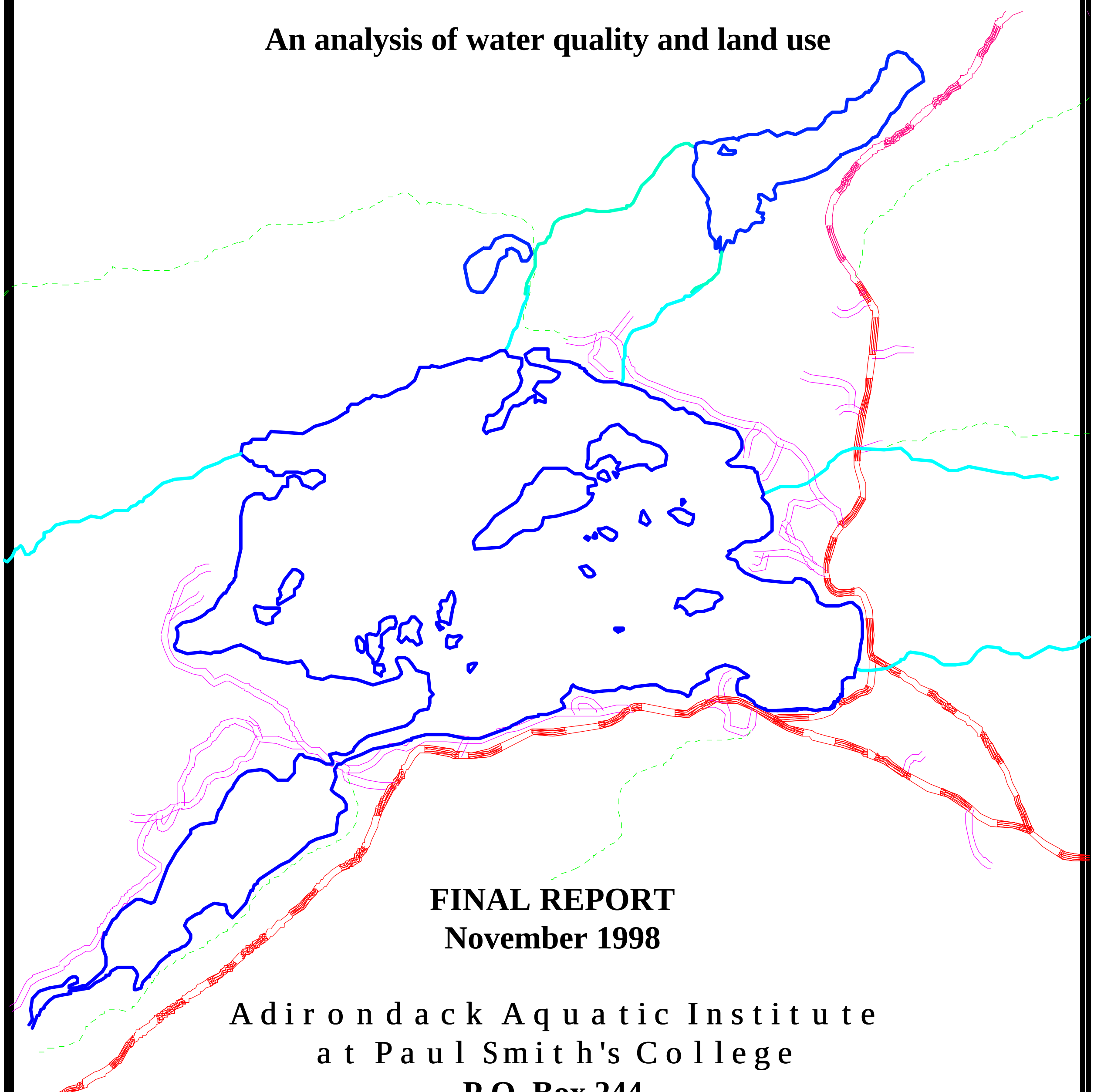
THE CARRYING CAPACITY OF BLUE MOUNTAIN LAKE

An analysis of water quality and land use



FINAL REPORT
November 1998

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BLUE MOUNTAIN LAKE

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5.0 Watershed Modeling

The effect of development within the Blue Mountain Lake watershed on the water quality of Blue Mountain Lake was modeled using EutroMod. Input variables were selected to best represent existing conditions and projected levels of development, and based upon our current knowledge and best professional judgement. While actual present day per capita numbers may vary slightly from those used in this analysis, those differences are not likely to result in significant changes in the results of the analysis. However, as with any model, the results given here should only be used as a guideline in assessing development within the watershed.

5.1 Existing Development and Development Potential

A Geographic Information System (GIS) was used to analyze land use and zoning within the Blue Mountain Lake watershed. Streams, rivers, lake shoreline, roads, trails, and structures were digitized from 7 ½ minute, 1:24000 series NYS Department of Transportation (DOT) topographic maps. Watershed boundaries were drawn on the DOT maps and also digitized. APA land classification were obtained from the Adirondack Park Agency. Land classification and development analysis for the Blue Mountain Lake watershed is presented in Figure 17 and Table 13.

Existing development within the watershed was calculated by examining the number and location of structures in the Blue Mountain GIS. There are several drawbacks to this methodology. The type of structure (ie., house, boat house, garage) can not be determined from the maps. In addition, the structures shown on the DOT maps were based upon 1954 USGS quadrangles, therefore any structures which were either torn down or built since that time would not show up in the GIS data layer. Based

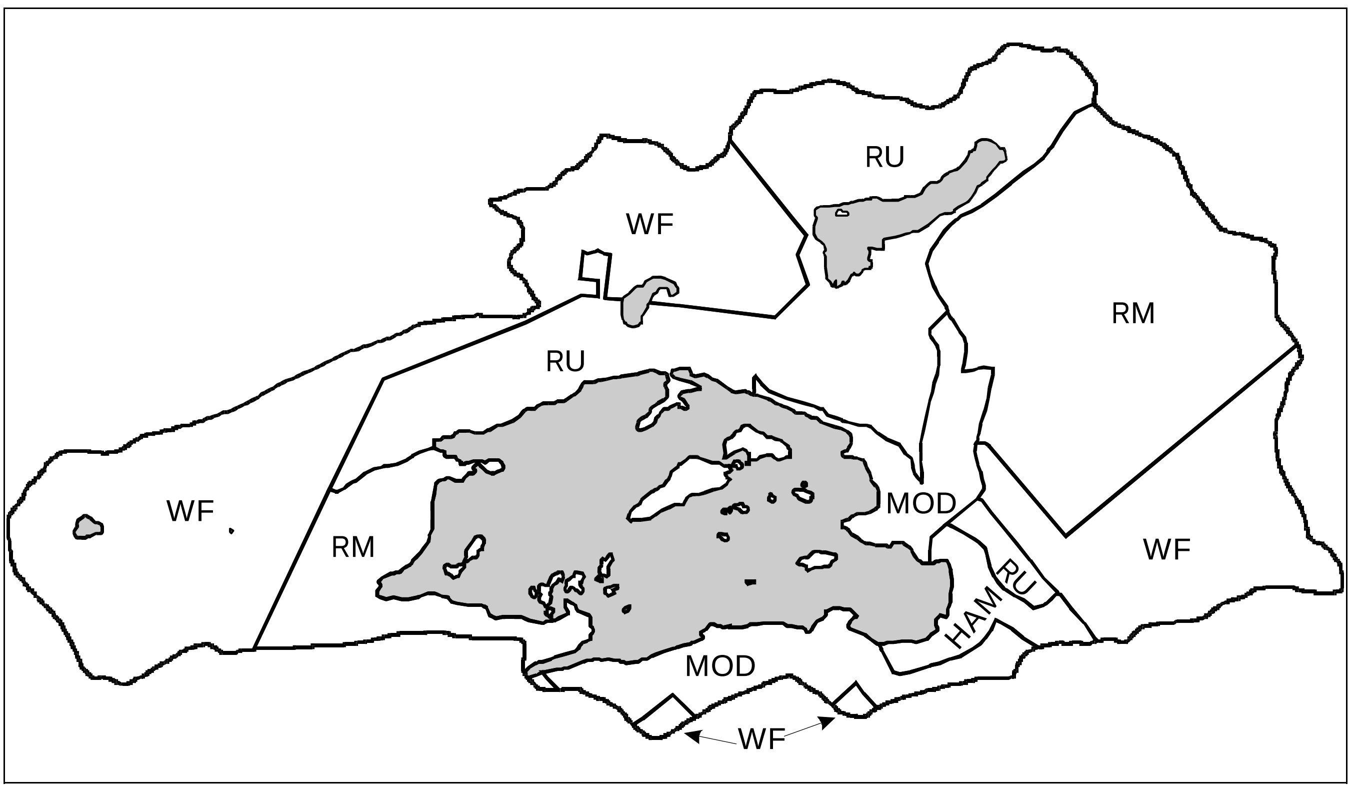

Figure 5 APA Land Use Classifications within the Blue Mountain Lake watershed (see Table 13 for legend

upon the GIS, there were a total of 259 structures within the watershed, including 89 along the shorefront. Approximately half (130) of those structures were within the zone of influence for modeling (within 200 m of Blue Mountain Lake or its tributaries). The initial modeling effort in 1993 had estimated 142 structures within 200 m zone around the lake. This count included rental cabins and a few stores and churches but did not include dwellings along any of the tributaries. A conservative value of 130 dwellings was used for this modeling analysis.

The zone of influence can be described as that area within 200 meters of surface water. It is important from a modeling perspective since there is a modeled impact directly related to the number of septic systems within this zone and the number of capita-years applied to those septic systems. Development of land outside of the zone of influence is important as well. Conversion of land use from forested to residential anywhere within the watershed results in increased phosphorus loading. For the purpose of this discussion, “shorefront homes” will be used interchangeably with “homes within the zone of influence.” Bear in mind that this category of homes includes any dwelling within 200 meters of the lake or its tributaries.

The development potential of the watershed was determined by examining the APA land clasifications within the watershed. The maximum number of homes within the zone of influence was calculated by dividing the amount of shorefront in a given zone by the minimum lot width for that classification (shorefront/minimum lot width) and taking into account the minimum lot size. The maximum number of shorefront homes was calculated by subtracting the number of shorefront homes within a given APA class from the total amount of homes that could be built within that APA class on an areal basis (# of shorefront homes minus zone area divided by minimum lot size). This type of analysis may tend to overestimate the number of allowable homes, since actual home construction is limited by suitable site conditions for the construction of homes, septic systems, roads and utility access. Based upon this analysis, there are a potential 347 homes within the 200 meter zone of influence and therefore the potential for an increase of 217 new homes within the 200 m zone over existing conditions.

Table 13
Development Potential of Blue Mountain Lake Watershed

Code	Classification	Min. Lot Size (ac)	Min. Lot Width (ft)	Area in watershed (ac)	Shoreline in watershed (ft)	Maximum shorefront homes†	Max. non-shore homes
HAM	Hamlet	0.25	50	136	3,756	75	470
MOD	Moderate Intensity	1.3	100	512	17615	176	217
RU	Rural Use	8.5	150	1,272	13,225	88	55
RM	Resource Management	42.7	200	1,475	15,301	8	26
WF	Wild Forest & Wilderness	n/a	n/a	1,982	n/a	n/a	n/a
					TOTALS	347	768

†zone of influence

5.2 Per Capita Calculations

Per capita estimates, the number of person-years spent near the lake, is an important part of the model. These numbers provide a basis for gauging model predictive performance and can be modified to simulate various development scenarios within the watershed. Per capita calculations were performed for those occupied structures within the 200 meter zone zone of influence around Blue Mountain Lake and its tributaries. The number of seasonal versus year round homes was estimated using a ratio of 35:65 for year-round to seasonal homes[1]. Existing development therefore consists of 85 seasonal and 45 year-round homes. Maximum new development would consist of 141 seasonal and 76 year-round homes. The capita-years for existing development and maximum development scenarios were calculated using 3.5 persons per home or camp. Seasonal homes and camps were assumed to be occupied for three months. Per capita numbers are summarized in Table 14.

In addition to homes and camps, the Adirondack Museum is the only other major source that contributes to phosphorus loading within the watershed. Assuming 100,000 visitors per year with an average length of visit of 2 to 4 hours, the Adirondack Museum occupancy is between 23 and 46 capita years. This is the equivalent of 6.5 to 13 year-round homes or 26 to 53 seasonal homes.

Based upon these numbers, Blue Mountain Lake has a current population within the 200 meter zone of influence of 255 to 278 capita years and the potential for a total population within the 200 meter zone of influence of 644 to 667 capita years.

Table 14
Capita-year calculations for Blue Mountain Lake Watershed

Usage	Existing Development		Maximum New Development	
	# of homes/camps	capita-years	# of homes/camps	capita-years
Seasonal	85	74.4	141	123.4
Year-round	45	157.5	76	266.0
Total	130	231.9	217	389.4

5.3 Additional Model Inputs

Median total phosphorus concentrations from the Blue Mountain tributaries were used as input to the EutroMod model. Undeveloped areas (forest) were assigned the lowest tributary median total phosphorus value, which was 0.009 mg/L in Minnow Brook East. Developed areas were assigned the highest tributary median value, which was 0.024 mg/L in Museum Brook. Both of these values are lower than the estimated values used during the 1993 model (0.015 mg/L for forest and 0.074 mg/L for developed areas).

[1] 1990 Census Bureau

The precipitation value used in 1993 modeling runs was revised to match the measured long-term annual average from the NCDC station at Indian Lake (see Section 3.2). Lake and watershed areas used in 1993 modeling runs were revised to match values determined from the Blue Mountain GIS. Phosphorus retention of septic system effluent by soil used in 1993 modeling runs was reduced to 10 percent for systems within the modeled zone of influence. This more closely matches that determined by top researchers in studies of similar lakes in the Canadian Shield[2].

The standard EutroMod model was found to predict phosphorus well but chlorophyll *a* and transparency poorly. Carlson's empirical formulae for predicting chlorophyll *a* and transparency from total phosphorus[3] were substituted for this portion of the model, producing much better results. An under-prediction of transparency in the lake is likely due to the better than average water clarity (lack of dissolved and particulate materials) in Blue Mountain Lake.

5.4 Model Results

The EutroMod model was run with the modifications and inputs as mentioned in the preceding sections. In the following list of model runs, "low" and "high" refer to the level of Museum contribution as explained in Section 5.2. Model runs consisted of existing development low (255 capita-yrs), existing development high (278 capita-yrs), maximum development (high only, 667 capita-yrs), and chlorophyll *a* criteria of 2 µg/L. A maximum chlorophyll *a* criteria of 2 mg/L was selected to determine the level of acceptable development since 2 mg/L is the boundary between oligotrophic and mesotrophic conditions and is close to existing conditions. Capita-years input was changed and land use was changed accordingly until a chlorophyll *a* level of 2 was predicted.

Results from the modeled scenarios are summarized in Table 15. The "existing high" was a better predictor of existing in-lake water quality than "existing low." The number of new homes under modeled scenarios was calculated by assuming the year-round to seasonal ratio would remain at 35:65.

Predicted water quality for each scenario is presented in Figures 18 through 20 for total phosphorus, chlorophyll *a* and transparency, respectively. The model predicted total phosphorus well using the "Existing High" scenario. The "Maximum Development" scenario predicted a total phosphorus concentration of around 0.013 mg/L, well into the mesotrophic range. The "chlorophyll *a* = 2" scenario predicted a phosphorus concentration of around 0.010 mg/L, which is at the oligotrophic-mesotrophic border.

The model predicted chlorophyll *a* concentration (1997 average) well using the "Existing High" scenario. The 1998 chlorophyll *a* concentration was high due to an unusually high readings in the east basin of the lake in August. This high concentration, though, unusual was replicated both by samples collected by the volunteer monitor and AAI personnel. The "Maximum Development" scenario predicted a chlorophyll *a* concentration of around 3 µg/L, which is in the mesotrophic range. The "chlorophyll *a* = 2" scenario predicted a chlorophyll *a* concentration of 2 µg/L, which is at the oligotrophic-mesotrophic border.

The model under-predicted lake transparency under both the "Existing High" and "Existing Low" scenarios. This may be due to the fact that Blue Mountain Lake has clear water (low color and particulate

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[2] Dillon, P.J., W. A. Scheider, R. A. Reid, and D.S. Jeffries. 1994. *Lakeshore capacity study: Part I — Test of effects of shoreline development on the trophic status of lakes.* Lake and Reserv. Manage. 8(2): 121-129 and P. Dillon, pers. comm. IN Martin et. al. 1998. The State of Upper Saranac Lake, section 9.3.3

[3] Carlson, R.E. 1977. *A trophic state index for lakes.* Limnology and Oceanography. 22(2): 361-369

matter) compared to many lakes, including perhaps the data set used to develop the empirical predictive formulae used by the model. The 1997 and 1998 average transparency (both stations together) in Blue Mountain Lake was 8.6 m and 6.6 m, respectively. The model predicted transparency of around 6 meters under both "Existing" scenarios. The "Maximum Development" scenario predicted a transparency of around 4 meters, which is in the mesotrophic range. The "chlorophyll *a* = 2" scenario predicted a transparency of around 5.2 meters.

Table 15
Summary of EutroMod Results for Blue Mountain Lake

Model Run	Water Quality Parameters		
	Total Phosphorus (mg/L)	Chlorophyll *a* (µg/L)	Transparency (m)
Actual 1997	0.009	1.65	8.8
Actual 1998	0.009	1.70	6.4 (east basin)
Existing Low	0.008	1.61	5.9
Existing High	0.009	1.69	5.8
Max. Development	0.013	2.97	3.9
Chl. *a* = 2 µg/L	0.010	2.00	5.2
Model Run	**General Land Use (acres)**		
	Forest	Rural Residential	Lakeside Residential
Existing Low	5,101	109	249
Existing High	5,101	109	249
Max. Development	1,403	2,695	1,361
Chl. *a* = 2 µg/L	3,077	1,590	637
Model Run	**Level of Development (total homes is sum of year round & seasonal)**		
	Total Capita-years (additional)	Total Year round Homes (additional)	Total Seasonal homes (additional)
Existing Low	255	45	85
Existing High	278	45	85
Max. Development	667 (389)	121	227
Chl. *a* = 2 µg/L	382 (104)	65 (20)	123 (38)

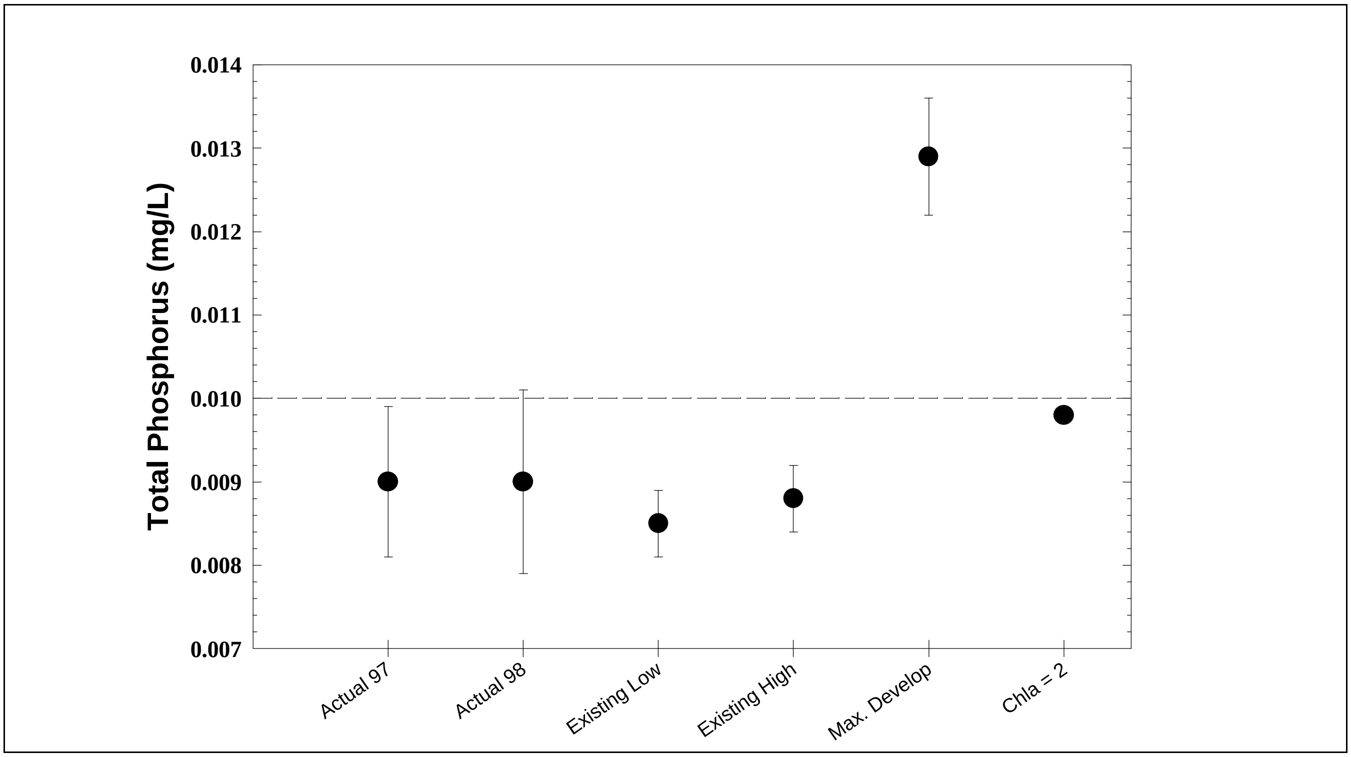

Figure 6 Prediction of total phosphorus concentrations in Blue Mountain Lake under various development scenarios. Dashed line indicates oligotrophic-mesotrophic boundary.

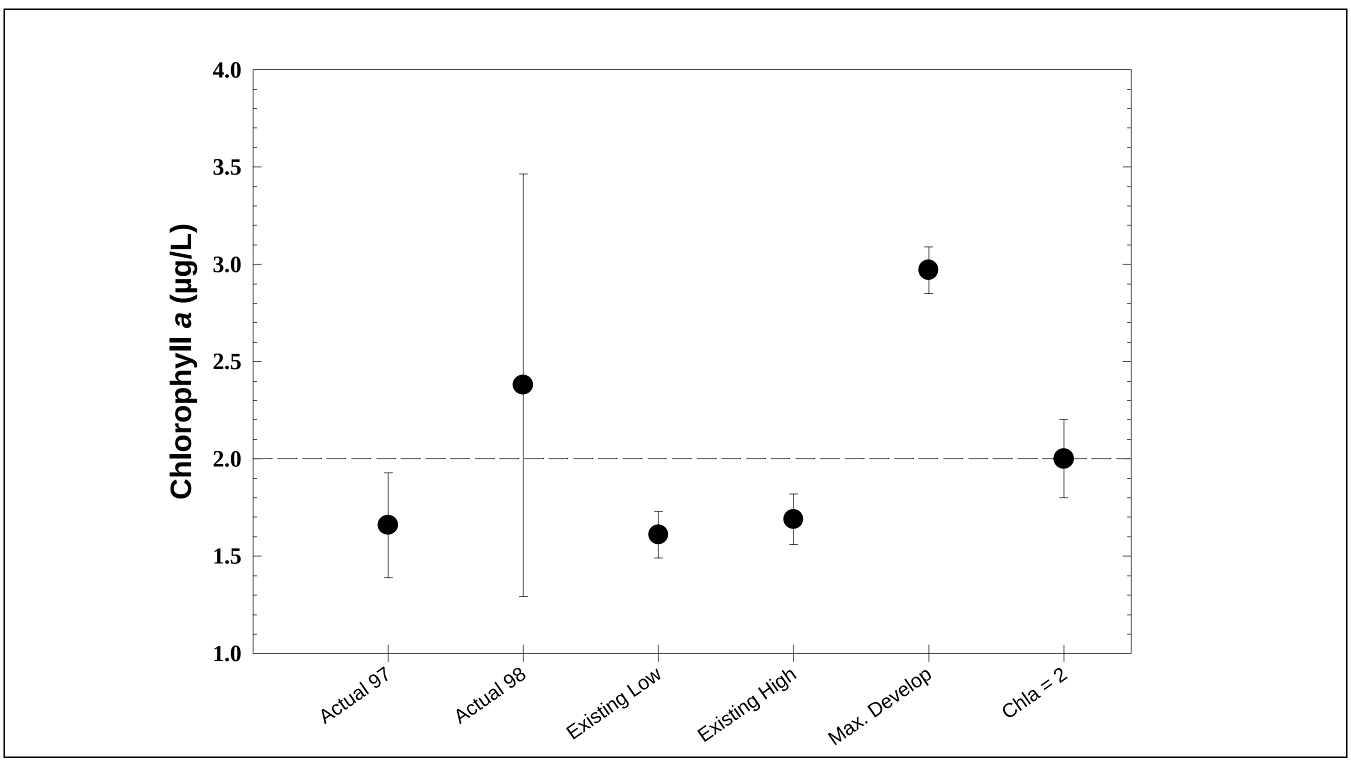

Figure 7 Prediction of chlorophyll *a* concentrations in Blue Mountain Lake under various development scenarios. Dashed line indicates oligotrophic-mesotrophic boundary.

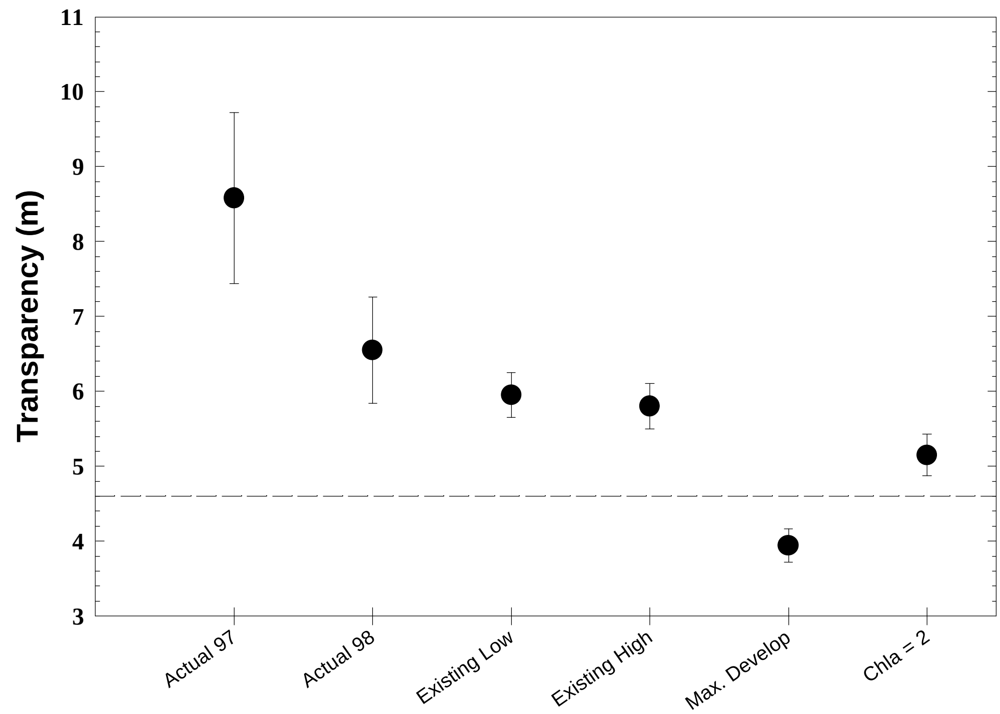

Figure 8 Prediction of transparency in Blue Mountain Lake under various development scenarios. Dashed line indicates oligotrophic-mesotrophic boundary.

6.0 Conclusions

Blue Mountain Lake is an oligotrophic lake with relatively low concentrations of total phosphorus and chlorophyll *a* and relatively high transparency. Water quality has changed significantly over the past century due primarily to human activities. Monitoring data shows that the lake has experienced significant changes in water quality particularly since 1993. Some of those changes may be associated with the blowdown and storm events of 1994. However, the long-term trend has been decreasing water quality since at least the late 1970s. These changes include an increase in total phosphorus and chlorophyll *a* concentrations and a decrease in lake transparency. Total phosphorus concentrations have increased from around 3 ppb in 1978 to between 8 and 9 ppb in 1998. Chlorophyll *a* concentrations have increased from around 1.5 ppb in 1994 to around 1.8 ppb in 1997, with an average of 3 ppb in the east basin during 1998. Transparency has decreased from around 10 meters in 1993 to around 6.5 meters in 1998.

The lake has become more acidic during the period of record. Levels of pH have decreased from around 7.3 units in 1933 to around 6.5 units in 1998. Alkalinity has decreased from 9 ppm to around 4 ppm during the same period. It is possible that the increasing acidity of the lake was responsible for improving transparency and chlorophyll *a* up until the early 1990s, when nutrient enrichment of the lake had occurred to a degree sufficient to negatively impact transparency and chlorophyll *a*.

The lake experiences a moderate loss of dissolved oxygen in the bottom waters during the summer months. This appears to be somewhat more apparent in the east basin of the lake, perhaps due to increased nutrient loading to the east basin from the hamlet and surrounding developed land or differences in basin morphology.

Museum Brook was the most impacted of the four monitored tributaries, while Minnow Brook East was the least impacted. Phosphorus sources to Museum Brook include a number of camps built close to the stream in areas of poor soil and bedrock and the direct stream discharge of wastewater by the Museum.

Existing wastewater systems, which include individual septic systems and the Museum wastewater facility, are apparently having a significant impact on the water quality of the streams and lake. Within the streams, we observed a degradation of water quality as each summer progresses, which correlates to the seasonal loading of the systems due to summer occupancy. Within the lake, we observed the aforementioned decline in water quality during the past 6 years. This is also evident in the lake from the sediment core work, which shows a trend of declining water quality over the past 100 years, particularly since the 1940s.

Water quality modeling showed that maximum development of the watershed, even with a mix of seasonal and year-round homes, would cause unacceptable changes in lake water quality. Modeling for a decrease in water quality to a chlorophyll *a* concentration of 2 ppb predicts total allowable new development consisting of 38 seasonal and 20 year-round homes. Given the present trend in water quality, however, it is likely that Blue Mountain Lake will reach that threshold even with the present level of development.

Existing development within the watershed needs to be examined critically and considerable effort needs to be directed towards upgrading all old and non-conforming septic systems. In addition, an alternative to stream discharge by the Museum should be investigated. Since the operation is seasonal, spray irrigation is a possible alternative that should be investigated.