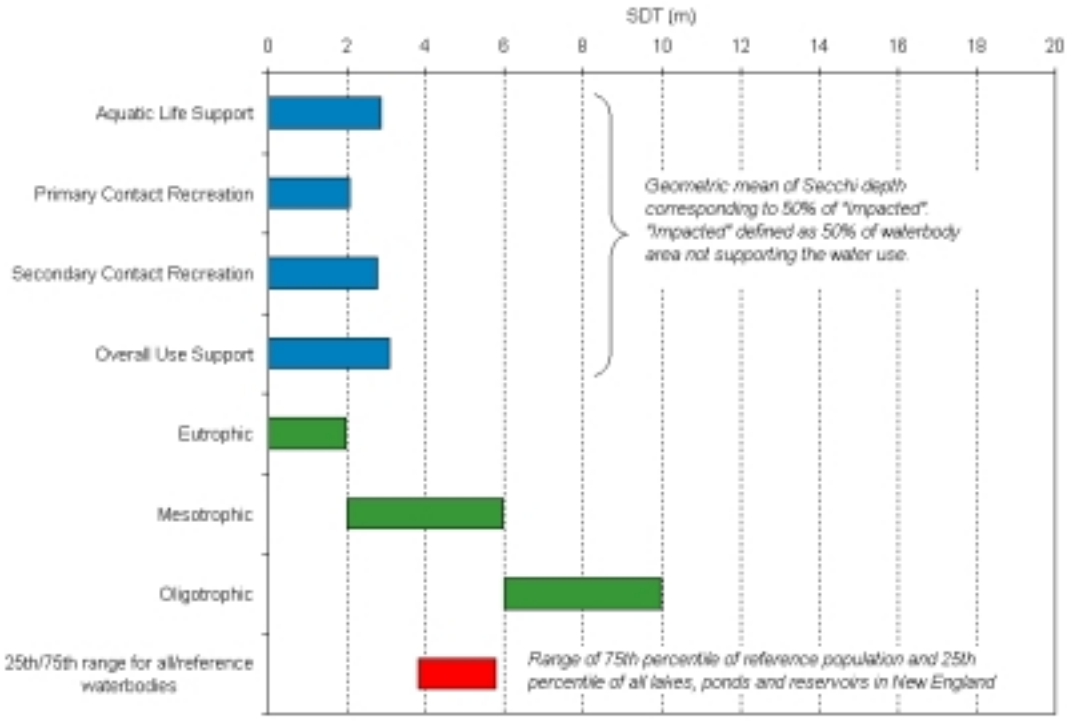

Figure 25: Comparison of Secchi Depth Transparency (SDT) range associated with selected water uses for target level of protection of 50% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

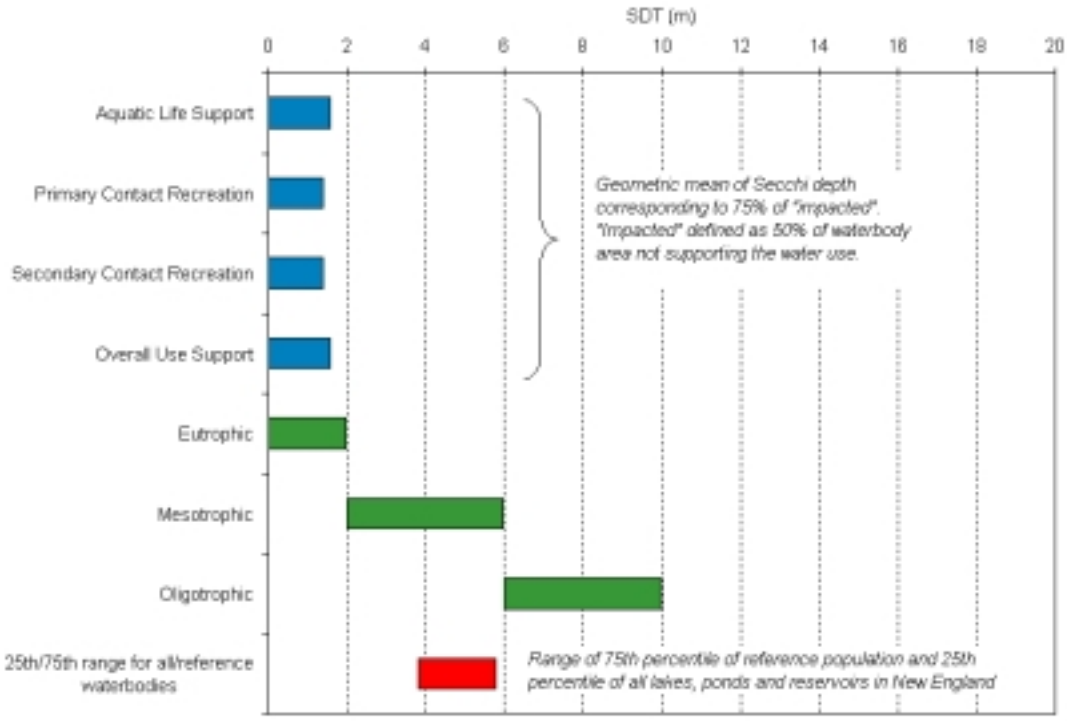

Figure 26: Comparison of Secchi Depth Transparency (SDT) range associated with selected water uses for target level of protection of 75% with typical ranges for trophic conditions, and range obtained using percentile approach presented in EPA guidance manual.

4.0 SUMMARY AND DISCUSSION

The analyses presented in this document have illustrated an alternative approach of linking historical data, as contained in the Nutrient Database, with the New England states assessment of designated use support for lakes, ponds and reservoirs. By evaluating the nutrient levels associated with different sets of lake populations assessed for impairment of specific designated uses, one can identify the range of nutrient concentrations that are associated with attainment of designated use. Two heuristic expressions of impairment, the fraction impacted (FI) and target level of lake population protection, were defined to provide insight to the practical implications of setting specific nutrient levels as targets. These conceptual devices also provide flexibility in defining a desired level of protection, both at the waterbody level, or for an entire lake population (e.g., as applied for New England, an ecoregion, or an individual state).

Nutrient levels estimated by degree of impairment were compared to other alternative approaches for setting nutrient criteria. For a FI of 50% of the lakes area and a target lake population protection level of 25%, the range of corresponding nutrient levels are within the range commonly associated with oligotrophic to eutrophic trophic conditions. For the same FI and a target population protection level of 50%, the nutrient concentration range is higher but still within the range commonly associated with mesotrophic conditions.

One of the shortcomings of using the 305(b) assessments to set target nutrient levels resides in the variability in the methods that the states use to assess their waterbodies. Although general guidelines are available, the states have a lot of freedom in evaluating to what level a given use is supported by the waterbody, and the areal extent of impairment.

Another difficulty of linking 305(b) assessments with the nutrient database is the potential circularity it creates regarding the development of nutrient criteria and their use for assessing the health of a waterbody. Using the 305(b) list to confirm the values proposed as nutrient criteria may preclude the use of the same criteria to evaluate whether a certain waterbody is impaired and development of the 305(b) list itself. However, nutrient criteria are likely to be evolved through a weight-of-evidence approach using more than one methodology, and the use of the 305(b) assessments provides a more direct consideration of nutrient effect on designated uses than other methods currently available.

Finally, the analyses presented above use the geometric mean of measurements taken at a given waterbody as a representative measure of water quality for the lake. This parameter is only a measure of central tendency and is not necessarily representative of the range of conditions encountered in a lake or pond; the conditions that may have played a crucial role in assessing the lake for the purpose of the 305(b) Report. Certain conditions may be seasonal and transient in nature and not have been accurately captured by monitoring data, but yet lead to a lake not supporting all of its designated uses.

Even with the limitations discussed above, the results presented in this report provide interesting insight into the connection between support of designated uses and historical water quality data. The approach presented reveal a promising avenue to ground-truth proposed nutrient criteria and estimate the protection level that they would potentially offer for New England lakes and reservoirs.

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