Forecasting Algal blooms in Surface Water Systems with Artificial Neural Networks

FINAL REPORT

Prepared and submitted by:

NOAH L.L.C.

610 Lawrence Road

Lawrenceville, NJ 08684

With participation of:

NEW JERSEY AMERICAN WATER COMPANY & PASSAIC VALLEY WATER COMPANY

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DEDICATION

To Dr. Geetha Angara, consummate scientist and water professional, who helped ensure a safe and reliable water supply for hundreds of thousands of people. Her enthusiasm, dedication, and expertise will be deeply missed by all who worked with her. This report is dedicated to her life and memory, as Dr. Angara represents the highest standard of excellence for the water industry.

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EXECUTIVE SUMMARY

This research projected, entitled "Forecasting Algal blooms in Surface Water Systems with Artificial Neural Networks," was funded by the New Jersey Department of Environmental Protection. The original objectives of this study were: 1) to assess the feasibility of using artificial neural networks (ANNs) as a real-time tool for accurately forecasting cyanobacteria counts, more commonly knows as blue-green algae, in surface water systems; 2) through sensitivity analyses conducted with the ANNs, identify critical climate, hydrologic, and water quality factors (i.e. variables) that may influence algae levels; 3) assess the feasibility of using ANNs with formal optimization for optimizing water treatment processes for reducing algae levels; 4) assess and provide guidance for improving data collection/organization for the purpose of improving algae level forecasting capability with the ANN technology. With regard to item 1 above, as discussed in more detail later, algal forecasting was expanded to include two additional classes; chorophytes and chrysophytes.

Blue-green algal blooms are becoming an increasingly serious water quality concern around the world as they pose threats to both environmental quality and human health. In addition to causing taste and odor problems, on a more serious level, cyanobacteria blooms constitute a potentially serious human health risk. Adverse health effects due to human exposure to water with high counts of cyanobacteria are varied, and include skin rashes from dermal contact and gastrointestinal illnesses from ingestion. At least one human fatality is reported to have occurred, for a person undergoing kidney dialysis treatment. Wildlife such as waterfowl and household pets like dogs can also be adversely affected by these blooms. Algal blooms are expensive to treat, and can translate into thousands of dollars per day for a water utility. In extreme cases, as reported by Maier et al. (1998), they can cause "considerable economic and social hardship with the restriction of the use of water for domestic, agricultural, and recreational purposes and increased treatment costs."

This research was motivated by the premise that development and implementation of an accurate real-time forecasting tool could provide utilities with a means to respond to potential algal blooms proactively, rather than reactively. A proactive capability, if not actually minimizing the risk of bloom occurrence, could at least minimize the consequences, possibly reducing treatment costs while providing higher quality potable water. In this project, artificial neural network (ANN) technology, a form of artificial intelligence, was investigated as a possible forecasting tool. The ANN technology offers the advantage of "learning" system behavior from historical data, and hence are not necessarily constrained by simplifying model assumptions inherent to mechanistic or physical-based models and statistical models. However, in order to effectively learn to generalize system behavior, ANNs also require sufficient training data that covers the expected range of conditions, as well as inclusion of important predictor (i.e. causal and/or correlative) variables. The highly complex nature of the algal surface water systems, which are reported as exhibiting non-linear behavior (Recknagel and others, 1997), increases the need for historical data sets of sufficient quality and quantity. One of the critical issues of this study, then, was a rudimentary assessment of the existing data, and analysis as to what sampling strategies might improve forecasting capability.

At the beginning of this project, New Jersey American Water was the sole participating utility, with the Swimming River facility serving as the test case. A preliminary research phase completed in August of 2004 used water quality and physical data collected by the utility, supplemented by weather data, to assess the feasibility of using artificial neural networks for predicting and enhancing understanding of algal blooms. Although the data sets were rather limited, particularly with regard to water quality parameters, the ANN technology demonstrated promise, and they outperformed linear models that were used for comparison. Still because of the limited data set, Passaic Valley Water Commission (PVWC) was invited to participate in the study to facilitate a more comprehensive study. Like American Water, PVWC routinely samples for a variety of parameters on their surface water supply system, including algae counts. The fact that their system consists of multiple water sources, while complicating the modeling exercise, also provided a means

for better understanding possible important predictor factors that may also be correlated with watershed conditions. As with Swimming River, data collected by the utility was supplemented by weather data from neighboring climate stations.

Consequently, in this comprehensive study, NOAH developed, tested, and assessed several hundred ANN models of a variety of types to forecast cyanobacteria counts at both Swimming River and PVWC. Many different models were developed, characterized by the input variables used, the forecasting horizons, the output variables, and for PVWC, the sampling locations. In addition, for PVWC, two additional algae groups were also modeled; chrysophyta (gold algae) and chlorophyta (green algae). These additional algae classes were added to the study as they exhibited more temporal fluctuation in counts than cyanobateria, and also present water quality and treatment concerns. Later, ANN models that classify algal counts within ranges or bins were also developed and tested for the PVWC facility. Finally, ANNs for predicting finished water quality were also developed using water quality and treatment data for the since renovated water treatment plant at Swimming River.

Based upon the modeling results for Swimming River, it was concluded by both NJDEP and NOAH that the ANN models were "over-fitting" the data. This is attributed to the relatively limited quantity of historical algae data available for this facility. Although there was a relatively large set of physical data for this facility (222 events), there were only 48 events that included water quality parameters that often serve as "limiting nutrients", including phosphorous and nitrate. This quality of this limited data set was further diminished by the fact that three station locations were modeled collectively rather than individually, due to the scarcity of the data. In addition, the modeling results tentatively indicate that for this facility, the limiting nutrients are important for accurately forecasting algal counts.

Another challenge in modeling this type of the system is the inherent impreciseness of the measured data values, and the uncertainty of how representative they are of system

conditions. Physical, chemical and biological variables in surface water systems often exhibit high spatial variability (i.e. heterogeneity) over relatively short horizontal and/or vertical distances. Further adding unquantifiable noise to the biological data are the analytical techniques used for measuring algae counts. As reported by PVWC: "Phytoplankton analytical methods are time consuming and subjective relying on observation and identification skills, which can vary by analyst. Existing sampling techniques are time consuming and subjective. Collecting a representative sample of a complex watershed is challenging at best. A one-liter sample is collected at some frequency typically once or twice per week, possibly at different depths along the water column and this is meant to represent the quality of the river." Previous literature cites that "precision of the cell count data can be ±20 percent or more" (Maier and others, 1998).

Modeling approaches for PVWC evolved to address important modeling issues that emerged during this project, including relatively limited number of historical data events, following submission of the first draft report to DEP for review. They included: 1) natural time lags in algal population dynamics, or temporal correspondence between system conditions/inputs and final measured algal counts; 2) importance of larger training data sets on model performance; 3) importance of select water quality variables on model performance; 4) the effect of so-called "correlative" water extraction input variables on model performance, and 5) feasibility of developing radial basis function nets for predicting the bin or classification range in which the final algal count falls, rather than a single numerical value estimate. The different approaches increased understanding of the surface water system and algal population dynamics, as well as enhanced awareness of data collection and design and development issues for the ANN forecasting models.

With regard to issue one above, the first or ***original*** ANN input structure or input approach consisted of model input values measured primarily at the beginning of the prediction period. The second or ***revised*** ANN input structure used model input values measured primarily at the end of the prediction period, coinciding with the final or

predicted algal count. For PVWC, the number of historical ***training*** events available for each forecasting problem ranged between 19 and 136, and averaged 65, far less than the minimum required number of 200, computed on the basis of the average number of input (i.e. 32) and output (i.e. 1) variables. To address the second data quantity versus quality issue, both the original and revised modeling approaches were assessed with two distinct data sets. The first set consisted of the smaller number of historical events, which included a higher number of input variables. The second set consisted of a larger number of historical events, and, by excluding five select water quality variables for two stations, and four for the third station, fewer model inputs. The five water quality variables, which included some of the so-called limiting nutrients, are: Biological Oxygen Demand (BOD), Total Phosphorous/Orthophosphate, Nitrite/Nitrate, Sulfate, and Total Organic Carbon (TOC), with BOD included for the third station (measured at higher frequency).

In general, both types of ANN models performed well during validation, and in many cases, accurately predicted large changes in algal populations. The level of accuracy was surprising, given the complexity of algal populations, their non-linear behavior, the expected noise in the data, and the relatively small number of historical events available for training. On the basis of validation correlation coefficients, the models that used input values measured at the beginning of the prediction period slightly outperformed those that used input values measured at the conclusion of the prediction period, with average values of 0.72 and 0.69, respectively. A more subjective visual comparison of the time-series for the validation figures appears to confirm that the original models did achieve higher performance. The models that excluded the select water quality variables for the benefit of more training events achieved a higher average validation correlation coefficient of 0.77, versus the 0.63 average value for models that included these variables. However, there was at least one case where the models that included the five select water quality variables achieved significantly higher validation performance.

That the ANN models developed with inputs measured at the beginning of the one-week and two-week ahead prediction periods accurately predicted formation and dissipation of

algal bloom events, as well as relative increase and decreases, may indicate that there are natural time lags between system conditions and algal population responses. Thus, algal populations may on average evolve predictably in response to system conditions, and the trajectory of the population over one and two-week forecast periods can be accurately forecasted on the basis of real-time measurements. This may also reflect that open water conditions do not typically change significantly in the short-term (e.g. weekly or even bi-weekly), and thus evolving algal populations are by nature predictable, and not prone to diverge significantly from trajectory paths. For example, because of the high specific capacity of water, significant temperature changes will not typically occur over one or even two-week prediction periods. Exceptions may occur with a particularly extreme weather event, such as a cold front or heavy precipitation event, which may also induce large water quality changes, but this will be atypical. Additional research is necessary to test the validity of these claims. Furthermore, the validity of any general rules concerning algal population dynamics will likely vary somewhat from system to system, or even over time as watershed characteristics change. However, one would expect certain fundamental behavior to remain fairly consistent.

That the ANN models that excluded the water quality variables on average slightly outperformed models that included them may signify less about the influence of these variables on algal population dynamics, and more about the inadequate number of training events. At the same time, it does indicate that during most time periods in the PVWC system, these variables may not be important predictors of algal populations, suggesting that they usually exist within a range of values that neither dissipate nor propagate algal blooms. This is weakly supported by the Swimming River results, where significantly better results were achieved when water quality variables were included, even though this meant a five-fold reduction in the number of data events.

It should be recognized that for some time periods, inclusion of some or all of these variables may be important. There was at least one case where inclusion of these variables significantly improved validation performance. A comparison of time-series

between nitrite/nitrate concentrations and algal counts suggest at least a correlative if not causal relationship, where extreme blooms events occurred during periods of high concentrations. Thus, with an adequate number of data events for training, inclusion of the select water quality variables could improve overall performance, and may increase the likelihood of forecasting the formation and dissipation of bloom conditions during unusual conditions.

A modeling concern that arose towards the end of the project was the effect of so-called "correlative" variables, namely volumetric extractions from water sources, on ANN forecasting performance. It was speculated that these variables may be more correlative than causative in nature, as they often reflect operational decisions instituted by PVWC in response to measured algal counts (e.g. discontinue extractions from a river during a bloom event). If indeed more correlative, it would not be appropriate to input correlative variables into models that are designed to capture the underlying mechanistic processes that govern algal population dynamics. To investigate this, volumetric extraction variables from various water sources were eliminated as input variables for select models. It was found that the ANNs still performed relatively well, particularly for the two river sampling stations where mixing of various source waters does not occur.

Finally, a different ANN forecasting paradigm was developed and tested for PVWC. Radial basis function (RBF) nets were developed to predict the pre-selected bin (i.e. (data range group or classification) within which the final measured algal count fell. Given the combination of inherent data noise and forecast uncertainty, this approach may be more appropriate when the goal is to classify water quality within ranges of conditions with relatively high probability for success. In consultation with NJDEP and PVWC, four different bins or classifications were selected for eight different modeling exercises. The ANNs, despite the limited number of historical events available for model development, performed extremely well, even for cases where significant variations in measured counts were present. For three of the eight cases, perfect classification was

achieved, with the poorest performing RBF model classifying 83 percent of the final counts into their correct bin.

The LMs, developed as an objective benchmark for comparison, did not perform as well, on average achieving significantly lower correlation coefficients and higher mean absolute errors, and in some cases, failed to predict very high count algal blooms while erroneously predicting other blooms during low count periods. It should be mentioned that the statistical distribution of input variables were not computed in this study, and consequently, data transformations performed (e.g. log normal). Had statistical transformations been made, it is possible that the LMs would have performed better. However, this also underscores one of the inherent advantages of ANNs; because of their universal non-linear modeling capability, they are not limited by the form of the data distribution(s).

To facilitate an understanding of the system and help assess model performance, three general types of sensitivity analyses were conducted. For the first analysis, the ANN models confirmed physical intuition that the three stations generally represent distinct water quality systems. This was determined on the basis of the higher model performance achieved when modeling each station individually, rather than collectively, although the later approach generated significantly larger data sets.

For the second analysis, a general ranking methodology identified the most important model predictor variables on the basis of the relative changes in root mean squared errors when the variables are excluded as inputs. Although this type of sensitivity analysis is suspect when data events are relatively spare, some consistent trends did emerge. Variables that ranked highly included reservoir and river extractions, which were presumed to be correlative rather than causal variables. Another finding was that the select “limiting nutrients” excluded from some models did not generally rank highly. In contrast, some weather/meteorological conditions like length of day did consistently rank high, with the exception for the models that excluded water extraction variables.

For the third sensitivity analysis already discussed above, exclusion of select variables was performed. First, the importance of the less frequently measured water quality variables was assessed by excluding them from various models. Statistically, there is an increase in predictive performance when these variables are excluded. Again, this may have more to do with the relative lack of historical events, than any physical relationship or lack thereof between these water quality parameters and algal populations. Still, on the basis of the other sensitivity analysis, where these variables did not generally rank highly, that during most time periods, they exist within a range of conditions that neither diminish nor propagate algal populations. Second, exclusion of the water extraction variables, as previously mentioned, was assessed for various models, and results indicate that the ANN models are not overly biased by possible correlations between utility operational decisions and algal counts.

This work provides a foundation for future modeling work as more data become available. Systematic elimination of input variables combined with additional sensitivity analyses may improve system understanding, and facilitate convergence to optimal sets of model input variables. Not only would increased ANN forecasting accuracy be achieved, but data collection strategies could be improved, which may even reduce sampling costs and efforts for the utility. Following ANN model refinement, implementation of various forecasting models in real-time would provide a more rigorous assessment of forecasting capability, as well as a comparative analysis of their performance, strengths, and limitations, which may further improve modeling methodology and forecasting capability.

For the water treatment modeling component of this project, significantly more data was available for model development, assessment, and refinement. The ANN models overall performed well in predicting finished water quality conditions, and even confirmed a non-intuitive relationship between raw water quality and temperature. However, consultation with utility personnel is necessary to assess whether the ANN models, as developed, are sufficiently robust for optimizing water treatment processes. At a

minimum, this modeling effort demonstrates how ANNs could possibly be used for water treatment optimization, and also affords the opportunity for future improvements and enhancements in accordance with utility guidance.

Because of the large number of models that were developed and assessed (several hundred), this document overviews the important general findings of this project and discusses representative results and important conclusions. To augment future efforts, and provided interested readers with additional information, an extensive collection of summary tables and figures for other ANN models are provided in the appendices. The presentation of algae modeling, results, and analysis for both Swimming River and the documentation and discussion of the original PVWC modeling efforts also appear in the appendices. Finally, the modeling data used in this study is also available in digital format.

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1. INTRODUCTION

This document constitutes the final report for the algae study, entitled "Forecasting Algal blooms in Surface Water Systems with Artificial Neural Networks," funded by the New Jersey Department of Environmental Protection, with participating utilities New Jersey American Water Company and the Passaic Valley Water Commission. The objectives of this study were: 1) to assess the feasibility of using artificial neural networks (ANNs) as a real-time tool for accurately forecasting cyanobacteria counts, more commonly knows as blue-green algae, in surface water systems; 2) through sensitivity analyses conducted with the ANNs, identify critical climate, hydrologic, and water quality factors (i.e. variables) that may influence algae levels; 3) assess the feasibility of using ANNs with formal optimization for optimizing water treatment processes for reducing algae levels; 4) assess and provide guidance for improving data collection/organization for the purpose of improving algae level forecasting capability with the ANN technology. With regard to item 1 above, as discussed later in this report, the algal forecasting was expanded to include two additional classes; chorophytes and chrysophytes.

For the initial phase of this project, the Swimming River reservoir system, owned and operated by New Jersey American Water, was used as a test case for assessing the feasibility of using ANNs for forecasting algae levels of cyanobacteria based upon weather/meteorological, hydrological, biological, and water quality conditions. Despite a relatively limited data set, particularly with regard to water quality data, the ANNs demonstrated potential as a useful algae level forecasting tool. The ANNs not only outperformed linear models, but surprisingly, when limited water quality data were included, accurately reproduced variable algae levels. A concern, however, was the relatively limited data events (48) that included water quality data, which is supported by relatively low validation accuracy. Given the relatively high number of input variables, and the possible range of conditions, it was concluded that additional data would be necessary to develop robust ANN forecasting models for the reservoir. However, as discussed in the initial report (August 4, 2004), additional follow-up modeling was still to

be conducted with this data set to further assess ANN model capability, and help identify potentially important predictor variables for possible future model refinement and implementation. Following review of the algal modeling results by both NOAH and DEP personnel, it was determined that the ANNs were likely "over-fitting" the state-transition equations to the limited data. Consequently, the detailed description and findings of this algal modeling work for this facility appears in Appendix A-1, and can be obtained from the NJDEP in disk form upon request.

The Swimming River facility also provided NOAH with a rather extensive water treatment data set, consisting of daily measurement values for a variety of parameters, spanning approximately 2.5 years, from July 2001 to December 2003. This data set, consisting of raw water quality conditions, chemical dosages, and final water quality conditions, was used for assessing the feasibility of using ANNs for optimizing treatment processes. Thus, in accordance with study objective 3 stated above, the feasibility of using ANNs for accurately predicting finished water quality following treatment was investigated, so that their potential for reducing treatment costs via optimization while achieving water quality standards could be assessed.

Finally, to facilitate algae study objectives, the Passaic Valley Water Commission (PVWC) was invited to serve as a second test case. This utility's participation provided at least two additional benefits. First, unlike Swimming River, where relatively few sampling events precluded individual modeling of sampling locations, a larger set of historical events at the PVWC utility permitted individual modeling of sampling stations. This site specific modeling issue may not be as relevant for Swimming River, as the three sampling locations in the reservoir essentially represent the same watershed/water sources, with perhaps some variability due to wind and hydraulic dynamics. At the PVWC utility, however, two sampling stations are located on two different rivers, each part of a different watershed with distinct water quality conditions. In addition, occasional diversions from a storage reservoir can induce unique water quality changes at

the third sampling location, which is usually a combination of the two river sources. Second, the PVWC routinely samples for a higher number of water quality indicators.

For the PVWC test case, in addition to cyanobacteria, ANN modeling efforts were extended to two other algae phyla/divisions: chrysophyta and chlorophyta. Discussions with Ms. Linda Pasquarello of PVWC determined that it would be helpful if the utility could also forecast levels for these two algae phyla/divisions. Although not posing the potential health problems as cyanobacteria, their elevated presence can create undesirable taste and odor problems for consumers, as well as clog water treatment filters. The capability to forecast possible high levels of these organisms, then, would allow the utility to implement proactive measures to minimize potential negative effects. In addition, over the period of records for the PVWC, these species exhibited greater temporal variability in counts than cyanobacteria, and provided an additional test for ANN forecasting capability.

Consequently, in this final study, NOAH developed, tested, and assessed a variety of ANN models to forecast cyanobacteria counts at both Swimming River and PVWC. Many different models were developed, each differing by the input variables used, the forecasting horizons, and, for PVWC, the sampling locations. In addition, for PVWC, two additional algae groups were also modeled; chrysophyta (gold algae) and chlorophyta (green algae). These additional algae classes were added to the study as they exhibited more temporal fluctuation in counts than cyanobateria, and also present water quality and treatment concerns. ANN models that classify algal counts within ranges or bins were also developed and tested for the PVWC facility. Finally, ANNs for predicting finished water quality were also developed using water quality and treatment data for the since renovated water treatment plant at Swimming River.

Modeling approaches for PVWC evolved to address important modeling issues that emerged during this project, following submission of the first draft report to DEP for review. They included: 1) natural time lags in algal population dynamics, or temporal

correspondence between system conditions/inputs and final measured algal counts; 2) importance of larger training data sets on model performance; 3) importance of select water quality variables on model performance; 4) the effect of so-called "correlative" water extraction input variables on model performance, and 5) feasibility of developing radial basis function nets for classifying algal counts into bins or ranges, rather than a single numerical value estimate. The different approaches increased understanding of the surface water system and algal population dynamics, as well as enhanced awareness of data collection and design and development issues for the ANN forecasting models.

Two different ANN model paradigms were used in this project; prediction of a single numerical algal count value using traditional multilayered perceptron nets, and classification of algal counts into bins or ranges using radial basis function (RBF) nets. The single value predictions used two general input variable structures or approaches. The first or original approach consisted of model input values measured primarily at the beginning of the prediction period. The second or revised approach consisted of model input values measured primarily at the end of the prediction period. Modeling performance was further assessed using two distinct data sets; a larger data set (i.e. more historical events) generated by eliminating select water quality variables that were less frequently measured, and a data set that included these water quality variables, resulting in fewer historical events, and more input variables. In addition, the influence of so-called correlative water extraction variables was assessed by including and then excluding for select forecasting problems. Sensitivity analyses were also conducted to try and help identify important predictor variables and increase system understanding. The study permitted a systematic analysis of available modeling and data collection options for performing real-time forecasting, particularly with limited data sets, with a general discussion of their comparative advantages and disadvantages, as well as their feasibility under real-time conditions. In addition, the multitude of approaches permitted a more general evaluation of ANN capability, as well as helping to cross-verify results and interpretations.

Despite relatively few historical events available for ANN training and validation, ANN models in general demonstrate the potential for accurately forecasting algal population counts. Different model types generally performed well during validation, accurately reproducing higher and lower algal count periods during validation, and even accurately predicting the incidence and magnitude of a number of blooms during validation, including dissipation. The original model input approach performed slightly better than the revised input approach, and larger training sets that excluded the less frequently measured water quality variables generally improved overall performance for the ANN models that explicitly predict single algal counts. The opposite result occurred for the few classification models developed and assessed, though larger data sets (i.e. eliminating five water quality variables) produced more events that border on two bins; still, they demonstrate strong potential for accurately differentiating between low count periods and algal bloom events.

ANN models because of the ease at which they can be implemented in real-time have the potential to serve as a powerful proactive management tool for utilities seeking to minimize the problems posed by algal blooms. By accurately forecast the occurrence of problematic algal blooms, they can provide utilities with sufficient lead time to implement cost-effective mitigative measures. These forecasting models also provide value added to expensive data collection systems, and may even be used to optimize sampling strategies, potentially reducing costs. As more data becomes available, the ANN models can relatively easily be retrained in real-time to increase forecasting capability.

The entire report, including appendices, presents the following ANN modeling work, with select linear models included for comparison; 1) additional cyanobacteria forecast modeling for the Swimming River facility; 2) modeling of finished water quality conditions at the Swimming River facility due to treatment processes; 3) individual forecast modeling of cyanobacteria, chrysophyta, and chlorophyta counts at the PVWC facility. In addition to presenting and assessing modeling predictive results, sensitivity

analyses are also presented, and are analyzed within the context of the physical system being modeled.

Because of the large number of models that were developed and assessed during this research, most of the results are presented in the appendices, including some detailed analysis. Appendix A-1 includes a description of the ANN and LM modeling approaches, results, and analyses pertaining to algae prediction for Swimming River. Appendices B-1 through B-6 generally present additional ANN and LM modeling results in tabular and figure form, with some text describe modeling efforts and results not presented in this main report document. Appendices C-1 through C-3 present additional water treatment modeling results and analyses for the Swimming River facility not presented in this report (e.g. seasonal models). Please note that the appendices as well as all data used in this project are available in electronic format upon request from NJDEP.

Lastly, because of water security issues, detailed facility site maps were not be provided in this report. The schematics and text use arbitrary naming conventions for the rivers and the reservoir to protect the identity of the water source and intake point locations.

2. ALGAL BLOOM MODELING PROBLEM

Although there is consensus among scientists that the incidence of algal blooms world-wide is increasing (Smith et al, 2006), and the detrimental effects of these blooms on the environment and water supplies are well documented, controversy remains over the important factors and mechanisms responsible for their occurrence, and the most effective means for both modeling and forecasting this phenomena.

Researchers have identified fundamental "nutrient" variables, primarily nitrogen and phosphorous, as "limiting" to the growth of algae. Because nitrogen and phosphorous are often strongly correlated with the quantity of algal biomass in water systems, researchers frequently develop models that predict algal biomass as a function of one or more of these compounds. Limiting the models to such highly reduced input-output relationships, while efficient and sometimes effective, not only ignores the complexity of processes that determine nutrient levels, but also overlooks the myriad of other factors that can influence algal biomass. For example, nitrogen may originate from a number of different sources, and its chemical form and concentration is dictated by different nitrogen processes, such as nitrification, which depends upon the presence of certain bacterial organisms. In some water systems, nutrients that might otherwise be considered limiting on the resident algal populations appear to persist within a range of concentrations that does not significantly affect the organisms.

Further complicating the dynamics of algal populations are the variety of physical and biological factors that influence the formation and dissipation of algal blooms. Sunlight is essential for the development of these photosynthetic organisms, and the amount of light that penetrates the water column is controlled by a number of factors, each of which may have multiple effects upon the system. For example, precipitation not only reflects a lower sunlight factor, but also influences the amount of turbidity in the water column via sediment transfer from rainfall run-off. The degree of run-off depends not only upon the quantity of precipitation, but also the size and characteristics of the watershed.

Precipitation also increases surface water flow velocities which can stir up and suspend sediments from the bottom and scour sediments from the banks. Other factors that influence algal levels, like dissolved oxygen are similarly affected by other conditions of the system, such as water temperature, wind speed and direction, and the presence of other competing or even predatory organisms.

Given the multitude, interplay, and complexity of various weather, water quality, biological, and hydrologic factors, many of which will vary over space and/or time, some researchers argue that there are no fast and true "rules" for predicting algal biomass and blooms. As with many complex natural phenomena, developing a robust model that adequately represents the site-specific conditions and dynamics of the system, specifically for the purpose of providing accurate prediction capability, can be a daunting challenge. It is undoubtedly true that some algal biomass models, while appropriate for some systems, will be inappropriate and/or infeasible for others, dictated largely by the degree to which the fundamental assumptions and characteristics of the model conform to the essential elements of the real-world system, as well as the quality and quantity of the data. Some researchers argue that reliance upon numerical models for predicting algal biomass is insufficient, given our inadequate "'level of understanding of how these complicated ecological systems work'" (Pelley, 2005).

The challenge then, is not only to increase our understanding of the complex dynamics that govern algal populations, but to develop different sampling protocols and models that can be adapted to our scientific understanding for improving real-time forecasting capability. This goal is becoming more important as algal biomasses around the world become more prevalent, contaminating water supplies, often in areas where acceptable alternative supplies to not exist. Thus, this research not only attempts to provide insights into algal populations in the surface water system considered here, which can perhaps be extrapolated to other similar systems, but to also provide an alternative paradigm for researchers and decision-makers seeking to model and forecast these organisms.

3. RELATED ANN RESEARCH

There is previous work in the scientific literature where ANNs were developed and tested for predicting algal blooms, as reported in two journal articles, both published in the Journal of Ecological Modeling. Both papers have researchers associated with the University of Adelaide in Australia, with the first published in 1997 and the second in 1998.

The first paper, "Artificial neural network approach for modeling and prediction of algal blooms" (Rechnagel and others, 1997) applies the technology to four different freshwater systems. The paper first introduces the complexity and non-linearity of algal bloom dynamics and the severe impacts associated with them, such as water discolorations and human exposure to toxins.

The researchers used at least six and up to ten years of what appear to be weekly data consisting of limiting nutrients, water temperature, light conditions, and, in one case, density data of zooplankton groups to train the ANN models to predict phytoplankton organisms. Two years of data not used for training were then used to validate or test each model. Typical ANN input variables included silica, total nitrogen, turbidity, color, water temperature, conductivity, pH, ortho-phosphate, nitrate, photosynthetic active radiation, wind speed, secchi depth, and oxygen. For one lake system, some of the grazing organisms, namely Rotifera, Cladocera, and Copepoda, were also used as inputs. For the sole river system, flow rate was considered an important predictor variable, and was included in the model. The output variable for a single ANN consisted of all the different algal organisms measured in the water body. As the authors state, the variables used represent those that were measured consistently over time.

In general, the ANNs were able to predict the timing and magnitude of different blooms, although there were some validation years where the ANNs did not perform particularly well. The ANNs were also used to conduct sensitivity analyses to assess the relative

importance of different predictor variables. The authors conclude that the results "provide a means of defining the primary components driving they dynamics of algae species."

In the second paper, "Use of artificial neural networks for modeling cyanobacteria *Anabaena spp*. in the River Murray, South Australia" (Maier and others, 1998), seven years of weekly data, consisting of eight input variables, was used to provide forecast algae counts four weeks into the future. This river is the same used in the study presented in the first paper, and the predictor variables consisted of color, turbidity, temperature, flow, soluble phosphorous, total phosphorous, oxidized nitrogen, and total iron. The four nutrient variables were collected on a monthly basis, but linear interpolation was used to estimate weekly values. With the exception of flow, which was measured on a daily basis, the remaining variables were measured on a weekly basis.

One issue explored in this research was the importance of using lagged inputs. The researchers concluded that models that did not use lagged inputs were "relatively unsuccessful", particularly with regard to flow. Inclusion of this variable allowed the ANN models to forecast the onset and duration of algal blooms. Different combinations of input variables were used, including models with just a single input. It was found that the most important variables were flow, temperature, and color for predicting blooms. Other variables, namely nutrients, iron, and turbidity, were not important for predicting blooms. The authors concluded that adequate nutrients were available for algal growth, and hence were not limiting factors for the river system studied.

One of the most relevant findings within the context of the NJDEP sponsored study is that the ANN models were unable to predict one particular algal bloom event. The authors attribute this bloom to an unusual hydrodynamic event, where a large flood transported algae populations from shallow lagoons connected to the River. Thus, because many of the algae did not originate on the river system, this was not a true "bloom" event, but rather a mixing of two different populations. Consequently, not only

was this event outside the physical bounds of the "closed" system, there were insufficient representations of this anomaly for the ANN models to effectively learn this extreme condition, which underscores the need for data that represents the expected range of system behavior.

With respect to water treatment, numerous sources in the literature document successful ANN applications. In the work of Skipworth and others (1999), ANN technology was demonstrated to accurately predict oxidation-reduction potential under different patterns of demand and using different sources at multiple locations within a water distribution system. Yu and others (1999) accurately predicted proper coagulant dosing for a water treatment plant, significantly outperforming a regression model. Mirsepassi and others (1995) used ANNs to accurately determine alum and polymer dosages, achieving correlation coefficients for both parameters of 0.97 (between measured and predicted values) for a water treatment plant in Australia.

Baxter and others (2001) present the application of ANN technology for optimizing several treatment processes in a large water treatment plant. The first application presented is for optimizing color removal through coagulation. The ANN achieved a mean absolute error (MAE) (< 0.32 TCU) less than the instrument error used to measured color in the clarifiers. Second, an ANN model was developed for turbidity removal via coagulation, using raw water quality, operations, and dose information. For the same process, an inverse model was developed, where the turbidity becomes an input to predict the alum dosage required for treatment. The models not only achieved low errors, but also provide insights into particulate removal by enhanced coagulation, and are being used in real-time to enhance operational decisions. The third application was for water softening, where ANNs were developed to estimate the total hardness in a softening clarifier effluent and the softening lime dose requirements. High predictive accuracy was achieved with the ANN models, with correlation coefficients for the validation data ranging between 0.84 and 0.95. Lastly, an ANN model was developed for predicting filter effluent counts following filtration. As stated in the paper, "there is currently a

weak understanding of relationships among particle count removal, chemical usage, and raw water quality, since the relationships are complex and nonlinear." The model achieved a mean absolute error for the validation data of 2.3 counts/ml, with a correlation coefficient of 0.79, demonstrating "excellent predictive capacity on previously unseen data."

In summary, limited research in the literature demonstrates the potential utility of ANN technology for predicting algal blooms and optimizing water treatment processes. However, every site, particularly in regard to algae population dynamics, will offer different challenges, and perhaps the most daunting challenge with algal bloom forecasting is implementation of the model in real-time conditions. That is, the current research has used historical data to test or validate the models, where the model inputs are known a-priori. The real challenge is to develop models that can accurately forecast water quality conditions in real-time using available measured data and forecasted conditions (e.g. weather).

4. ARTIFICIAL NEURAL NETWORKS

ANN technology is a compelling alternative to the physical-based modeling approaches, and as discussed previously in the Related Research section, has been used with success for algal bloom prediction problems (Recknagel and others, 1997; Maier and others, 1998). An ANN, through proper development and training, "learns" the system behavior of interest by processing representative data patterns through its architecture. What sets an ANN apart from a physical-based model is that because it does not rely upon the governing physical laws, information regarding physical parameters is often not required for its development and operation.

Because of its empirical nature, ANN technology is sometimes erroneously referred to as an "advanced" type of regression analysis. What distinguishes ANN technology from regression is the famous Kolmogorov's Theorem (Hecht-Nielsen, 1987, Sprecher, 1965). Specifically, this theorem asserts that any continuous function, from R^m to R^n, can be represented *exactly* by a three layer feedforward neural network with n elements in the input layer, 2n+1 elements in the hidden layer, and m elements in the output layer, where n and m are arbitrary positive integers. By contrast, regression is guaranteed to provide only an approximation by computing the best fit from a given function family. In addition, unlike regression, which treats all output variables independent of each other, the presence of common arcs in the ANN architecture allows it to identify important inter-relationships that may exist between output variables.

Figure 1 depicts a sample three-layer feedforward ANN architecture. Each ANN layer consists of individual nodes (elements), and the nodes are interconnected across layers by special non-linear (usually non-rational) transfer functions, expressed in terms of the nodal input variables and connection weights. During training, data patterns are processed through the ANN, and the connection weights are adaptively adjusted until a minimum acceptable error between the ANN predicted output and the actual output is

achieved. It is at this point that the ANN has "learned" to predict the system behavior of interest (i.e. values of output variables) in response to the values of the input variables.

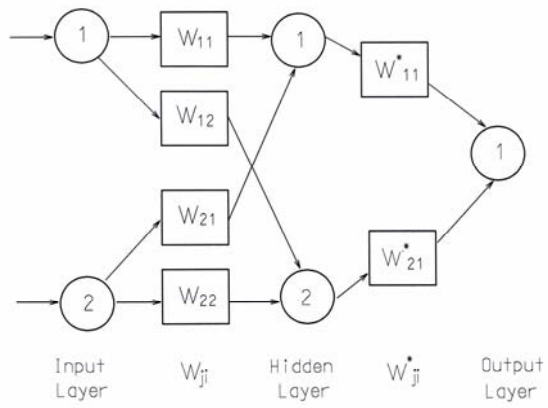


Figure 1. Architecture for a simple multi-perceptron ANN

In this work, the commonly employed non-linear hyperbolic tangent transfer function,

$$f_j(Sum_j) = \frac{e^{Sum_j} - e^{-Sum_j}}{e^{Sum_j} + e^{-Sum_j}} \quad , \qquad \textbf{(1)}$$

was used, where Sum_j represents the weighted sum for a node in the hidden layer, and e denotes the basis of the natural logarithm. In Sum_j, the input value received by each node in the hidden layer is multiplied by an associated connection weight, whose value is identified during learning. This weighted sum can be formally represented as:

$$Sum_j = \sum_{i=1}^{n} w_{ji} x_i + w_{jb}, \qquad \textbf{(2)}$$

where w_{ji} represents the connection weight between the ith node in the input layer and the jth node in the hidden layer. The input x_i is known, and represents the values of the input variables for node i in the input layer. A bias unit, which helps to provide numerical stability, is merely added as the connection weight w_{jb} because it has a constant input value of 1.0.

There are various kinds of ANN learning algorithms, and the interested reader is referred to the work of Poulton (2001) for more details. In this work, a combination of back

propagation and conjugate gradient algorithms were used. The prediction accuracy of an ANN is measured by the mean squared difference between the actual and predicted output values. For a preselected ANN model and corresponding data set, this mean squared error depends only on the values of the connection weights. During learning, the ANN processes training patterns consisting of input-output patterns through the network, systematically adjusting the connection weights, so that the measure of the overall goodness of the ANN model defined as the root mean squared error (RMSE) between the ANN-estimated output values and the actual values, is minimized. The minimization learning algorithm is always iterative, and each step is considered "learning".

The RMSE is mathematically defined as:

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\left(\gamma_k - C_k\right)^2} \qquad \textbf{(3)}$$

where γ_k is the ANN-estimated/predicted algae count value for the *k*th training event, C_k is its corresponding measured algae count, and *N* denotes the total number of such events.

In selecting the most appropriate ANN model, a variety of factors must be considered. This includes the functional form of the ANN transfer functions, the number of hidden layers and nodes, the most appropriate set of input variables, and the method used to minimize the objective function. This process is typically conducted in an iterative manner within the context of professional judgment and modeling experience. For example, selection of an appropriate set of input variables during initial ANN development requires a basic understanding of the governing system dynamics. However, a sensitivity analysis in conjunction with trial and error can help the modeler converge to the most appropriate feasible set of predictor variables. The sensitivity analysis, which quantifies the relative importance of each input variable for accurately predicting each output variable, can be used in lieu of common statistical methods.

During ANN development in this project, learning proceeded in a series of training and verification steps. The ANN is presented with training data during which patterns are processed through the network, and the learning algorithm adaptively adjusts the network connection weights to minimize the RMSE between actual and estimated output values. Intermittently, the training phase is interrupted, and a separate (verification) data set is processed through the ANN to verify progressive learning, as indicated by a declining RMSE value obtained with the verification data set. Verification guards against overtraining, where the ANN has memorized or over-fitted the connection weights to the training patterns. Training proceeds until the verification RMSE either stabilizes or begins to increase. At this point, ANN training is terminated, and the ANN can now be validated with a third data set not previously used for training or verification. Validation is used to determine whether the ANN has learned system behavior of interest over the range of expected conditions. To provide robust training, verification, and validation, statistically similar data sets spanning the expected range of system behavior were used for ANN development and validation. One half of the available data are used for training, one quarter for verification, and the remaining one quarter for validation or testing.

Being "data-driven" models, robust ANN development is absolutely dependent upon the quantity and quality of the data used to train the models. As discussed by Coppola and others (2003), "appropriate training set size for an ANN depends upon a number of factors, including its dimension (i.e. number of connection weights), the required ANN accuracy, the probability distribution of behavior, the level of noise in the system, and the complexity of the system." Complexity within the context of ANN modeling refers to a system where small changes in model input values produce large and even contradictory changes in model output values. A system that does not exhibit this type of complexity may then be referred to as a "well-behaved" system.

Researchers have developed a number of heuristic equations for estimating the minimum number of training data required for robust ANN model development. One such rule

uses the following mathematical relationship, where this number is a function of the number of ANN input or predictor variables, designated m, and the number of ANN output or prediction variables, designated n:

$$\text{Minimum Number of Required Training Samples} = [(1.5 \times m) + (1.5 \times n)] \times c \qquad \textbf{(4)}$$

where c is some constant, typically ranging between 4 and 10. Thus, assuming an average sized model for the algae work conducted for PVWC, consisting of 32 inputs and one output, the summation in the brackets, $[(1.5 \times 32) + (1.5 \times 1)]$, computes to 50 (rounded up). Using the range of values for the constant c, the computed number of training events required for robust ANN training ranges from 200 to 500 sample events.

Because algae population dynamics are highly complex and even considered non-linear in behavior (reference), and, given the expected noise in the data, the number of required training data necessary for robust ANN model development is probably closer to the upper value approaching 500 events. It should not be overlooked that more data also permits validation of the models under a greater range of conditions.

The poor performance for the Swimming River facility is also related to the second data issue, quality, as pertaining to model inclusion of all important causal or predictor variables governing the behavior or outputs of interest. As discussed above, ideally, the modeler should have a well-founded intuitive or empirical if not theoretical understanding of the governing dynamics of the system. This understanding ensures that all necessary predictor variables are included as model inputs. An excellent illustration of this requirement, and in stark contrast to the PVWC case, is that ANN performance for the Swimming River facility declined significantly following elimination of four water quality parameters intermittently sampled for by the utility (ammonia, turbidity, nitrite/nitrate, and phosphorous). This decline in predictive performance occurred even though the sample size for ANN development and assessment increased more than five-fold, from 48 to 221 events.

As part of the quality issue, data should also span the expected range of system conditions. For example, if there is the possibility for algae blooms during cooler months, data collected should include these months, and not only warmer months when blooms occur at higher frequency. While ANNs are excellent interpolators, they generally do not extrapolate well outside of the range of conditions for which they have been trained.

As was done in this research, sensitivity analysis and selective inclusion and exclusion of input variables can help the modeler converge to an appropriate set of predictor variables. However, ideally, the modeler should have a basic understanding of the system, which eliminates the possibility of excluding an important variable, but also promotes a more expedient convergence to a robust model. This understanding can help the modeler assess the potential strengths and weaknesses of the model, and identify situations under which its predictive capability may be suspect, or where inclusion of a certain variable critical. In addition, the modeler can help design a sampling program to include important or potentially important variables that to date have been sample either infrequently or not at all. This type of analysis is an accepted modeling methodology to reduce the dimensionality of the problem, and also eliminate spurious input variables (Swingler, 1996).

Two statistical measures in particular are used to assess ANN performance in this study; mean absolute error and correlation coefficient, mathematically defined as:

$$\text{Mean Absolute Error} = 1/\text{N} \sum_{k=1}^{N} \left| Yk - Ck \right| \qquad \textbf{(5)}$$

$$\text{Correlation Coefficient} = \frac{Scy}{\sqrt{SccSyy}} \qquad \textbf{(6)}$$

where γ_k is the ANN-estimated/predicted algae count value for the kth event, C_k is its corresponding measured algae count, N denotes the total number of such events, S_{cc} and

S_{yy} denote the sample variances of the final predicted algal counts and final measured algal counts, respectively, and S_{cy} represents the covariance between final predicted and final measured counts. Mean absolute error is a measure of the absolute average difference between final measured and final predicted algal counts. Correlation coefficients range between -1 and +1, with values close to +1 indicating a strong positive correlation between predicted and measured values, and values closer to 0 indicating little correlation. In this analysis, no correlation values were below 0.

At the end of this project, radial basis function (RBF) neural networks were also developed for eight select cases. As discuss in more detail later, instead of forecasting a single count value, as done previously, the RBF nets were developed to predict the bins or classification range (four pre-specified bins or classes) in which the final measured algal counts would fall.

For the RBF nets used for predicting the bin or classification range of the final measured algal counts (into four pre-specified bins or classes), a slightly different learning approach are used. For this paradigm, it is assumed that it input patterns are mapped to a higher dimensional space, there is a greater chance that the problem will become linearly separable based on Cover's Theorem (Cover, 1965; Haykin, 1999). For RBF's, the input pattern is non-linearly mapped to this higher dimensional space through the use of radially symmetric functions (usually Gaussian), with similar input patterns transformed through the same RBF node. The training process starts with an unsupervised phase during which the center and width of each RBF node must be trained. The centers start with random values and for each input pattern, and the center with the minimum distance to the input pattern is updated to move closet to that input pattern. Once the center vectors are fixed, the widths of the RBFs are established based on the root-mean-squared distance to a number of nearest neighbor RBFs. Following completion of the unsupervised phase, the connection weights between the RBF layer and the output layer are trained.

As discussed above, networks with a large number of input variables can be susceptible to over-fitting and a sign of over-fitting is a network function with high curvature. High curvature of the fitted function is a result of large connection weights. One method to reduce the network complexity or curvature is to penalize large connection weights through a process of weight regularization. The method of Weigend et al. (1991) is commonly used, where a penalty term in Equation 7 is calculated and added to the error term and to the connection weight's derivative at each step. Weights with large values are penalized the most and driven to small values. Once the weights are below a user-defined threshold the input variable or the hidden processing element is eliminated if all connection weights attached to it fall below the threshold value.

$$\text{Penalty} = \lambda \Sigma w_i^2 / (w_0 + w_i^2) \qquad \textbf{(7)}$$

λ and w_0 are user specified constants.

For the RBF modeling only, this approach was used, with a threshold value of 0.5 assigned to determine when a variable or processing element should be eliminated during training.

For all modeling conducted in the project, the commonly used modeling software Statistica was used. NOAH has used this software in a variety of projects, including an EPA Water Security Project and groundwater modeling. Dr. Mary Poulton, a NOAH principle and ANN expert modeler, uses this software in her graduate level course at the University of Arizona. Both she in this course and NOAH in its work have benchmarked the software against MATLAB's neural network toolbox and NeuralWare, two other popular ANN software programs, and it has comparatively performed well. In addition, the software was also used for the linear modeling in this project, which served as a benchmark for ANN performance.

5. THE STUDY AREAS

5.1 Swimming River

The Swimming River facility is located in Tinton Falls, New Jersey, approximately 6 miles west of the Atlantic Ocean. The facility has a history of algal blooms, which normally occur in warmer months. The data set used for developing and assessing the ANN methodology included most variables that are considered potentially important for predicting algae levels. A total of 221 weekly events of physical parameters measurements were initially generated from the available data, as well as 48 water quality samples collected intermittently over the period March 2002 to November 2003. Data provided by the New Jersey American Water Company (NJAWC) for the study site included water temperature, dissolved oxygen or D.O., secchi depth, pH level, algae counts per class, Total Phosphorus (µg/L), Nitrite/ Nitrate (µg/L), Ammonia as N (µg/L), Turbidity NTU, Silica (mg/L), Iron (mg/L), and Manganese (mg/L). Much of the data was provided in paper format, which was entered by NOAH personnel, and then underwent QA/QC for transcription accuracy, by an independent assessor. For this preliminary assessment, the later three constituents were not used, as they were measured relatively infrequently. Climate data was obtained from the National Oceanic and Atmospheric Administration (NOAA) and included total daily precipitation, average daily temperature, wind speed, wind direction and sky cover, while solar radiation data were taken from stations operated and maintained by NJDEP. The weather station used for precipitation, wind speed, and direction was Belmar, which is located approximately 8 miles southeast of the study area. For the relatively few days where data was missing, a linear regression was performed using Glendola's and Belmar's data from January 1, 2002 to July 24, 2003, with which missing precipitation values were estimated. Solar radiation data was collected at the Flemington station, located approximately 44 miles from Tinton Falls. In this final phase, additional modeling efforts and refinement were restricted to the 48 events that included water quality conditions. The rationale for this is the most accurate modeling performance was achieved with this data set, even though the

"physical" data set, which did not include any of the "chemical" parameters (total phosphorous, nitrite/nitrate, ammonia, and turbidity), had significantly more data available for training.

The conclusion drawn from these preliminary modeling results, and supported by algae population dynamics, is that inclusion of water quality conditions can be important for developing robust models that can accurately forecast algal levels. As discussed previously, following review of the algal modeling results by both NOAH and DEP personnel, it was determined that the existing data set was insufficient for model development, and the ANNs were likely "over-fitting" the state-transition equations to the data. Consequently, a detailed description and analysis of this modeling effort is not included in this document, but is provided in Appendix A-1, which can be obtained upon request by interested individuals from NJDEP in disk format.

For the water treatment modeling, the data set provided by New Jersey American constituted approximately 2.5 years of daily data consisting of 60 variables, of which 57 were used as model inputs, with the remaining 3 serving as outputs. The outputs were**:** average daily turbidity, highest daily turbidity, and average daily number of readings above 0.1 NTU.

The variables used in the water treatment problem can be classified into four basic groups: physical water data, chemical water data, water treatment data, and weather data. For example, physical water data includes variables such as total daily flow and average water temperature. Chemical water data include average daily measured turbidity, pH, and average daily chlorine levels. Water treatment data was the quantity or doses of chemicals added for treatment, such as sodium hydroxide and hydryfluosilicic acid.

A variety of different modeling exercises were conducted for the water treatment problem. However, because of length concerns, only the most important and representative modeling work and results are presented in this document. Similar to the

Swimming River algal modeling, the complete description and analysis of this modeling effort is provided in Appendices C-1 through C-3, which can be obtained upon request by interested individuals from NJDEP in disk format.

5.2 Passaic Valley Water Commission (PVWC)

Passaic Valley Water Commission (PVWC) is a wholesale and retail provider of drinking water to over 750,000 customers in Northern, New Jersey. The Commission owns and operates the Little Falls Water Treatment Plant (LFWTP), located in Totowa, New Jersey. The treatment plant was recently upgraded to include high rate sand-ballasted flocculation, ozonation and biological filtration to provide multiple barriers of microbial protection and to comply with recently implemented Safe Drinking Water Act Regulations.

Algal blooms result in two basic types of treatment challenges: effective particle settling/removal and objectionable tastes and odors. PVWC has an extensive watershed water quality monitoring program in place to assist with decision making for source water selection and prediction of water quality changes. Grab and online sample data are supplemented by USGS flow and water quality monitoring stations located throughout the watershed. The existing algal monitoring program consists of analyzing key water quality parameters and correlating changes in concentrations to predictions of algal concentrations. Routine direct measurement of the odorants Methyl Isoborneol and Geosmin, both algal metabolites, at key watershed, plant and finished water locations provide additional guidance for source water selection, in particular to minimize algal related taste and odor events. However, PVWC is continually exploring innovative methods to provide early warning of changes in water quality, and in particular, presence of algal blooms with sufficient response time to adjust treatment as required for mitigating negative water quality impacts.

Figure 2 provides a schematic representation of the system used in this project, with actual site location names omitted for water security reasons. The figure depicts the two possible river sources and a surface water reservoir used to supply the utility with its source water, which enters the LFWTP intake point for treatment. River B is gravity fed to the treatment plant intake. River A flows into and becomes part of River B upstream of the LFWTP intake, but can also be directly pumped to the plant intake via Pumping Station 2, thereby influencing the blend of River A being treated at the plant. A third surface supply, Reservoir A, is available on a limited basis to dilute any negative water quality impacts that may be present in Rivers A and B. Reservoir A is recharged with water from River A via Pumping Station 1 as needed to maintain adequate raw water storage levels, and in times of abstraction, is delivered directly to the plant intake location in the canal.

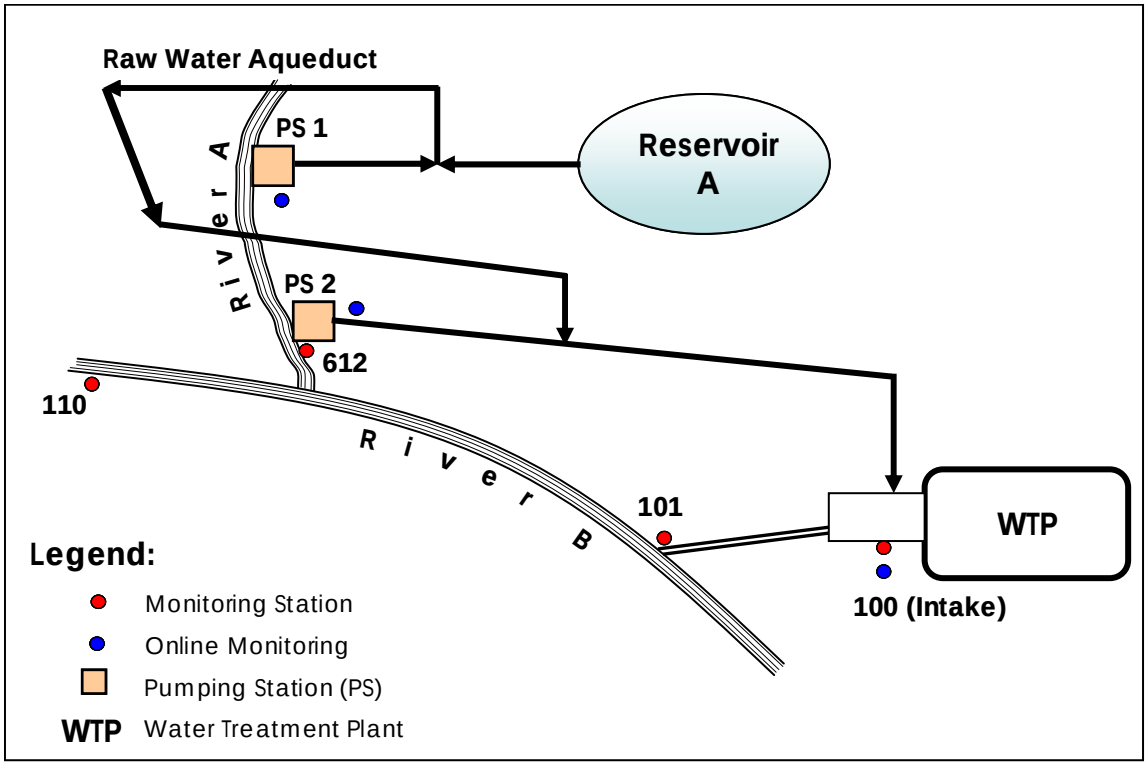


Figure 2. PVWC Raw Water Configuration

The LFWTP typically treats raw water from either one of two surface water supplies, Rivers A and River B, or some blended combination thereof. A third raw water reservoir, Reservoir A, is available on a limited basis, as needed during drought conditions and/or to minimize negative water quality impacts from either of the two primary surface water sources. These source waters are highly variable in both quality and quantity with respect to seasonal changes and precipitation related events. Source water selection is based primarily on water quality conditions followed by economic factors such as treatment and pumping costs.

Rivers A and B have historically exhibited variable and unique water quality characteristics that impart differing degrees of treatment challenges. River B is considered to be of poorer water quality because of higher organic concentrations, while River A has a higher incidence of extreme algal blooms, which have challenged the treatment plant prior to the recently upgrade treatment processes.

The three water quality monitoring or sampling stations, numbered 100, 101, and 612 shown in figure 2 were used in this study. Sampling Station 100 is located at the raw water intake point for the LFWTP, and is representative of the water sources used to supply the treatment plant. The water source(s) entering the intake point at sampling Station 100 can at any given time originate from one or more of three possible sources; River A, River B, and Reservoir A. Water quality sampling Station 612, located at the intake for Pumping Station 2, is almost always representative of water quality on River A (in past years, some low flow extreme conditions coupled with high extractions at Pumping Station 2 captured some portion of River B for short periods). The third and last water quality sampling location, Station 101, located at the mouth of the canal that leads from River B to the LFWTP, is representative of water quality conditions on River B capturing conditions after the confluence of Rivers A and B.

As part of the recent plant upgrade, online water quality monitoring stations were installed at the pumping stations 1 and 2 and at the plant intake to provide continuous

data for source water selection and for advanced warning of water quality changes. Because the largest source of water used by the utility during the study period was derived from River A, for most time periods, water quality at Station 100 (i.e. intake location) is highly correlated with water quality at Station 612 (i.e. Pumping Station 2 on River A). During most of the data collection period of this study, Station 100 intake water was a blend of River A (100 – 60%) and River B (0 – 40%) water. On rare occasions, it was a blend of River B and Reservoir A water.

The data set used for developing and assessing the ANN methodology included most variables that are considered potentially important for predicting algae levels. The final ANN models were developed for two forecast prediction periods; one-week ahead and two-weeks ahead. The two forecasting horizons were selected in part recognizing that the best available weather forecasts that provide some measure of confidence do not extend much beyond two weeks or so. In addition, these forecast horizons provide the utility with sufficient lead time to plan and implement effective proactive measures and strategies.

It was found that to improve model performance, each station should be individually modeled, rather than collectively as was done with Swimming River. This finding conforms to physical intuition, as two of the stations measure water quality conditions on different rivers, each with unique watershed characteristics. A summary of modeling results for the combined station modeling effort is presented in Appendix B-4.

A total of 553 measurement events, consisting of water quality, hydrologic, and water data collected intermittently over the period January 1999 to August 2004 were used in the study. The three individual stations were sampled at different frequencies, and thus events between stations do not always correspond in time. Station 100, located at the intake point, was sampled at the highest frequency, with as many as 270 historical events available for model training and validation. At the other extreme, Station 101, located on the least frequently abstracted river source, was sampled much less frequently, with as

few as 41 events and no more than 109 available for model training and validation. Station 612, located on the most frequently abstracted River A, also had relatively few historical events, but when the five select water quality variables were eliminated, it had the largest relative increase in sample size, from approximately 40 or 50 events to as many as 174 events.

The parameters provided by PVWC are listed in Table 1 below.

Table 1. Parameters Provided by PVWC for the Algae Modeling Study

Parameter	Unit	Parameter	Unit
Water Temperature	^{0}C	Total Phosphorus	mg/L
pH		Orthophosphate	mg/L
Turbidity[1]	NTU	Nitrite	mg/L
Alkalinity[1]	mg/L as CaCO3	Nitrate	mg/L
Hardness, Total	mg/L as CaCO3	Ammonia	mg/L
Hardness, Ca[4]	mg/L as CaCO3	Total Suspended Solids[3]	mg/L
Color[2]	Cu	Total Solids[4]	mg/L
Odor		Total Dissolved Solids [4]	mg/L
Conductivity	Umhos/cm	UV_{254}	cm^{-1}
Dissolved Oxygen	mg/L	Total Organic Carbon	mg/L
Biochemical Oxygen Demand	mg/L	Total Amorphous Materials[2]	Cells/ml
COD[4]	mg/L	Cyanobacteria counts	Cell/ml
Sulfate	mg/L	Chrysophyta counts	Cell/ml
Chloride	mg/L	Chlorophyta counts	Cells/ml
Fluoride[4]	mg/L		

1 – value estimated for Station 100, 2 – data not available to Station 100
3 – data not available to Station 101 and 612, 4 – very limited data, not used in ANN development

The data were provided to NOAH in electronic format by Ms. Linda Pasquarello, Water Quality Specialist. Climate data was obtained from National Oceanographic and Atmospheric Administration (NOAA) and included total daily precipitation, average

daily temperature, wind speed, and wind direction. There was no available data for solar radiation; hence data for sky cover, heating degree days, and length of day were also used, with values for the two first variables also obtained from NOAA, and the last obtained from sunrise and sunset tables obtained from the following website: www.jgiesen.de/GeoAstro/GeoAstro.htm.

The weather stations included Caldwell, located approximately 6 miles southeast of the site, Newark, located approximately 11.4 miles south of the site, and Tetterboro, which is located approximately 9 miles southwest of the site. Flow data were collected by the United States Geologic Survey (USGS) at the River A gauging station. PVWC also provided daily volumetric extraction data for River A, River B, Reservoir A and Pumping Station 1 and Pumping Station 2. Pumping Station 2 is at the intake point of River A.

6. WATER TREATMENT MODELING – SWIMMING RIVER RESERVOIR

6.1 Overview

As discussed above, for the water treatment modeling, the data set provided by New Jersey American spanned approximately two and a half years, consisting of 60 variables recorded for each day. The variables used in this water treatment modeling problem can be classified into four basic groups- physical water data, chemical water data, water treatment data, and weather data. For example, physical water data includes variables like total daily flow and average daily water temperature. Chemical water data include average daily measured turbidity, pH, and average daily chlorine levels. Water treatment data was the quantity or doses of chemicals added for treatment, such as sodium hydroxide and hydryfluosilicic acid. Weather variables were the most limited, consisting of only three variables; middle ambient air temperature, average daily ambient air temperature, and maximum daily ambient air temperature.

The water treatment output variables for which ANN prediction models were developed were average daily effluent turbidity reading (average turbidity), highest daily effluent turbidity reading (highest turbidity), and daily number of readings above 0.1 NTU (daily readings). All three of these variables are a measure of how effectively water treatment processes have removed suspended materials, such as sediments and organic material, like algae. A complete list of the input variables can be found in Appendix C-3, Table 1.

Somewhat less modeling was performed for the highest daily turbidity reading output variable. Because most of the variables measured represent average or total daily values, it may not be realistic to accurately model and predict a system state that is highly dependent on system changes that occur over much shorter time periods (e.g. hourly). Nevertheless, modeling of this variable was conducted for most cases. It should be noted that improved modeling performance was achieved with ANN models developed for each season, and a detailed overview of these results, and comparison with the models presented here, can be found in Appendix C-1.

6.2 Initial ANN Modeling Results

Figure 3 depicts the three prediction output variables of interest over the roughly 2.5 year period of record, from July 1, 2001 to December 31, 2003. As shown, the levels of the three variables generally increased over time, and this could be due to a reduction in the effectiveness of the water treatment processes. A plotting of the turbidity levels for the raw water does not exhibit an obvious increase with time, but instead, is correlated with seasons, which will be discussed in more detail later.

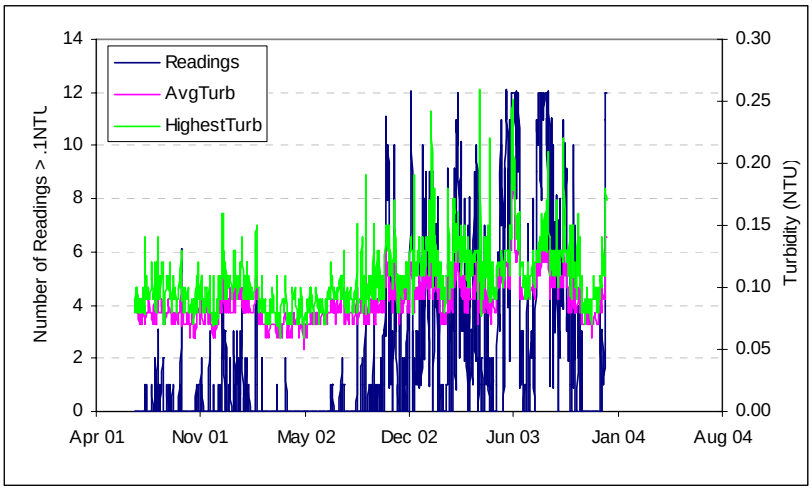


Figure 3. Daily turbidity readings above 0.1 NTU, average daily turbidity, and highest daily turbidity with respect to time over data record for Swimming River.

For the initial modeling exercise, seven different ANN models were developed and tested; two to predict average turbidity, two to predict daily readings, and three to predict highest turbidity. More than one ANN was trained for each so that, as with the Swimming River modeling efforts described above, the robustness of the models as indicated by consistency in both statistical performance and sensitivity analysis results could be assessed. Table 2 below compares the overall model performance achieved for the seven initial models.

Table 2. Overall Statistical Performance of the ANN Models for Swimming River Water Treatment

	Average Turbidity		Highest Turbidity			Daily Readings	
	First	Second	First	Second	Third	First	Second
MAE	0.01	0.01	0.025	0.03	0.01	1.48	1.49
Correlation Coefficient	0.72	0.66	0.11	0.18	0.61	0.72	0.72

As shown, the ANN models for average turbidity and daily readings performed consistently well, with relatively high correlation values. In contrast, there were inconsistent results for the three individual ANN models developed for predicting highest daily turbidity, with generally low correlations. Relatively similar performance can be observed from Table 3, which compares, for each of the best models for each variable, overall ANN model performance against performance during training and validation (i.e. testing).

Table 3. Comparison of Overall Performance versus Training and Validation for Best ANN Water Treatment Models for Swimming River

	Overall		**Training**		**Validation**	
	MAE	Correlation Coefficient	MAE	Correlation Coefficient	MAE	Correlation Coefficient
Average Turbidity	0.01	0.72	0.01	0.71	0.01	0.80
Highest Turbidity	0.01	0.61	0.01	0.66	0.02	0.58
Reading	1.53	0.72	1.27	0.81	1.56	0.66

The training and validation results are most similar for the ANN models that predict average daily turbidity and daily readings. There is more discrepancy between training and validation for the ANN model that predicts highest daily turbidity, as shown by the mean absolute errors.

Figures 4 through 6 compare measured against ANN model predicted values, for average turbidity, highest turbidity, and daily readings, respectively. As shown, for average

turbidity and daily readings, the ANN models generally follow the higher and lower readings. For average turbidity, the ANN model has a stronger tendency to under-predict extremely high readings, and over-predict very low readings. This tendency to miss extremes is likely due to relatively few extreme examples for which the ANNs can learn from. Similarly, for the highest turbidity, the models have a stronger tendency to under-predict extreme high values and over-predict extreme low values.

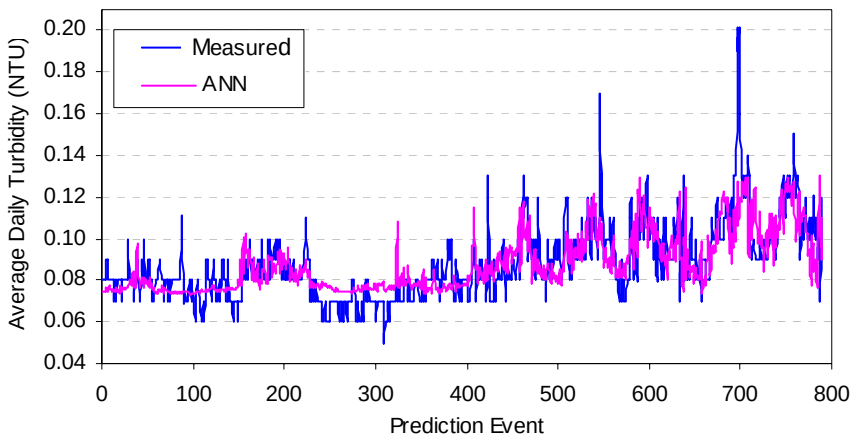


Figure 4. Measured average daily turbidity readings versus ANN predictions For Swimming River.

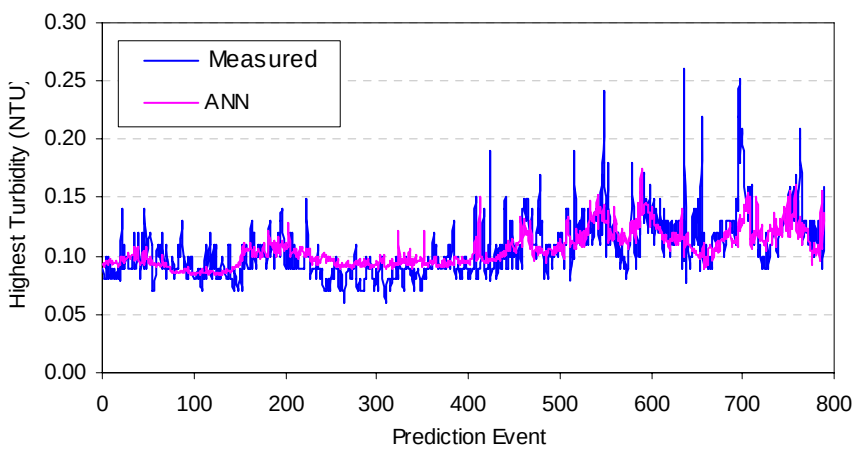


Figure 5. Measured highest daily turbidity readings versus ANN predictions for Swimming River.

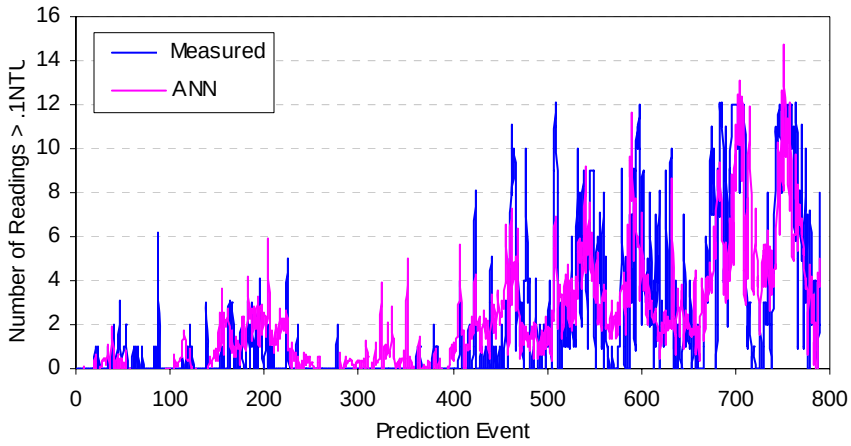


Figure 6. Measured daily turbidity readings above 0.1 NTU versus ANN predictions for Swimming River.

6.3 Sensitivity Analysis

As was done with the Swimming River algae modeling component, sensitivity analyses were conducted for the ANN water treatment models. Tables 4, 5, and 6 depict representative results for all ANN models used for the three prediction variables, average turbidity, highest turbidity, and average readings, respectively. The ten highest and lowest ranking variables for each model are displayed in the tables. Color coding has been used to facilitate recognition of identical input variables. The complete tables can be found in Appendix C-3.

Table 4. Comparison of Sensitivity Analysis Results for Average Daily Turbidity Models with top 10 and bottom 10 variables in terms of RMSE ratio values for Swimming River

Model 1				Model 2			
Variable	Input Variable No.	Ratio	Rank	Variable	Input Variable No.	Ratio	Rank
Temp Raw °C	Var45	1.087	1	Turbidity Settled NTU	Var35	1.061	1
Turbidity Settled NTU	Var35	1.036	2	Chlorine mix mg/l	Var41	1.021	2
Chlorine mix mg/l	Var41	1.034	3	Filters Washed/24H	Var3	1.015	3
Chlorine Eff mg/l	Var44	1.028	4	Chlorine Eff mg/l	Var44	1.014	4
Filters Washed/24H	Var3	1.021	5	Chlorine PPM/24H	Var24	1.012	5
Temp Eff °C	Var46	1.02	6	Temp Raw °C	Var45	1.011	6
Chlorine PPM/24H	Var24	1.016	7	Polyaluminum chloride gals/24H	Var15	1.011	7
Hydryfluosilicic acid PPM/24H	Var26	1.015	8	Sysdel SR Midd MGD	Var31	1.01	8
Fluoride avg.mg/l/24H	Var47	1.011	9	pH Settled	Var39	1.01	9
Air temp °C min/24H	Var54	1.011	10	Fluoride avg.mg/l/24H	Var47	1.01	10
Washwater MGD	Var4	0.999	48	Turbidities measured/24H	Var49	1	48
pH Mix	Var38	0.999	49	pH Mix	Var38	0.999	49
Peak flow raw MGD/24H	Var52	0.999	50	Zinc orthophosphate PPM/24H	Var27	0.999	50
Air temp °C avg/24H	Var56	0.999	51	Air temp °C min/24H	Var54	0.999	51
Chlorine lowest mg/l/24H	Var50	0.999	52	Raw MGD/24H	Var1	0.999	52
Zinc orthophosphate gals/24H	Var19	0.999	53	Air temp °C avg/24H	Var56	0.999	53
Polymer PPM/24H	Var22	0.999	54	Air temp °C max/24H	Var55	0.999	54
Settled readings >2,0 NTU/24H	Var57	0.998	55	Peak flow raw MGD/24H	Var52	0.999	55
Polymer gals/24H	Var16	0.997	56	System Delivery MGD	Var2	0.997	56
Carbon PPM/24H	Var25	0.997	57	pH Effluent	Var40	0.962	57

Table 5. Comparison of Sensitivity Analysis Results for Highest Daily Turbidity Models with top 10 and bottom 10 variables in terms of RMSE ratio values for Swimming River.

Model 1				Model 2				Model 3			
Variable	Input Variable	Ratio	Rank	Variable	Input Variable	Ratio	Rank	Variable	Input Variable	Ratio	Rank
Turbidity Settled NTU	Var35	1.003	1	Settled readings >2,0 NTU/24H	Var57	1.008	1	Turbidity Settled NTU	Var35	1.028	1
Temp Raw °C	Var45	1.001	2	Turbidity Settled NTU	Var35	1.003	2	pH Raw	Var37	1.015	2
Turbidity Raw NTU	Var34	1.001	3	Temp Raw °C	Var45	1.001	3	NaOH PPM/24H	Var23	1.015	3
Air temp °C min/24H	Var54	1.001	4	Turbidity Raw NTU	Var34	1.001	4	Chlorine mix mg/l	Var41	1.013	4
Sysdel SR Main MGD	Var30	1	5	Temp Eff °C	Var46	1.001	5	Temp Raw °C	Var45	1.012	5
Chlorine lbs/24H	Var8	1	6	Chlorine lbs/24H	Var8	1	6	Chlorine PPM/24H	Var24	1.011	6
Zinc orthophosphate gals/24H	Var19	1	7	Zinc orthophosphate PPM/24H	Var27	1	7	Raw MGD/24H	Var1	1.011	7
Hydryfluosilicic acid PPM/24H	Var26	1	8	Chlorine CW mg/l	Var43	1	8	Fluoride avg.mg/l/24H	Var47	1.01	8
Fluoride avg.mg/l/24H	Var47	1	9	Sysdel SR Main MGD	Var30	1	9	Filters Washed/24H	Var3	1.007	9
Polymer lbs/24H	Var7	1	10	Fluoride avg.mg/l/24H	Var47	1	10	Polyaluminum chloride PPM/24H	Var21	1.007	10

Table 6. Comparison of Sensitivity Analysis Results for Highest Daily Turbidity Models with top 10 and bottom 10 variables in terms of RMSE ratio values for Swimming River (continued)

Model 1				Model 2				Model 3			
Variable	Input Variable	Ratio	Rank	Variable	Input Variable	Ratio	Rank	Variable	Input Variable	Ratio	Rank
Polyaluminum chloride lbs/24H	Var6	1	48	CW Lowest level/24H	Var51	1	48	Polymer gals/24H	Var16	1	48
Carbon PPM/24H	Var25	1	49	Sodium Chlorite gals/24H	Var20	1	49	Zinc orthophosphate lbs/24H	Var12	1	49
Polymer gals/24H	Var16	1	50	Chlorine PPM/24H	Var24	1	50	Turbidity Raw NTU	Var34	1	50
Settled readings >2,0 NTU/24H	Var57	1	51	Polyaluminum chloride PPM/24H	Var21	1	51	Chlorine lbs/24H	Var8	0.999	51
Average % solids/liter	Var14	1	52	Polyaluminum chloride gals/24H	Var15	1	52	Air temp °C avg/24H	Var56	0.999	52
Chlorine PPM/24H	Var24	1	53	Washwater MGD	Var4	1	53	Settled readings >2,0 NTU/24H	Var57	0.999	53
Temp Eff °C	Var46	1	54	Carbon lbs/24H	Var5	1	54	Zinc orthophosphate PPM/24H	Var27	0.999	54
NaOH PPM/24H	Var23	1	55	Hydrofluosilicic acid lbs/24H	Var11	1	55	Ferric chloride PPM/24H	Var28	0.998	55
Chlorine mix mg/l	Var41	1	56	Chlorine Settled mg/l	Var42	1	56	Air temp °C max/24H	Var55	0.998	56
Air temp °C max/24H	Var55	1	57	pH Raw	Var37	1	57	pH Effluent	Var40	0.996	57

Table 7. Comparison of Sensitivity Analysis Results for Readings above 0.1 NTU Models with top 10 and bottom 10 variables in terms of RMSE ratio values for Swimming River.

Model 1				Model 2			
Variable	Input Variable Number	Ratio	Rank	Variable	Input Variable Number	Ratio	Rank
Sodium chlorite lbs/24H	Var9	1.148	1	Turbidity Settled NTU	Var35	1.095	1
Chlorine mix mg/l	Var41	1.107	2	Temp Raw °C	Var45	1.081	2
Air temp °C min/24H	Var54	1.076	3	Chlorine mix mg/l	Var41	1.062	3
Temp Raw °C	Var45	1.060	4	Fluoride avg.mg/l/24H	Var47	1.021	4
Turbidity Settled NTU	Var35	1.059	5	Hydrofluosilicic acid lbs/24H	Var11	1.018	5
Air temp °C max/24H	Var55	1.057	6	CW Lowest level/24H	Var51	1.011	6
Hydryfluosilicic acid PPM/24H	Var26	1.037	7	Chlorine Settled mg/l	Var42	1.010	7
Chlorine lbs/24H	Var8	1.037	8	Filters Washed/24H	Var3	1.010	8
System Delivery MGD	Var2	1.034	9	pH Raw	Var37	1.008	9
Ferric chloride lbs/24H	Var13	1.000	48	Polyaluminum chloride gals/24H	Var15	1.000	48
Sodium chlorite PPM/24H	Var29	1.000	49	Sysdel NS Midd MGD	Var33	1.000	49
Turbidities required/24H	Var48	1.000	50	Raw MGD/24H	Var1	0.999	50
NTU over limit	Var36	1.000	51	Sysdel SR Midd MGD	Var31	0.999	51
Turbidities measured/24H	Var49	1.000	52	Sysdel SR Main MGD	Var30	0.999	52
pH Effluent	Var40	1.000	53	Polyaluminum chloride PPM/24H	Var21	0.998	53
Sysdel SR Midd MGD	Var31	0.999	54	Average % solids/liter	Var14	0.998	54
Carbon lbs/24H	Var5	0.999	55	pH Settled	Var39	0.998	55
Zinc orthophosphate lbs/24H	Var12	0.999	56	Zinc orthophosphate gals/24H	Var19	0.998	56
Ferric chloride PPM/24H	Var28	0.995	57	pH Effluent	Var40	0.994	57

What is first striking is that none of the variables for any of the seven models had a particularly high ratio value. That is, no single input variable was particularly important for predicting the final output value. For predicting average turbidity, there was consistency between the two models. The two models shared seven of the ten highest ranking predictor variables, with raw water temperature, turbidity settled, and both chlorine mixed and chlorine effluent ranking right near the top. All of the ten highest ranking variables had a ratio value about 1.01. There was less similarity for the ten least important variables, all of which had a ratio value < 1.0.

For predicting highest turbidity, because three models rather than two were developed, it is less likely to have similar rankings between all models. However, for all three models, the same two input variables, turbidity settled and raw water temperature, rank within the top five. Other input variables, such as chlorine (lbs/24hr) raw water turbidity, and zinc orthophosphate, rank within the top ten most important variables for two models. Fluoride appears within the top ten for all three models. In terms of least important, no single variable occurs in all three models as ranking within the bottom 10.

The two ANN models developed for predicting daily readings share some highly ranked variables. Turbidity settled, mixed chlorine, and raw water temperature rank within the top five for both models. For the least important variables, two rank near the bottom; pH effluent and zinc orthophosphate.

One would expect that on average, out of 57 input variables, there would be some overlap between higher and lower ranking variables. However, for the three prediction output variables, two input variables ranked within the top six most important variables for all seven models; raw water temperature and settled turbidity. In terms of chemicals added, besides chlorine, no single coagulant or chemical agent appears to consistently rank high for any single finished water quality output variable. For predicting average turbidity, filters (washed/24hr) ranked highly for both models.

6.4 ANN versus Linear Models

As a comparison of ANN performance, linear models (LMs) were applied to the identical data sets. Table 8 below is a statistical performance comparison between the best ANN models against the LMs developed for each of the three output prediction variables

Table 8. Statistical Performance Comparison of LMs versus Best ANNs for Water Treatment Modeling at Swimming River

	Average Daily Turbidity	Maximum Daily Turbidity	No. of Readings > 0.1 NTU
ANN Mean Absolute Error	0.0095	0.014	1.48
LM Mean Absolute Error	0.0096	0.018	1.81
ANN Correlation Coefficient	0.72	0.60	0.72
LM Correlation Coefficient	0.65	0.14	0.41

For the best performing ANN models, and in fact, for the two different models that were used for predicting average turbidity and daily readings, the ANN models consistently outperformed the LMs. The discrepancy between the model types for average turbidity was relatively small; it was more significant for high turbidity and daily readings. However, some of the poorer performing ANN models did not statistically perform as well as the LMs for predicting highest turbidity.

Figures 7 through 11 further below compare measured versus linear model predicted values for average turbidity, highest turbidity, and average readings, respectively. What is interesting is that while on average, the LMs performed well, there are rare events where a highly erroneous output value is computed by the linear model. At least one of these erroneously high computed values was due to a data input error, which will be discussed later within the context of the sensitivity analyses results.

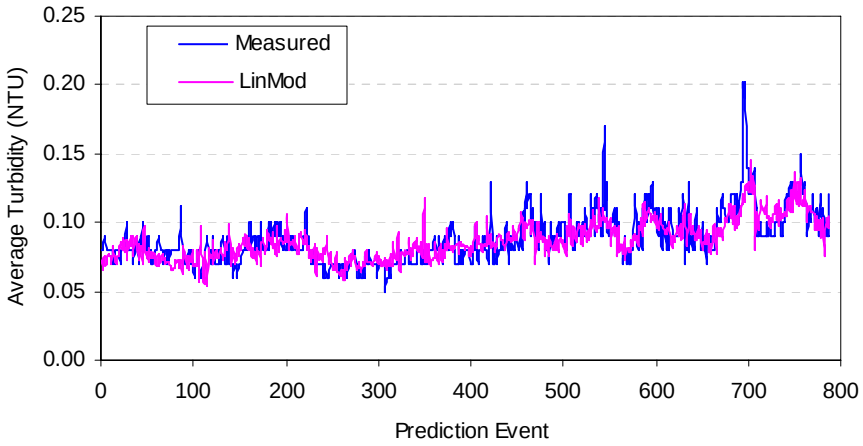


Figure 7. Comparison of measured average daily turbidity versus LM predictions for Swimming River.

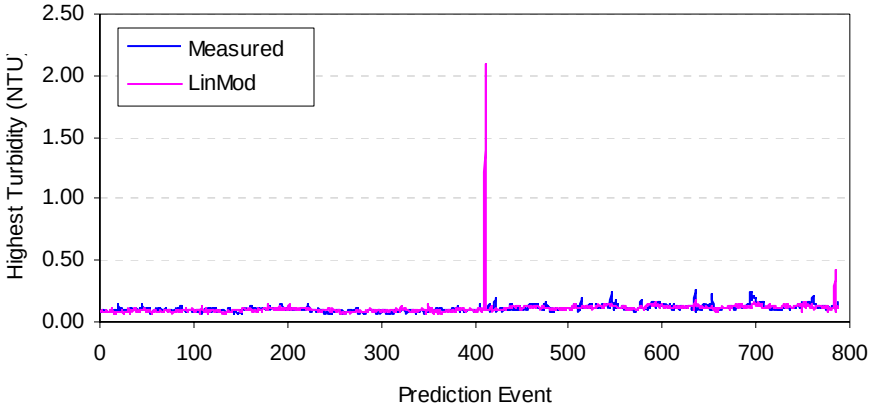


Figure 8. Comparison of measured highest daily turbidity versus LM predictions for Swimming River

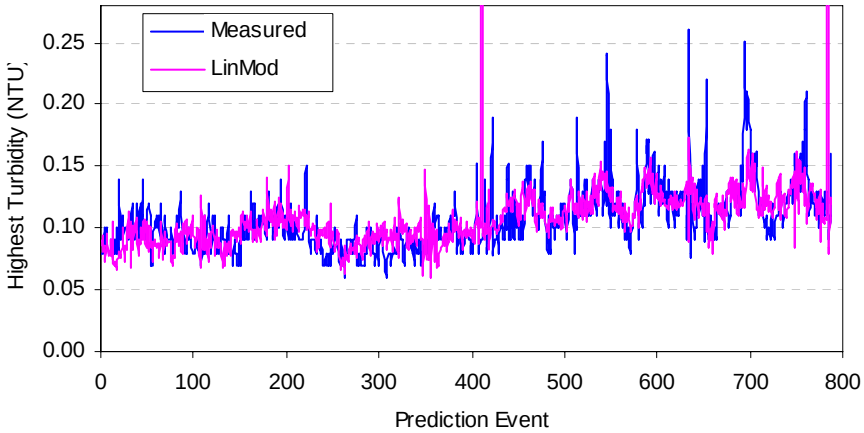


Figure 9. A magnification of Figure 19 above.

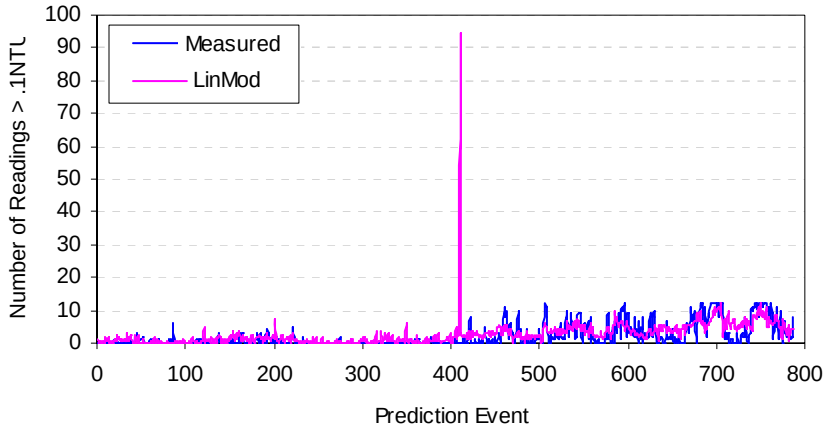


Figure 10. Comparison of daily turbidity readings above 0.1 NTU versus LM predictions

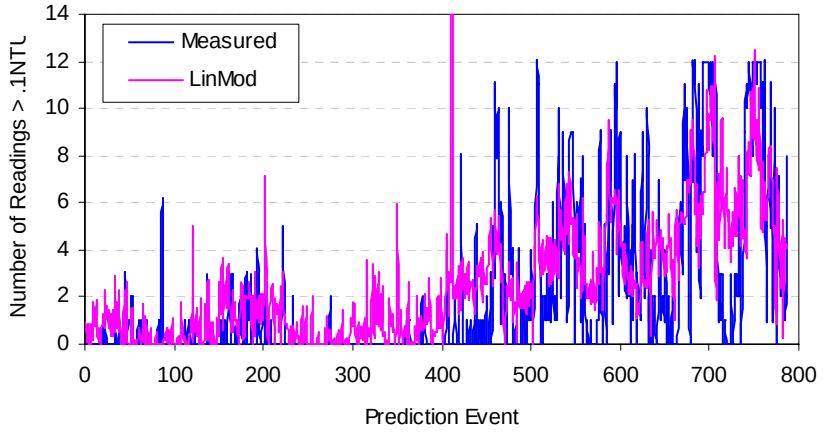


Figure 11. A magnification of Figure 21 above.

Tables in Appendix C-3 summarize the sensitivity analyses results for the LMs. Many of the variables identified as important by the ANN models were not identified as important by the LMs. For each of the three output variable prediction problems, only two variables appeared in the top 10 for both the ANN and LM; chlorine (ppm/24hr) for the average and highest turbidity outputs, and sodium chlorite (lbs/24hr) for daily readings.

As was reported in the preliminary report (August 4, 2004), the LMs have a tendency to have variables with extremely high RMSE ratio values (e.g. 10^{14}), which signifies an instability in the solution for the model coefficients. This instability has the potential to produce highly erroneous outputs. In this problem, an extremely low ratio value

achieved by the LM produced is associated with a highly erroneous output value. This occurred for prediction event 433 with both output variables highest turbidity and daily reading, where extremely erroneous high values were computed by the LMs. A review of the data showed that an infeasible value of 85 was reported and used for the input variable pH effluent, which likely should have been 8.5.

For the pH effluent input variable, the LM produced a ratio value of 0.313 for predicting highest daily turbidity and a ratio value of 0.619 for predicting daily readings above 0.1 NTU. By comparison, the ANN models for this variable had computed ratio values of 0.996 and 1.00 for the highest turbidity and daily reading outputs, respectively. In these cases, then, that the LMs may have a tendency to "over-react" or overcompensate for a single erroneous value, while the ANN models are not as affected by an erroneous, or in this case, infeasible input value for pH.

6.5 ANN Models (Reduced) with Fewer Input Variables

The next modeling exercise was to develop ANNs with only the most important predictor variables, as identified by the sensitivity analyses discussed above. The primary objective is to determine whether the ANNs can provide relatively accurate predictions with fewer variables, which could have cost savings benefits. In addition, this would help confirm the importance of or lack thereof of certain model input predictor variables.

The ten most important predictor variables as identified by the sensitivity analyses results (i.e. ten highest ranked variables) were used to develop a new ANN model for each of the three output variables, average daily turbidity, highest daily turbidity, and daily readings. Because all of these variables had computed ratio values above 1.0, they would all be expected to improve overall model performance. Table 9 compares the statistical performance of the original best ANN models with the best performance for each of the three output variables against the models that used only 10 input variables. It should be noted that the ANN models that used only 10 inputs had more events. Some days had at least one variable with a missing value, for which the model cannot be used. Thus, the

model using fewer input variables will have fewer days (i.e. events) with at least one missing value.

Table 9. Statistical Performance Comparison of Complete versus Reduced ANN Models for Water Treatment at Swimming River

	Average Turbidity	Highest Turbidity	No. of Readings > 0.1 NTU
Complete ANN Mean Absolute Error	0.00948	0.0143	1.48
Reduced ANN Mean Absolute Error	0.00933	0.0148	1.63
Complete ANN Correlation Coefficient	0.720	0.605	0.721
Reduced ANN Correlation Coefficient	0.703	0.582	0.690

Although the complete ANN models consistently outperformed the reduced ANN models, the discrepancy is relatively small. This is somewhat unexpected given the fact that in the original sensitivity analyses results, far more than ten variables in each case attained ratio values >1.0, approximately 45 total. Figures 12 through 14 compare measured versus ANN predicted values by the reduced models for average turbidity, high turbidity, and daily readings, respectively. On the other hand, probably relatively few variables are critical state and water treatment variables for the process.

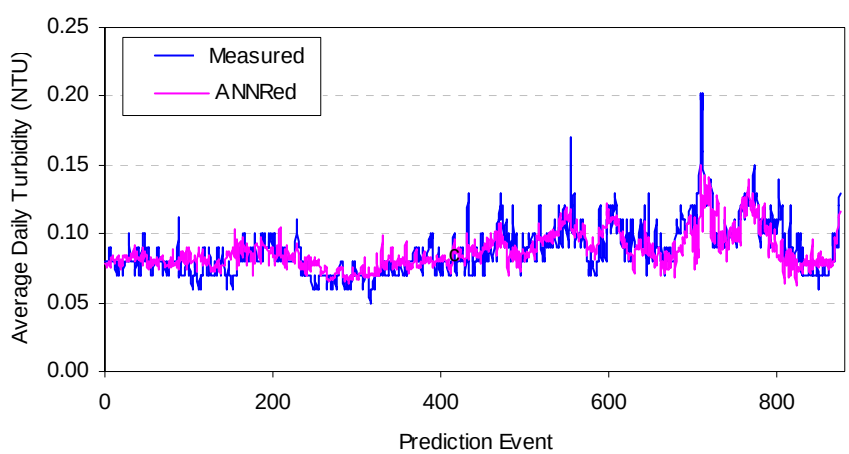


Figure 12. Average daily turbidity measurements versus reduced ANN model predictions for Swimming River

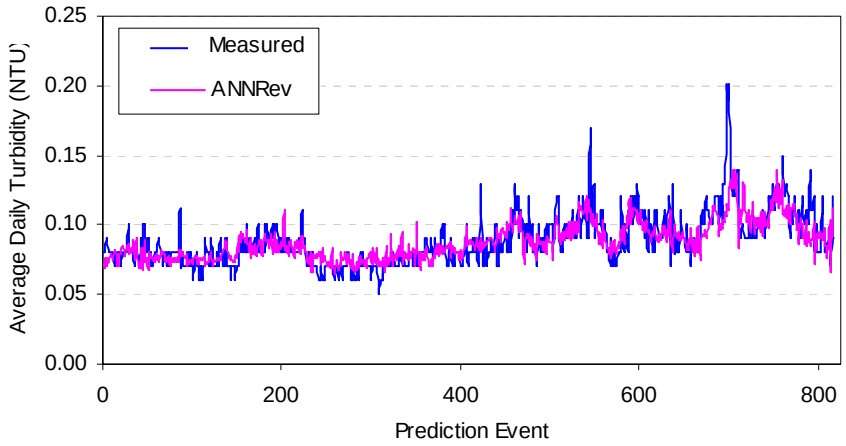


Figure 13. Highest daily turbidity measurements versus reduced ANN model predictions for Swimming River

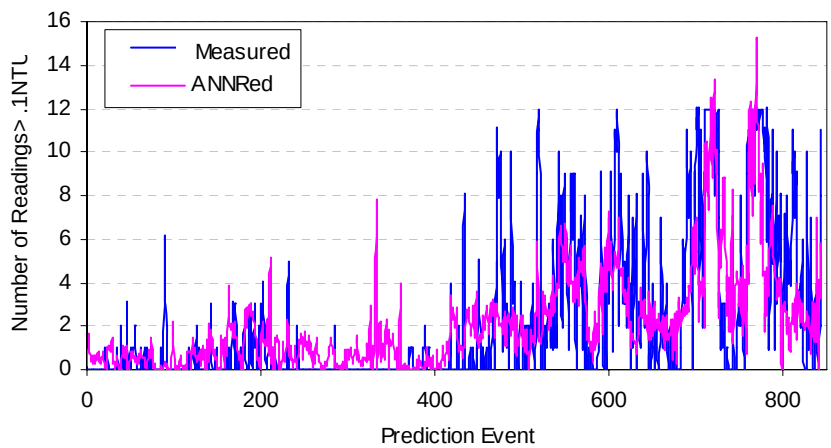


Figure 14. Daily readings measurements versus reduced ANN model predictions for Swimming River

A comparison of the sensitivity analysis results for the complete versus the reduced ANN models shows that the relative rankings of the ten variables are relatively dissimilar for the corresponding models (e.g. average turbidity, etc.). The tabulated sensitivity analyses results can be found in Appendix C-3.

6.6 More Refined ANN Models

As an additional analysis, instead of using only the ten most important predictor variables, as identified by the sensitivity analysis, as ANN model inputs, all variables that had an overall computed ratio value of at least 1.001 was used. For average turbidity, there were 32 variables; for highest turbidity, 28 variables; and for daily readings, 33 variables. Table 10 compares the statistical performance of the best performing complete ANN models against the ANN models with the refined input set.

Table 10. Statistical Performance Comparison of Complete ANN models versus Refined ANN Models for Water Treatment at Swimming River

	Turbidity	Highest Turbidity	Readings
Complete ANN Mean Absolute Error	0.00948	0.0142	1.48
Refined ANN Mean Absolute Error	0.00927	0.0144	1.52
Complete ANN Correlation Coefficient	0.720	0.605	0.721
Refined ANN Correlation Coefficient	0.722	0.6118	0.708

Statistically there is nominal difference between the refined and the complete ANN models. Not only did the refined models on average perform almost as well as the complete ANN models, but at times, their accuracy was better. This similar performance would potentially have cost implications, where marginal improvement may be offset by increased sampling costs. What is necessary is a more clear understanding of what is essential for predicting water quality variables of interest to acceptably accurate standards. What is also important to consider is the likelihood that the utility is following a consistent pattern of treatment strategies, based upon raw water quality conditions, etc., and that the ANN is consequently "keying" off surrogate variables, which implicitly represent chemical doses, etc. Figures 15 through 17 depict the modeling results.

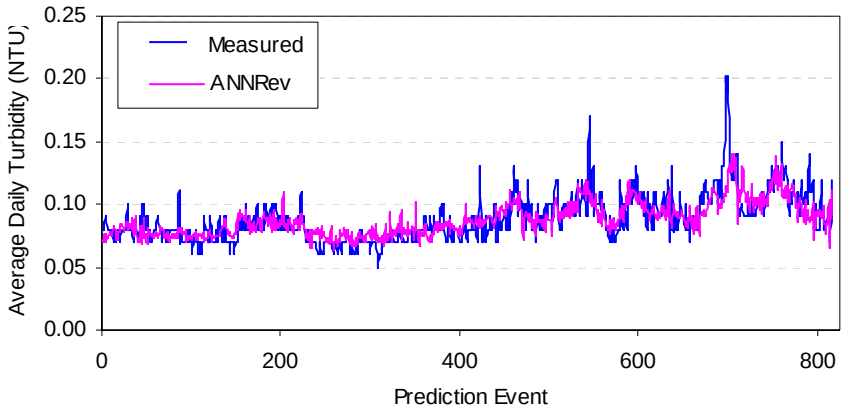


Figure 15. Comparison of average daily turbidity measurements versus ANN predictions for Swimming River with refined model.

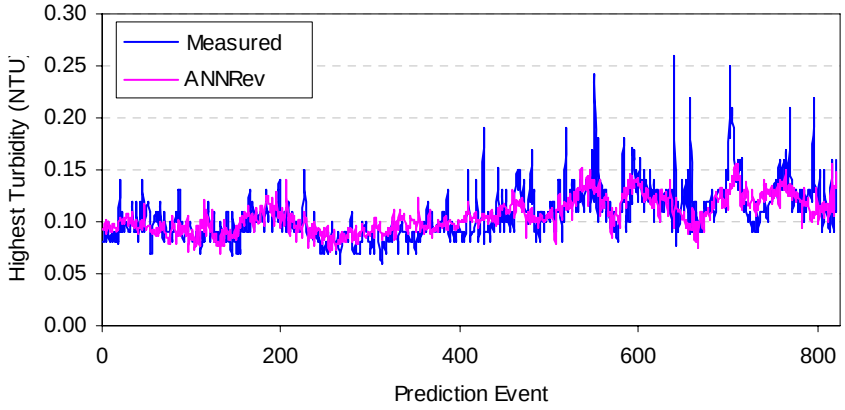


Figure 16. Comparison of highest daily turbidity measurements versus ANN predictions for Swimming River with refined model.

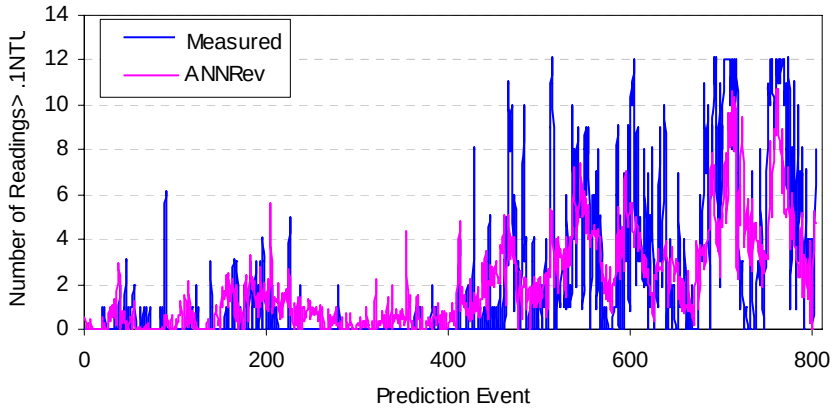


Figure 17. Comparison of daily readings above 0.1 NTU versus ANN predictions with refined model.

A sensitivity analysis comparison was also performed for the two models. Again, the input variables identified by the complete ANN as important (i.e. RMSE ratio above 1.001) were used as the input variables for the corresponding refined ANN models. Tables 11 through 13 compare the variable ratios and rankings for the variables in the refined models that ranked above 1.001. Color coding is again used to facilitate reviewer comparison. A complete listing of the sensitivity analyses results is provided in Appendix C-3.

Table 11. A Comparison of the Top 15 Variables for Complete and Refined ANN Models that Predict Average Daily Turbidity for Swimming River

Complete ANN Model				Refined ANN Model			
Temp Raw °C	Var45	1.087	1	Temp Raw °C	Var45	1.177	1
Turbidity Settled NTU	Var35	1.037	2	Temp Eff °C	Var46	1.118	2
Chlorine mix mg/l	Var41	1.035	3	Turbidity Settled NTU	Var35	1.101	3
Chlorine Eff mg/l	Var44	1.029	4	Hydryfluosilicic acid PPM/24H	Var26	1.095	4
Filters Washed/24H	Var3	1.021	5	System Delivery MGD	Var2	1.077	5
Temp Eff °C	Var46	1.020	6	Sodium hydroxide gals/24H	Var17	1.046	6
Chlorine PPM/24H	Var24	1.016	7	Chlorine mix mg/l	Var41	1.041	7
Hydryfluosilicic acid PPM/24H	Var26	1.015	8	Filters Washed/24H	Var3	1.040	8
Fluoride avg.mg/l/24H	Var47	1.012	9	Sysdel NS Main MGD	Var32	1.031	9
Air temp °C min/24H	Var54	1.011	10	Fluoride avg.mg/l/24H	Var47	1.025	10
CW Lowest level/24H	Var51	1.009	11	Polyaluminum chloride PPM/24H	Var21	1.025	11
Sodium hydroxide gals/24H	Var17	1.008	12	Turbidity Raw NTU	Var34	1.024	12
Sysdel NS Midd MGD	Var33	1.008	13	pH Settled	Var39	1.022	13
Zinc orthophosphate lbs/24H	Var12	1.007	14	Sysdel NS Midd MGD	Var33	1.022	14
Chlorine CW mg/l	Var43	1.007	15	Zinc orthophosphate PPM/24H	Var27	1.021	15

For average turbidity, of the original 32 input variables used in the refined model, 15 retained a ratio above 1.001. Both the complete and refined ANN models exhibit similarities in terms of the top ranking variables, with eight of the same variables ranking within the top fifteen for both models. Raw water temperature and turbidity settled were within the top three for both models. Also within the top eight for both models were temperature of the effluent, chlorine mixed, filters washed, and hydrofluosilic acid.

Table 12. A Comparison of the Top 16 Variables for Complete and Refined ANN Models that Predict Highest Daily Turbidity for Swimming River

Complete ANN Model				Refined ANN Model			
Turbidity Settled NTU	Var35	1.028	1	Temp Raw °C	Var45	1.123	1
pH Raw	Var37	1.015	2	Turbidity Settled NTU	Var35	1.049	2
NaOH PPM/24H	Var23	1.015	3	Hydrofluosilicic acid lbs/24H	Var11	1.045	3
Chlorine mix mg/l	Var41	1.013	4	Hydryfluosilicic acid PPM/24H	Var26	1.044	4
Temp Raw °C	Var45	1.012	5	Polyaluminum chloride PPM/24H	Var21	1.044	5
Chlorine PPM/24H	Var24	1.011	6	Raw MGD/24H	Var1	1.028	6
Raw MGD/24H	Var1	1.011	7	Temp Eff °C	Var46	1.024	7
Fluoride avg.mg/l/24H	Var47	1.010	8	Chlorine mix mg/l	Var41	1.020	8
Filters Washed/24H	Var3	1.007	9	Chlorine CW mg/l	Var43	1.017	9
Polyaluminum chloride PPM/24H	Var21	1.007	10	Sodium hydroxide lbs/24H	Var10	1.016	10
Temp Eff °C	Var46	1.006	11	Peak flow raw MGD/24H	Var52	1.015	11
Sysdel NS Midd MGD	Var33	1.006	12	Filters Washed/24H	Var3	1.014	12
Chlorine Eff mg/l	Var44	1.006	13	Air temp °C min/24H	Var54	1.010	13
pH Settled	Var39	1.005	14	pH Raw	Var37	1.009	14
Hydryfluosilicic acid PPM/24H	Var26	1.004	15	Sysdel NS Main MGD	Var32	1.009	15
Polyaluminum chloride lbs/24H	Var6	1.004	16	Sysdel NS Midd MGD	Var33	1.008	16

For predicting highest daily turbidity, 16 of the original 28 variables in the refined ANN model retained a ratio value above 1.001. Both the complete and refined ANNs had the same nine variables within the top 16. As with the ANN models that predicted average turbidity, both models had raw water temperature and settled turbidity ranked highly; in this case, within the top 5 for both models. However, compared to the average turbidity models, there were not as many shared variables that ranked near the top (i.e. within top half of the table).

Table 13. A Comparison of the Top 17 Variables for Complete and Refined ANN Models that Predict Number of Turbidity Readings > 0.1 NTU for Swimming River

Complete ANN Model				Refined ANN Model			
Sodium chlorite lbs/24H	Var9	1.148	1	Temp Raw °C	Var45	1.164	1
Chlorine mix mg/l	Var41	1.107	2	Turbidity Settled NTU	Var35	1.131	2
Air temp °C min/24H	Var54	1.076	3	Sodium hydroxide lbs/24H	Var10	1.093	3
Temp Raw °C	Var45	1.060	4	Temp Eff °C	Var46	1.087	4
Turbidity Settled NTU	Var35	1.059	5	Polyaluminum chloride PPM/24H	Var21	1.084	5
Air temp °C max/24H	Var55	1.057	6	Chlorine mix mg/l	Var41	1.079	6
Hydryfluosilicic acid PPM/24H	Var26	1.037	7	NaOH PPM/24H	Var23	1.052	7
Chlorine lbs/24H	Var8	1.037	8	Sodium hydroxide gals/24H	Var17	1.049	8
System Delivery MGD	Var2	1.034	9	Air temp °C min/24H	Var54	1.041	9
Chlorine CW mg/l	Var43	1.031	10	Raw MGD/24H	Var1	1.026	10
Temp Eff °C	Var46	1.029	11	Chlorine Settled mg/l	Var42	1.017	11
pH Raw	Var37	1.027	12	Zinc orthophosphate PPM/24H	Var27	1.017	12
CW Lowest level/24H	Var51	1.026	13	Average % solids/liter	Var14	1.014	13
Washwater MGD	Var4	1.024	14	Chlorine lbs/24H	Var8	1.010	14
Polyaluminum chloride PPM/24H	Var21	1.024	15	Hydryfluosilicic acid PPM/24H	Var26	1.010	15
pH Settled	Var39	1.022	16	pH Raw	Var37	1.009	16
Sodium Chlorite gals/24H	Var20	1.020	17	Chlorine CW mg/l	Var43	1.008	17

Of the 33 original input variables for the refined ANN model developed for daily readings, seventeen retained a ratio value above 1.001. As with the ANN models for average and highest turbidity, raw water temperature and settled turbidity ranked within the top five for both the complete and refined ANN models. Chlorine mixed also ranked within the top six variables for both models.

Overall, then, for the three predictor variables, approximately half of the original inputs for the refined models retained ratio values above 1.001. In addition, approximately half of the highest ranking variables for the refined models ranked near the top for the complete models. As was found previously for the complete ANN models, raw water temperature and settled turbidity consistently ranked near the top, and in fact both were always within the top three most important variables for the three refined ANN models.

6.10 Incremental Sensitivity Analysis

As a final modeling exercise, model simulations were run to assess the effect of select variables on computed outputs. In this exercise, as was done for the cyanobacteria count modeling, several events were selected for which the value of a single input variable was systematically changed, with all other input variables held constant, from which a new output value was computed. This exercise was repeated for several input variables to assess their effect on the output variable. For example, would an increase in raw water temperature increase or decrease average turbidity of the finished water? As previously discussed, it should be emphasized that this analysis is rather limited and simplistic, and discretion should be used when interpreting the significance of the results. Again, for complex and non-linear systems**,** such cause and effect relationships may not be straightforward. That is, the corresponding changes of the system are undoubtedly related to the state of the system with respect to other variables. In this case, similar increases in temperature for two events may product two different outcomes, depending upon the other states or inputs into the system. In addition, incremental temperature changes may induce a different range of responses, depending upon the temperature values over which these incremental changes occur. However, this exercise may also

help identify some basic tendencies, and helps to illustrate how perhaps ANN technology can be used to help optimize treatment strategies.

Two different spring ANN models were used; both used all original 57 inputs, with the first predicting average turbidity only, and the second predicting both average turbidity and average readings (model outputs). For predicting average turbidity, five different prediction events were used, each representing a different range of system conditions (i.e. season), for each of which seven different input variables were incrementally varied. Of the seven variables, five of the most important variables, as identified by the sensitivity analysis, were selected, and they are: raw water temperature, in °C; system delivery, in million gallons per day; ferric chloride added, in parts per million per 24 hours; zinc orthophosphate added, in lbs per 24 hours; and turbidity settled, in NTU. As a comparison, two of the least important predictor variables were also used; measured chlorine effluent, in mg/l, and polyaluminum chloride, in lbs/24H. For each iteration, the selected input variable was changed from the actual measured value for the event to its minimum, mean, or maximum measured values for that particular variable. Table 14 below lists these values for the seven parameters.

Table 14. Input Variables Used in the Sensitivity Analysis for the Average Turbidity Model, with their Corresponding Ratio Rankings and Minimum, Mean, and Maximum Measured Values.

Ratio Ranking	Name	Min	Average	Max
1	Temp Raw °C	3.00	11.63	20.00
2	Sysdel NS Midd MGD	1.900	5.364	10.480
3	Ferric chloride PPM/24H	5.38	11.51	15.95
4	Zinc orthophosphate lbs/24H	957.00	2752.38	3834.38
5	Turbidity Settled NTU	0.36	0.72	2.10
56	Chlorine Eff mg/l	0.5	1.5	1.6
57	Polyaluminum chloride lbs/24H	0.00	1065.85	2260.50

Bar figures 18 and 19 depict representative results for two events, which were consistent for all five events, with the other bar graphs contained in Appendix C-2. The bar graphs show that for each perturbed input variable, the corresponding computed output for the actual event value versus the corresponding computed outputs associated with the minimum, mean, and maximum input values listed above in Table 14.

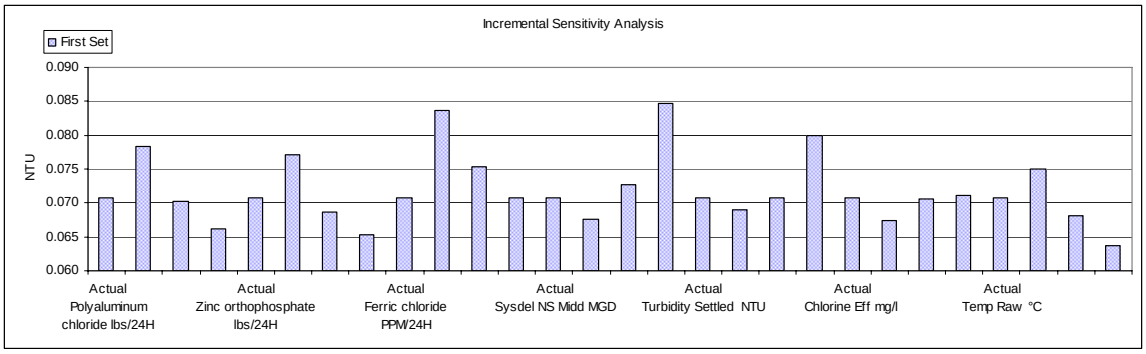


Figure 18. Predicted average daily turbidity in response to different input values for different variables for the first event for Swimming River.

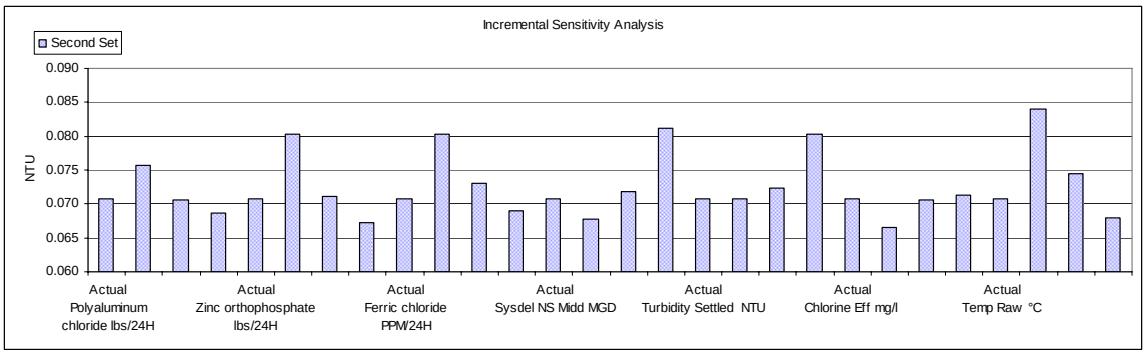


Figure 19. Predicted average daily turbidity in response to different input values for different variables for the second event for Swimming River.

Both higher water deliveries and higher settled turbidity readings both resulted in higher average turbidity levels for finished water. Both of these tendencies would appear to make sense, as both of these variables are measures of the quantity of mass in the raw water. If all other variables (e.g. chemical dosages) are held constant, turbidity removal is not increased, and thus average turbidity levels of the finished water will be elevated.

The inverse relationship between raw water temperature and average turbidity identified with the above analysis is consistent with the inverse relationship first identified when these two variables were plotted against each other. Thus, at higher temperatures, the raw water has lower turbidity. By extension, then, the treated finished water would also be expected to have lower turbidity during times when the raw water has a higher temperature, such as in summer months.

Lastly, chlorine effluent appears to be weakly positively correlated with average turbidity. This may have some physical basis, as the presence of organic material, such as algae, will increase raw water turbidity, which will increase the quantity of chlorine added. Figure 20 depicts raw water turbidity versus chlorine effluent, and does not show an obvious relationship.

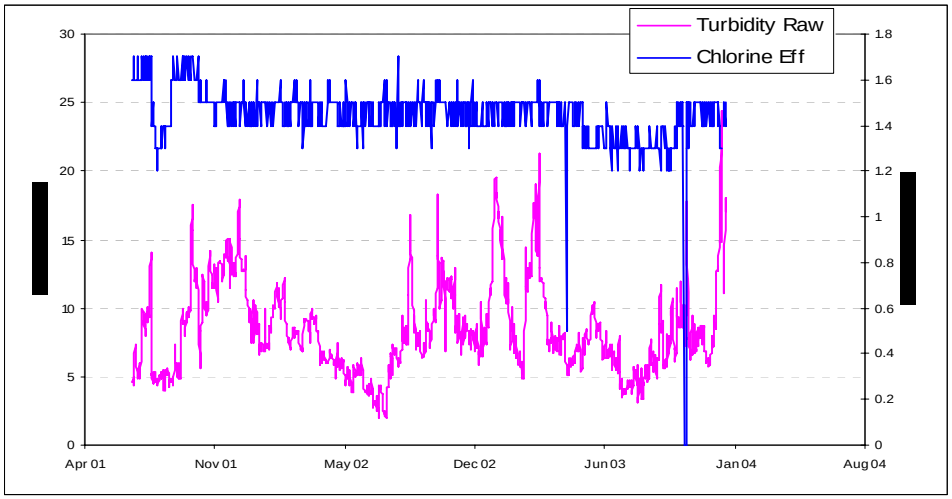


Figure 20. Raw water turbidity versus chlorine effluent concentrations for Swimming River.

The next analysis was to compare the average range over which the output values changed with respect to each of the seven input variables against the *relative* effect of each of the different input variables on the outputs. This was done using the five events. Again, because different variables can assume significantly different ranges of values, a direct comparison in computed output values using minimum and maximum possible

values provides limited information. The relative effect of each input variable on the corresponding outputs was computed using the sensitivity ratio provided previously in Equation 5.

In effect, the sensitivity ratio provides not only a measure of whether an input is positively or negatively correlated with a particular output, but also the unit change of the output per unit change of the select input variable. This understanding can be important for helping to identify treatment strategies. At the same time, as discussed earlier, it must be emphasized that the unit responses will not be uniform in a non-linear system, and may also depend upon the other states of the system. Table 15 below compares the RMSE ratio ranking against the range ranking and sensitivity ranking, with the computed values for the later two measures.

Table 15. Comparison of different variable's relative effect on average daily turbidity

Variable Name	RMSE Ratio Ranking	Range Change	Range Ranking	Sensitivity Ratio	Sensitivity Ranking
System Delivery	2	0.0162	1	0.00155	3
Raw Water Temp	1	-0.0149	2	-0.000552	4
Zinc Ortho	4	-0.0141	3	-1.47E-06	7
Ferric Chloride	3	-0.0122	4	-0.000352	5
Polyalum. Chloride	57	-0.0111	5	-2.75E-06	6
Turbidity Settled	5	0.0101	6	0.00492	1
Chlorine Effluent	56	0.00523	7	0.00436	2

For the events considered, turbidity settled and chlorine effluents have the greatest relative effect on average daily turbidity, while zinc orthophosphate has the least.

For the dual ANN model that included two output variables, average turbidity and average readings, the sensitivity analysis results were somewhat different than that for the single (output) ANN model. In this case, the five most important variables, in descending order of importance, are: raw water temperature, in °C; pH Effluent; maximum air

temperature, in °C per 24 hours; polymer added, in lbs per 24 hours, and settled readings in NTU. The two least important were Sodium hydroxide lbs/24H and pH Raw. Table 16 below reports the range of values for these seven input variables.

Table 16. Input Variables Used in the Sensitivity Analysis for the Dual Average Turbidity and Number of Readings Model, with their Corresponding Ratio Rankings and Minimum, Mean, and Maximum Measured Values

RMSE Ratio Ranking	Name	Min	Mean	Max
1	Temperature Raw °C	3.00	11.50	20.00
2	pH Effluent	7.20	7.5	7.80
3	Air temperature °C max/24H	-1.00	17.5	36.00
4	Polymer lbs/24H	45.45	204.525	363.60
5	Settled readings >2,0 NTU/24H	0.00	5	10.00
56	Sodium hydroxide lbs/24H	957.00	2395.69	3834.38
57	pH Raw	6.50	7.05	7.60

It should be noted, however, that the ratio and corresponding ranking values are computed cumulatively for the two outputs. Thus, a particular input variable that is not an important predictor for one output variable may be relatively important for the other output variable. In this case, because average turbidity and average are physically related, and hence are probably correlated**,** it is expected that there would be some consistency between these two variables. This apparent correlation is shown by the plotting of normalized average turbidity versus normalized average readings in Figure 21, where the values have been normalized between 0 and 1 to facilitate a more direct comparison.

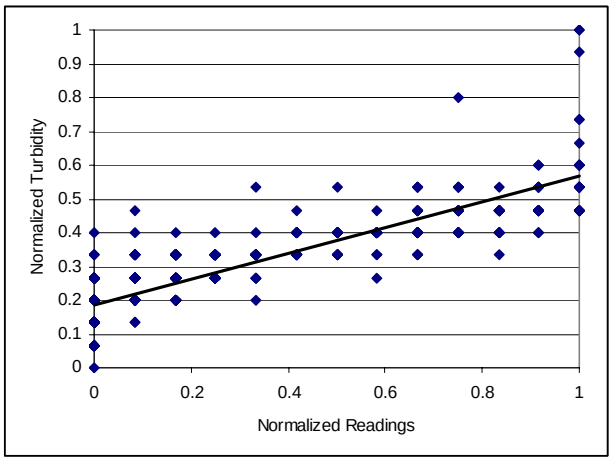


Figure 21. A regression chart comparing average daily turbidity versus daily readings about 0.1 NTU with a Line of Best Fit for Swimming River.

As the figure shows, lower average turbidity correlates with lower average reading, and similarly, higher average turbidity correlates with higher average readings.

Table 17 lists the variables in descending order relative to the computed sensitivity values, with a comparison to the ratio rankings.

Table 17. Comparison of Different Variable's Relative Effect on Average Daily Turbidity for the Dual ANN Output Model

Variable Name	RMSE Ratio Ranking	Range Change	Range Ranking	Sensitivity Ratio	Sensitivity Ranking
Temp Raw °C	1	-0.0136	1	-0.000798	3
Polymer lbs/24H	4	0.00986	2	3.1E-05	6
Air temp °C max/24H	3	0.00703	3	0.00019	5
Sodium hydroxide lbs/24H	56	0.00489	4	1.7E-06	7
pH Effluent	2	-0.00417	5	-0.00695	1
Settled readings >2,0 NTU/24H	5	0.004	6	0.0004	4
pH Raw	57	-0.00123	7	-0.00111	2

Figures 22 and 23 depict for two representative events the computed output response for average turbidity associated with individual changes in model inputs for the seven variables. Four variables consistently demonstrate a positive correlation with average daily turbidity, where increases in values for these inputs increased average daily

turbidity. The four variables include polymers added, sodium hydroxide, air temperature, and settled readings.

The single input variable that consistently exhibits an inverse relationship with average readings is raw water temperature. This inverse relationship is consistent with what was obtained with the ANN model with average turbidity as the single output. What appears to contract this relationship is how the model predicts that higher air temperatures result in a decrease of average daily turbidity. One would assume a positive correlation between air temperature and raw water temperature, and, by extension, would expect air temperature to be negatively correlated with average daily turbidity, as raw water temperature is. Both the input variables pH raw and pH effluent don't exhibit consistent behavior in terms of being positively or negatively correlated with average daily turbidity.

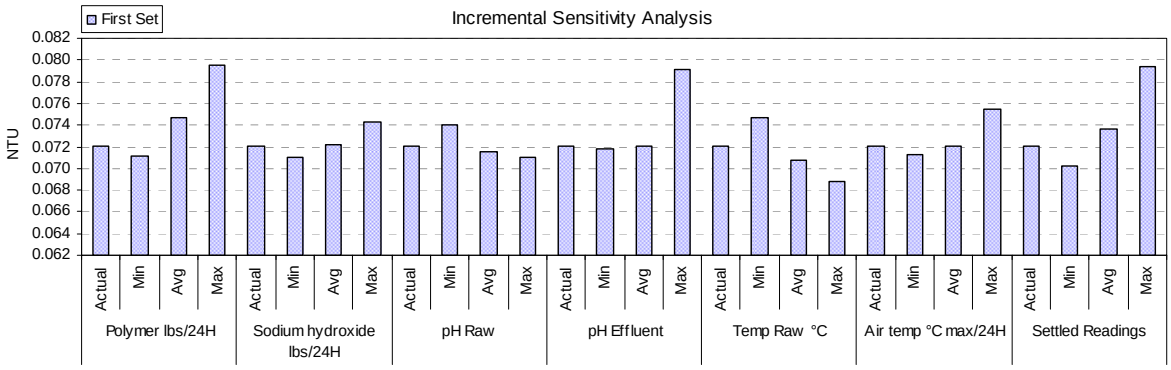


Figure 22. Predicted average daily turbidity in response to different input values for different variables for the first event for Swimming River

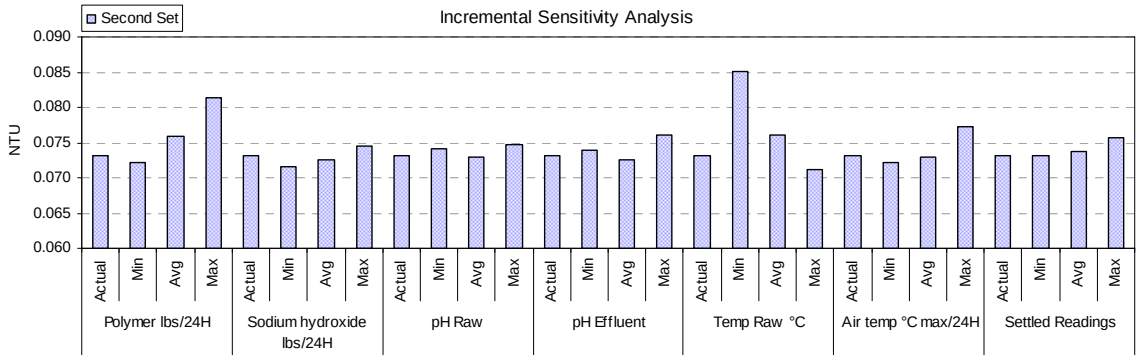


Figure 23. Predicted average daily turbidity in response to different input values for different variables for the second event for Swimming River

7. PVWC DATA

7.1 General Overview

Data utilized for the development of ANN models included the physical and chemical water data collected at three distinct sampling station locations. As discussed previously in the Study Area section, and depicted in Figure 2, Station 612 is located on the River A at the intake point for the Pumping Station 2. Station 101 is located just inside the mouth of the canal that connects River B with the PVWC treatment plant. Station 100 is located further inside the canal at the intake point for the PVWC water treatment plant. Measured conditions, then, at stations 612 and 101, are generally representative of water quality on Rivers A and B, respectively. Measured conditions at Station 100 are representative of water entering the treatment plant from the rivers and reservoir. When River B is not used for supply, hydraulic loading of water from the other source(s) minimizes its mixing at Station 100. Thus, if most of the source water for the day is extracted from either River A via the Pumping Station 2 or the Reservoir A, water quality at Station 100 is more representative of these water sources. Conversely, when River B is the predominant water source for the day, water quality conditions at Station 100 will be more representative of this river. Because of unique water quality conditions specific to each station, it was found using ANN models that the best predictive performance was achieved by modeling each station individually.

The sampling data used in this study were collected over the following time periods for the three stations; Station 100 - April 1999 to September 2004; Station 101 – May 1999 to October 2004; and Station 612 - April 1999 to September 2004. Available data sets at the three stations consisting of water quality, hydrologic, and weather were paired with corresponding counts of three different algae classes; Chrysophyta and Chlorophyta (under the kingdom Protista), and Cyanophyta (under the Kingdom Monera).

The initial data set used for developing and assessing the ANN methodology included most variables that are considered potentially important for predicting algae levels. Table 18 summarizes the number of historical data events available for modeling development and testing by station, potential prediction period, and data set (i.e. complete and reduced). From the data collected intermittently during the periods listed above, a total number of 156 sampling events were available for station 100, 41 events for station 101, and 52 events for station 612. For generating data events for model development purposes, however, incomplete data records reduced the final number of events available for ANN training and validation. That is, some sampling events had missing physical and/or chemical measurements, and in some cases, missing algal count measurements. In accordance with guidance provided by PVWC, some missing values were estimated by interpolation. For the second reduced data set used in this study, which excluded the less frequently measured water quality variables (four for Station 100, five for Stations 101 and 612), a total number of 266 sampling events were available for Station 100, 109 events for Station 101 and 173 events for Station 612. The actual number of these events available for model development and assessment depended on predicted on the length of forecasting horizons, as events separated by the prediction period (e.g. one-week ahead) had to be paired. (Note that 3-weeks ahead is included for previous modeling efforts – contained in Appendices).

Table 18. Available number of data events for each station for different modeling horizons

Station	Prediction Horizon	Original Models		Revised Models	
		Complete	Reduced Input	Complete	Reduced Input
100	One-week Ahead	156	266	182	270
	Two-week Ahead	160	249	167	252
	Three-week Ahead	150	236	142	218
101	One-week Ahead	41	109	47	96
	Two-week Ahead	40	106	35	66
	Three-week Ahead	48	110	36	71
612	One-week Ahead	52	173	51	174
	Two-week Ahead	54	139	40	140
	Three-week Ahead	56	135	45	135

As overviewed previously, data provided by the Passaic Water Valley Commission (PWVC) for the study station included water temperature, pH level, alkalinity, color, odor, conductivity, total hardness, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), sulfate, chloride, total phosphorus/orthophosphate, nitrite/ nitrate, ammonia, total suspended solids (TSS), UV 254, total organic carbon (TOC), algae counts for Chrysophyta, Cyanobacteria and Chlorophyta, fluoride and chemical oxygen demand (COD). Most of the data was provided in electronic format by PVWC and underwent further organization and assimilation by NOAH personnel. In this project, the later four constituents namely fluoride, COD, TDS and total solids were not used, as they were measured relatively infrequently. Climate data were obtained from NOAA and included total daily precipitation, wind speed, wind direction, sky cover, and heating degree days. Water source extraction data were provided by PVWC for Rivers A and B, Reservoir A (supplies water directly to Station 100) and Pumping Stations 1 and 2. Daily river flow data collected by the United States Geologic Survey for River A were also used.

As advised by Ms. Pasquarello of PVWC, data gaps at Station 100 for turbidity and alkalinity were estimated by taking a weighted average of values for these parameters measured at Stations 612 and 101, by proportioning their relative contribution to the PVWC treatment plant for the subject time period. Other missing data for a particular variable (e.g. temp, pH, conductivity, etc.) were estimated using linear regression with highly correlated variables; for example, turbidity was estimated from total algae counts using linear regression**.** Although less preferable to actual measurements, this is a reasonable approach for generating adequate data for this preliminary modeling assessment. In addition, this method was employed relatively infrequently; from less than 1% (one estimated value out of 166 events) for temperature and pH to 7% (12 out 166 events) for total suspended solids (TSS) for Station 100; 2% (temperature and pH) to 24% (total hardness) of the data for Station 101; and 1% (turbidity) to 17% (BOD) for Station 612.

Table 19 below presents a statistical tabulation of all the variables used in this modeling effort by Station. As was mentioned previously in section 5.2, and is discussed in more detail in the Modeling Section, a number of the less frequently measured variables, including some of the so-called "nutrients", were systematically eliminated as model inputs. In addition, so-called "correlative" or water extraction variables, were also eliminated from select models. Again, a complete presentation of the original models that used the complete set of input variables is presented in Appendices B-1 through B-4. The remainder of this section provides a detailed discussion of each of the variables used in this modeling problem. It should be noted that many of the variable types used for modeling the PVWC system were also used for modeling the Swimming River reservoir system.

Table 19. Statistical tabulation for all model variables used by Station

Parameter*	Unit	Station 100			Station 101			Station 612		
		Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
Water Temperature	^{o}C	0.1	13.6	25.8	0.6	13.5	26.5	0.0	13.2	27.8
pH		6.4	7.4	8.8	6.3	7.3	8.5	7.0	7.6	9.8
Turbidity	NTU	0.0	4.0	22.5	2.6	9.7	22.1	1.7	7.1	55.0
Alkalinity	mg/L as CaCO3	0.0	41.6	103.5	6.4	72.7	106.0	30.0	68.1	110.0
Total Hardness	mg/L as CaCO3	38.0	101.5	194.0	30.0	116.3	192.0	60.0	108.6	220.0
Conductivity	umhos/cm	168	432	1312	203	540	1307	253	445	756
Color	umhos/cm				15.1	44.1	153.0	12.0	34.8	195.0
Dissolved Oxygen	mg/L	4.8	10.5	16.2	5.3	9.6	15.1	4.8	10.3	15.5
Biochemical Oxygen Demand	mg/L	0.7	4.2	10.2	0.4	4.2	8.1	4.8	10.3	15.5
Chloride	mg/L	25.0	85.1	283.0	52.0	109.0	192.0	44.0	87.8	174.0
Sulfate	mg/L	10.3	22.2	55.7	12.2	27.7	61.1	10.6	20.2	39.3
T.Phosphorus/Orthophos-phate	mg/L	0.0	0.3	1.7	0.0	0.7	2.5	0.0	0.2	1.5
Nitrite/Nitrate	mg/L	0.0	1.6	5.3	0.4	2.3	6.2	0.4	1.4	3.7
Ammonia	mg/L	0.0	0.1	0.4	0.0	0.1	0.4	0.0	0.1	0.2
Total Suspended Solids	mg/L	1.0	13.4	47.0						
UV-254	cm^{-1}	0.1	0.1	0.3	0.1	0.2	1.0	0.1	0.1	0.1
Total Organic Carbon	mg/L	2.7	4.8	11.3	3.1	6.2	11.4	0.0	3.8	8.5
Prediction Period's Precipitation Total	inches	0.0	0.7	3.6	0.0	0.8	4.6	0.0	0.9	8.1
Prediction Period's Lagged Precipitation Total	inches	0.0	0.9	8.2	0.0	0.8	3.0	0.0	0.6	3.0
Wind Direction	$0\text{-}360^{0}$	52	211	301	93	214	293	120	219	299
Wind Speed	mph	4.7	7.4	11.2	4.7	7.3	10.9	4.9	7.6	10.9
Heating Degree Days	^{o}C	0.0	12.5	45.6	0.0	12.6	38.2	0.0	13.0	45.5
Sky Cover		0.9	4.3	9.1	0.6	4.2	8.7	0.4	4.2	8.0
Length of Day	hour	9.2	12.5	15.1	9.3	12.6	15.1	5.3	12.2	15.1
River A Streamflow	cu.ft./sec	30	546	3684	40	375	2569	30	379	4159
River A Extraction	MGD	0.0	35.4	62.1	0.0	31.8	59.1	0.0	29.9	60.2
River B Extraction	MGD	0.0	19.0	89.7	0.0	24.6	89.7	0.0	26.7	86.4
Reservoir A Extraction	MGD	0.0	0.4	19.5	0.0	0.6	19.5	0.0	0.6	18.3
Pumping Station 1 Extraction	MGD	0.0	0.6	28.0	0.0	1.8	31.4	0.0	0.9	29.6
Total Algae Count	Cells/ml	8	167	1520	8	115	572	16	187	842
Chrysophyta Count	Cells/ml	0	84	656	0	67	200	0	88	616
Cyanophyta Count	Cells/ml	0	30	1364	0	6	180	0	47	760
Chlorophyta Count	Cells/ml	0	49	608	0	40	304	0	48	420

Min = minimum, Max = maximum, Ave = Average

* - Total Amorphous Materials were measured as Light, Medium and Heavy

7.2 Biological Data

7.2.1 Cyanobacteria

Cyanobacteria, more commonly known as blue green algae (after the color of the first known species), are prokaryotic organisms that belong to the kingdom Monera. They are relatives of bacteria because they share similar structures but they are also related to the chloroplasts present in eukaryotic organisms (algae). They are sometimes referred to as blue-green algae. Cyanobacteria occur naturally in fresh water and in marine environments and along with the eukaryotic algal phyla, comprise the important component of phytoplankton community. However under favorable conditions, they can become dominant and can turn into a phenomenon called a bloom. Cyanobacteria blooms appear mostly in summer months or during periods of hot weather, when lack of mixing of surface and deeper water layers in a river or reservoir can lead to thermal stratification. Factors that contribute to thermal stratification of water bodies include temperature, wind, solar radiation and flow. Cyanobacteria prosper in non-turbulent conditions where water column stability enhances their ability to maintain an optimum position in the water column for photosynthetic activity and growth.

Similar to other algae, cyanobacteria are photoautotrophic organism, producing their own food by using chlorophylls (and other pigments) to fix carbon as starch through the process of photosynthesis. Nutrients also play a role in their growth and reproduction. Dissolved organic carbon, as well as phosphate, nitrate, ammonia and iron, are important factors. Cyanobacteria are one of very few groups of organisms that can convert ("fix") inert atmospheric nitrogen into an organic form, such as nitrate or ammonia. Cyanobacteria reproduce asexually and photosynthesis also plays a large and important role in their reproduction and growth. The wavelength of the light available determines what form of Cyanobacteria will grow.

The taxa included in the phylum for Cyanobacteria published under the Bacteriological Code (1990 Revision) include the classes *Chroobacteria*, *Hormogoneae* and *Gloeobacteria*; the orders *Chroococcales*, *Gloeobacterales*, *Nostocales*, *Oscillatoriales*, *Pleurocapsales* and *Stigonematales*; the families *Prochloraceae* and *Prochlorotrichaceae*, and the genera *Halospirulina*, *Planktothricoides*, *Prochlorococcus*, *Prochloron*, *Prochlorothrix*.

Figure 24 compares measured cyanobacteria counts for each of the three stations with respect to time. At Station 100, over the four year period, cyanobacteria bloom episodes occurred from June to October 1999, with the highest levels measured in August and September of this year at 1072 and 1364 cells/ml, respectively. By comparison, relatively small counts of cyanobacteria occurred over the remaining years, with a minor algal bloom occurring in July 2002 with a count of approximately 200 cells/ml.

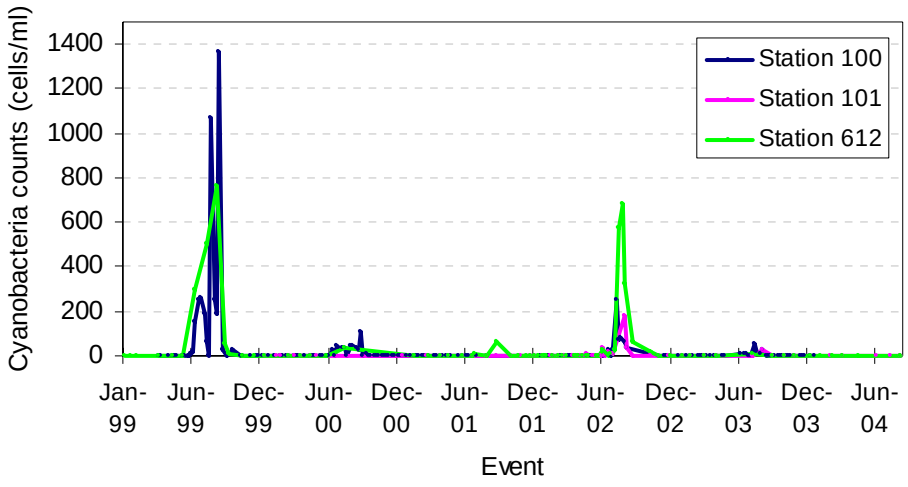


Figure 24. Comparison plots of measured cyanobacteria counts at three sampling stations

At Station 101, no data were available in 1999 to compare algae counts with Station 100. An algal bloom did occur at this station from July through August 2002, with the highest levels measured at 180 cells/ml in August.

Like Station 100, Station 612 had two cyanobacteria bloom events in the same years, the first in 1999 and the second in 2002. As shown in the figure, the bloom episodes that occurred in 1999 at this station (with the highest of 506 and 760 cells/ml in August and September, respectively) coincided with the blooms at Station 100. Similarly, the 2002 bloom incidence (highest at 684 cells/ml in August) also coincided with the bloom at Station 101. The 2002 bloom occurred over the period when water was extracted from the Point View Reservoir (July 24 to August 30). The Pumping Station 2 was temporarily turned off on July 23, 2002 and the Reservoir A was online the following day. Over this five week period, an average of 35% (13-100%) of daily water supply came from the Reservoir A. This water source was likely used to mitigate the algal bloom on the River A. By contrast, in 1999, only the River A through the Pumping Station 2 and the River B supplied water to the treatment facility.

In summary, then, the cyanobacteria bloom episode that occurred at Station 612 in July to September 1999 coincides with the bloom at Station 100. Station 101 during this period did not experience any bloom episodes. Another coincident bloom at Stations 100 and 612 occurred in July 2002; however, the algae levels at Station 100 started to decline by the end of the month, as the alternative reservoir source was used. At Station 612, the high algae counts persisted until the middle of August, around which time a bloom at Station 101 occurred. Most of the time, particularly during low cyanobacteria periods, counts at the three stations are more or less equal. However, during bloom events, cyanobacteria counts at Station 612 could be as much as eight times more than the other two stations. Thus, the River A appears to be the surface water source most subject to cyanobacteria bloom events, and extraction of this source appears to be responsible for bloom events measured at Station 100.

7.2.2 Chrysophyta

Chrysophytes are eukaryotes organisms that are abundant in freshwater, but may also be found in marine environments. These protists are particularly important in lakes where

they are the primary food source for zooplankton. Chrysophytes are also called golden algae because the yellow and brown caroteneoid (including fucoxanthin) and xantophyll accessory pigments masks the chlorophylls a and c, imbuing them with a golden color. There are more than a thousand described species of golden algae, mostly unicellular or colonial, swimming or floating in lakes and oceans as phytoplankton. In many chrysophytes, the cell walls are composed of cellulose with large quantities of silica, while some species are amoeboid forms with no cell walls. Motile species may have one or two flagella, which can be similar or dissimilar in structure. In shallow ponds that dry up in summer or freeze completely in winter, golden algae survive by forming protective cysts that can withstand the harsh conditions. When favorable conditions return, the algae emerge from the cysts.

The vast majority of golden algae are autotrophs (photosynthetic). They store food outside of the chloroplasts in the form of oil or polysaccharide laminarin, or chrysolaminarin. However, some biologists do not consider them to be truly autotrophic since they become facultatively heterotrophic (get energy from non-photosynthetic sources) in the absence of adequate light, or in the presence of plentiful dissolved food. When this occurs, the chrysoplasts atrophies and the alga may turn predator, feeding on bacteria or diatoms (www.ucmp.berkely.edu). Very few chrysophytes do not have chloroplasts, and those few live on dead organic material. However, some golden algae can use dead and organic materials, or use chloroplasts for energy, and thus switch back and forth between the two modes of nutrition, depending upon conditions (Lund and Lund).

Motile forms of golden algae reproduce by fission, while non-motile forms produce motile zoospores. There is also a special type of spore unique to this group, known as a statospore. It is spherical with a plug, which is popped out as the spore germinates. Isogamous sexual reproduction is rare. The unicellular species with a single flagellum include *Chromulina, Chrysococcus* and *Mallomonas* and the larger colonial forms comprise of *Synura, Chrysophaerella*, *Uroglena* and *Dinobryon.*

Figure 25 compares measured chrysophyta counts for each of the threes stations over time.

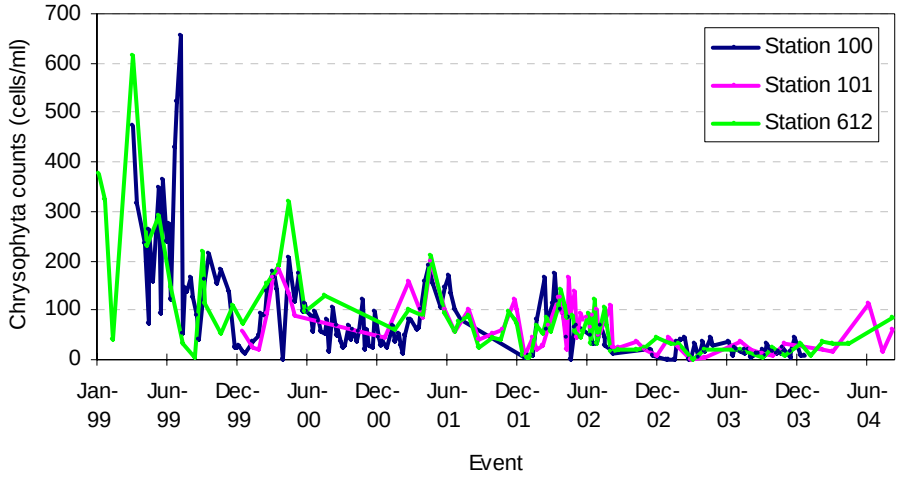


Figure 25. Comparison plots of measured chrysophyta counts at three sampling stations

At Station 100 (PVWC intake point at treatment facility), the highest counts of Chrysophytes over the period 1999 into 2004 were recorded in July and August 1999 at 520 and 656 cells/ml, respectively. With the exception of 2003, when measured concentrations were relatively low throughout the year, seasonal patterns over each of the years are evident. Higher Chrysophytes levels generally occurred in late winter/early spring (March) until the earlier to middle part of summer (June or July), while for the remainder of the year, counts were low.

At Station 101 (River B), the highest Chrysophytes counts were measured in April 2000 at 184 cells/ml and in May 2001 at 200 cells/ml. In general, a temporal pattern similar to Station 100 is evident, in which counts rise begin around the month of March until June, after which levels decline and remain low for the rest of the year. As at Station 100, low counts were also recorded at this station over 2003.

Station 612 (River A) exhibited a pattern consistent with the other two stations, with higher levels beginning in March and lasting though June or July followed by lower

levels through the end of the year. The highest Chrysophytes counts were measured in April 1999 at 616 cells/ml, and in May 2000 at 320 cells/ml.

7.2.3 Chlorophyta

Chlorophytes are eukaryotic organisms that form the largest phylum of the algae, the Chlorophyta. Commonly known as green or grass-green algae, the abundance of chlorophyll pigments in their chloroplasts gives them the bright green color. There are about 8,000 species of chlorophytes, mostly aquatic, but some are terrestrial living on damp soil or attached to land plants and even in snow and ice. These protists range in size from microscopic unicellular plankton that grow in lakes and oceans, to colonial filaments of pond scum, to leaflike seaweeds that grow along rocky and sandy intertidal areas. Some species are symbiotic, forming lichens with fungi or living with corals, while others can be found in freshwater sponges, imbuing the sponges with a bright green color, or in permanent snow banks, turning the snow reddish in color because of the secondary pigment that masks the chlorophyll. These green algae are also found on damp soil or attached to land plants (a few are parasitic).

Green algae are photosynthetic, containing organelles called chloroplasts which are characterized by clearly stacked thylakoids (any of the membranous disks of lamellae within plant chloroplasts that are composed of protein and where photochemical reactions of photosynthesis occur). Their photosynthetic pigments contain chlorophylls a and b, and various carotenoids are found in plants and in similar proportions. Food reserves are stored inside their plastids in the form of starchs, fats and oils. Most green algae have cell walls made up of two layers: an inner cellulose layer and an outer layer of pectin. Like most protists, chlorophytes have two or more flagella (tail like appendage) near the apex of the cell, at least once in their life cycle.

Green algae may reproduce vegetatively, by fragmentation and by cell division; asexually, by means of spores and zoospores that develop directly into new plants; and

sexually by the fusion of pairs of sex cells (gametes). In multicellular chlorophytes, alternation of generations is common, where the algae alternate between gametophyte and sporophyte generations.

Green algae are an extremely important source of food for other aquatic life forms. This makes green algae vital to many ecosystems on the planet. They also make a major contribution to the world's oxygen supply through photosynthesis and by fixing approximately 10^{10} tons of carbon per year. Classes of Chlorophyta include: *Chara, Chlamydomonas, Cladopjora, Coleochaete Desmid, Eremosphaera, Hydrodictyon, Oedogonium, Pandorina, Pediastrum, Spirogyra Ulothrix, Ulva and Volvox.*

Figure 26 compares measured chlorophyta counts for each of the three stations with respect to time.

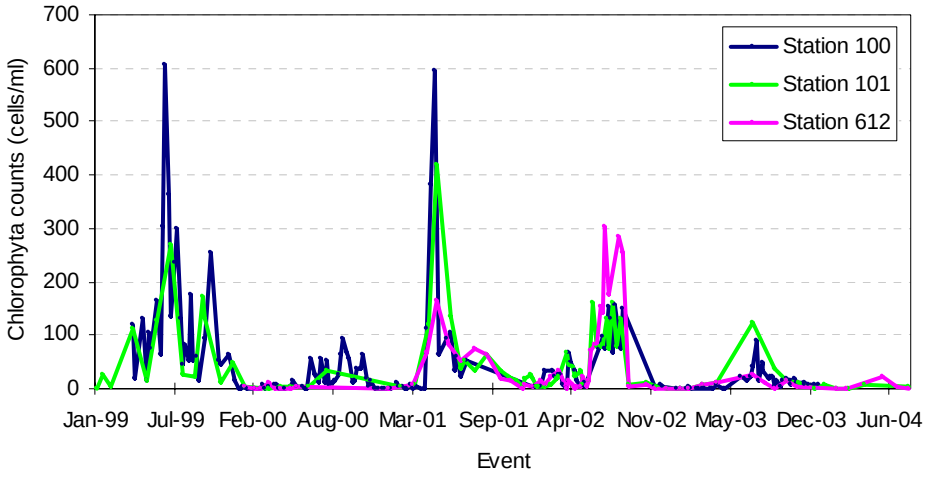


Figure 26. Comparison plots of measured chlorophyte counts at three sampling stations

At Station 100, counts were comparatively high throughout 1999, while levels over the succeeding years through 2004 counts were low, with exception to one sudden rise in May 2001. As depicted by the figure, higher levels generally occurred in the middle part of the year from approximately May to September, and the highest counts occurred in June 1999 and May 2001 with counts of 608 and 596 cells/ml, respectively. At Station

101, the highest Chlorophyte counts was measured in May 2001 at 164 cells/ml, and in 2002, high values of 304 and 284 cells/ml were measured in July and August, respectively. Station 612 exhibited more or less the same pattern as Station 100, wherein high chlorophytes levels usually occurred in May to September. The highest were measured at this station 612 were measured at 268 cells/ml in July 1999 and 420 cells/ml in May 2001. Because most of the source water at Station 100 originates from the River A, the correlation between Stations 100 and 612 is not unexpected.

7.3 Physical Data

7.3.1 Temperature

Most algae are freshwater organisms, and like most aquatic organisms, are unable to internally regulate their core body temperature. Consequently, temperature exerts a major influence on their biological activity and growth. Each species thrives within a narrow range of temperature, with some preferring cooler temperatures over warmer temperatures, while others have the opposite preference. When temperature gets too far above or below the preferred range, algae concentration decreases until there may be few or none.

Water temperature data collected at the three sampling stations were plotted against algae counts, and are presented in Figures 27 through 29. Temperature as expected exhibits a seasonal component. Different relationships between temperature and algae counts are exhibited by algae types and Station locations. At Station 100 as shown in Figure 27, higher chrysophytes level from 2000 to 2003 coincide with periods before temperatures reached their peak for each year, usually within the range of 10 to 20°C, while the highest chrysophtes levels in 1999 coincide with periods when temperatures were highest (above 20°C) in the year. Higher Chlorophytes counts that occurred primarily during the middle part of the year also coincide with high temperature periods above 15°C. Similarly, the

two cyanobacteria bloom events in 1999 at this station coincide with periods of highest temperatures, measured from 20 to above 25°C.

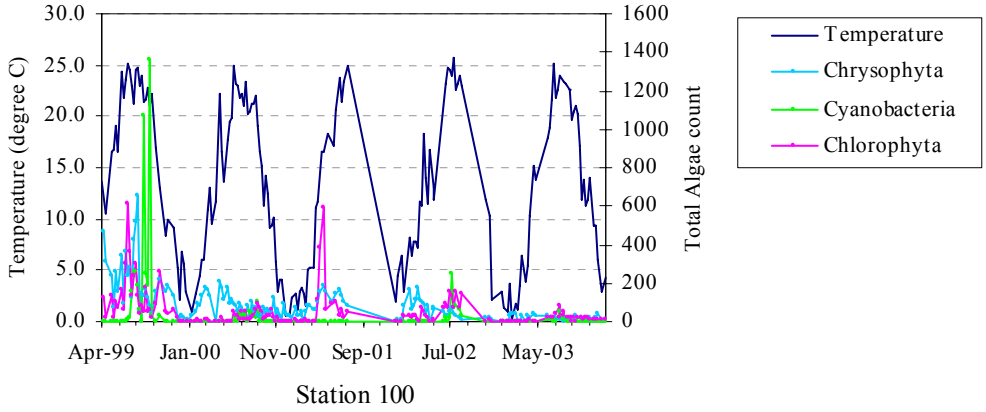


Figure 27. Total Algae counts versus Temperature measured at Station 100

At Station 101, chrysophytes counts from in 2000 through 2003 exhibited an almost identical pattern to that observed at Station 100, where higher counts coincide with periods before temperature (below 20°C) reached their annual peaks. High Chlorophytes counts that occurred in 2002 coincided with higher temperatures measured above 20°C, while in 2001, higher chlorophytes counts occurred when temperatures were lower (around 15°C). Cyanobacteria blooms at this station that occurred in 2002 coincide with periods of high temperatures, measured above 25°C. The relationship between temperature and high cyanobacteria and chrysophytes counts at this station was observed to be consistent with that of Station 100.

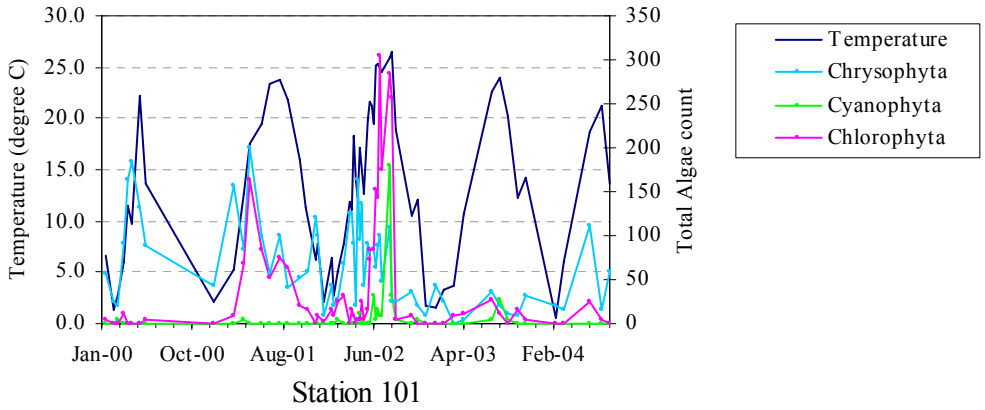


Figure 28. Total Algae counts versus Temperature measured at Station 101

At Station 612, the three algae types exhibited somewhat similar behavior to those from the other two stations. Most high Chrysophytes levels occurred during relatively warmer periods, around 10 to 20°C, as temperature warmed up to their peaks (>20°C) towards the summer period. As for the chlorophytes, higher levels during the years 1999 and 2002 coincide with periods of higher temperatures measured above 20°C. In 2001, however, the highest algae levels occurred when temperatures were lower, around 15°C. Cyanobacteria exhibited a consisted pattern at all three stations, in which blooms occurred during times when temperatures were highest (above 20°C in 1999 and above 25°C in 2002).

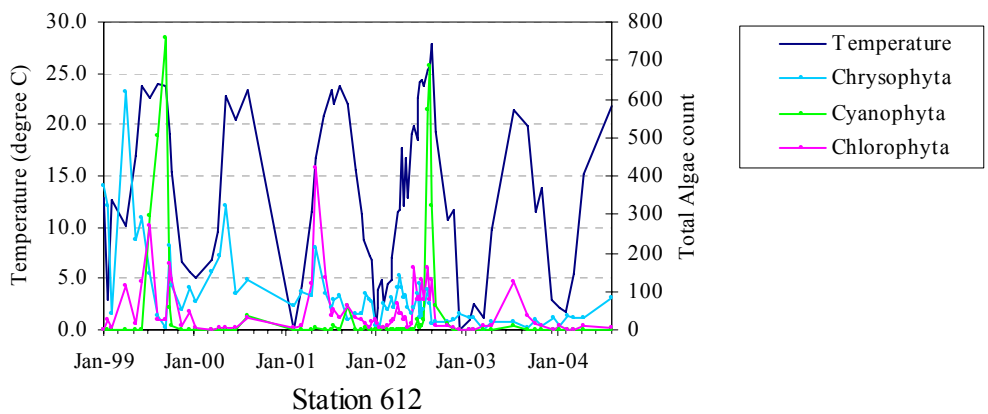


Figure 29. Total Algae counts versus Temperature measured at Station 612

7.3.2 pH

The pH is by definition a measure of concentration of hydrogen ions in a water sample (negative log of the concentration). During photosynthesis, algae consume hydrogen molecules, diminishing the hydrogen ion concentration, and therefore increasing the pH. Consequently, pH is generally higher during daylight hours or during the growing seasons, while the process of respiration and decomposition decreases pH.

As depicted in Figures 30, 31 and 32, pH levels fluctuate from 6.4 to 8.8 at station 100, 6.3 to 8.5 at station 101 and from 7 to 9.8 at station 612, respectively. High algae levels coincide with high pH levels at the corresponding sampling stations. Chrysophyta,

chlorophyta, and cyanobacteria are organisms that produce their own food through photosynthesis, thereby increasing the pH level during the process.

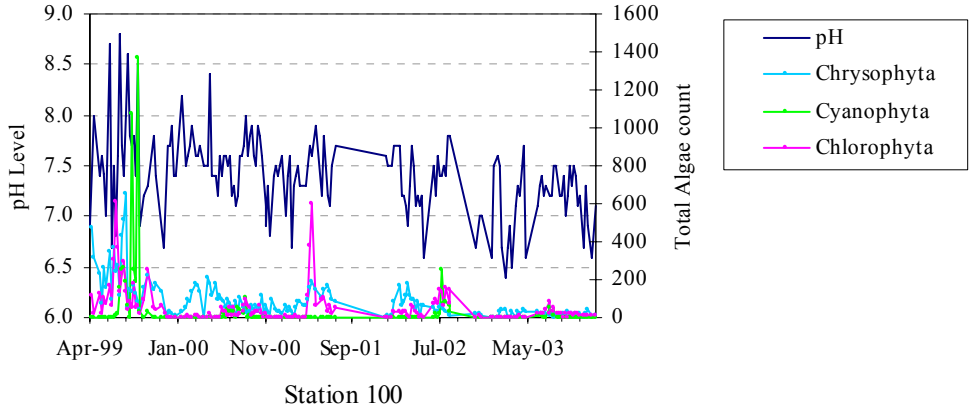


Figure 30. Total Algae counts versus pH measured at Station 100

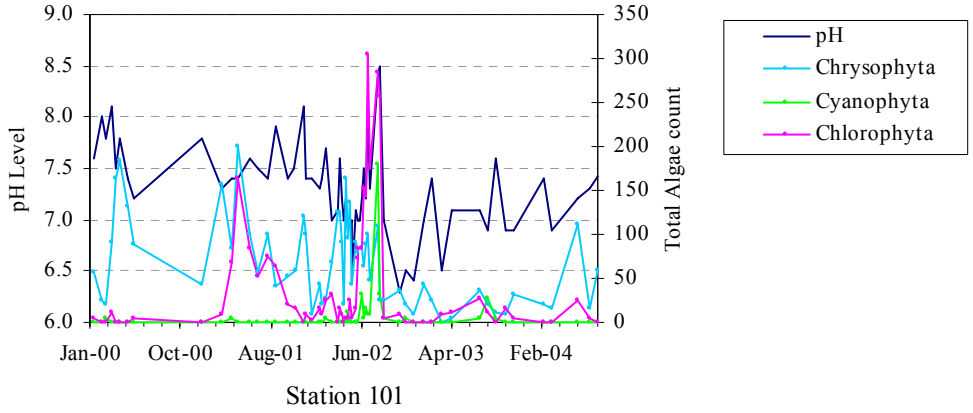


Figure 31. Total Algae counts versus pH measured at Station 101

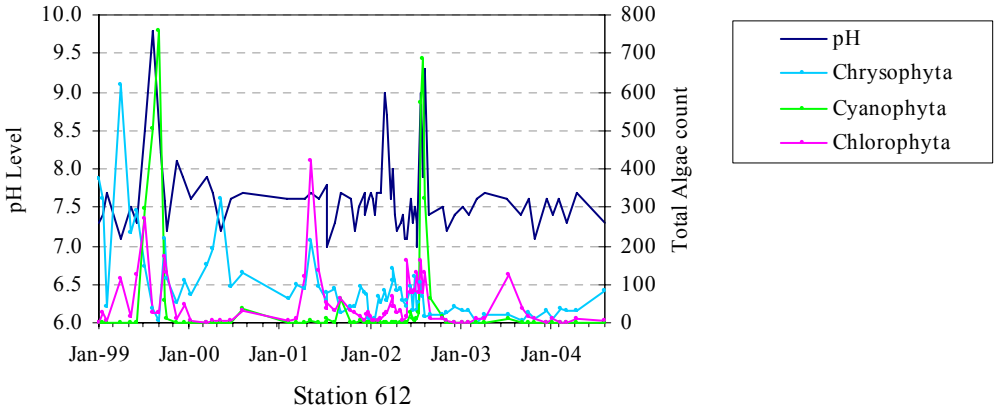


Figure 32. Total Algae counts versus pH Level measured at Station 612

7.3.3 Turbidity

Turbidity refers to "solids and organic matter that do not settle out of water" (Driscoll, 1986), and can include constituents ranging from clay, silt, and plankton to industrial wastes and sewerage. It is an important factor in algae prediction because it affects the light penetration into the water column, which regulates photosynthesis of organisms as well as the temperature of water that affects their biological activities. However, the measured turbidity may also be a measure of the amount of algae in the water column.

Figures 33 through 35 depict the comparison plots of turbidity levels against total algae counts at the three sampling stations. At Station 100 (water treatment intake point), no clear relationship between algae levels and of turbidity levels emerged. At Station 101 (River B) however, higher levels of turbidity coincide with higher levels of chrysophyta chlorophyta and cyanobacteria, most evident of which was in August 2002. During this month, the highest recorded turbidity level was measured at 22 NTU, which coincided with a cyanobacteria bloom, as well as the highest overall chlorophytes level measured at this station. In addition, the chrysophytes count was also relatively high during this period.

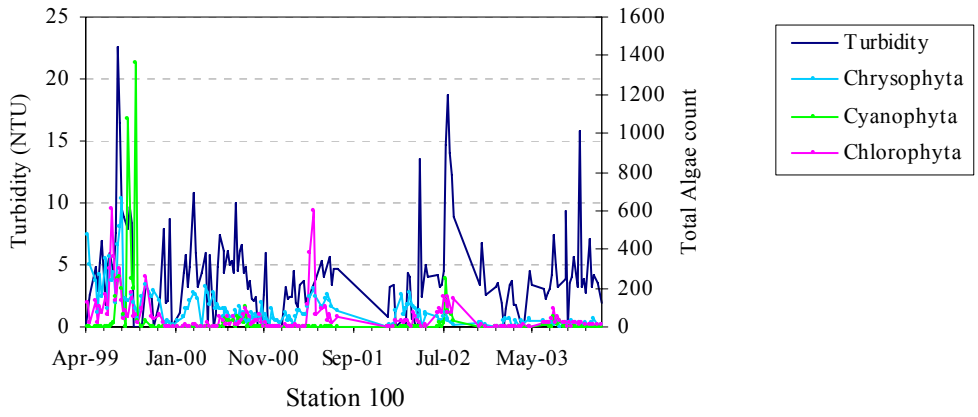


Figure 33. Total Algae counts versus Turbidity measured at Station 100

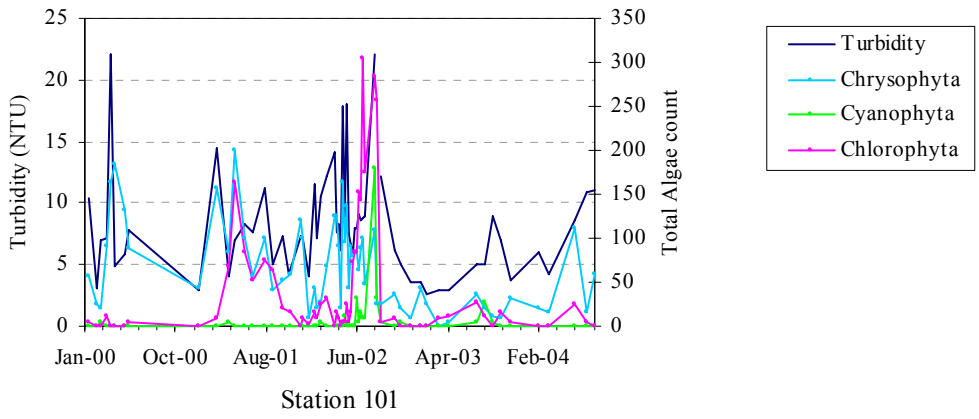


Figure 34. Total Algae counts versus Turbidity measured at Station 101

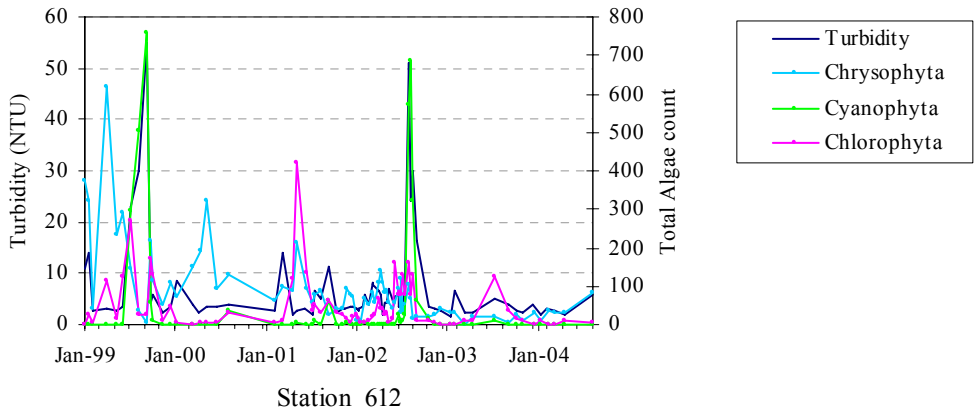


Figure 35. Total Algae counts versus Turbidity measured at Station 612

At Station 612, the highest turbidity levels over the 4-year records (51 and 55 NTU in September 1999 and July 2002, respectively) coincide almost perfectly with cyanobacteria bloom incidences. The other two algae types, chrysophyta and chlorophyta, exhibited different behavior, in which higher levels occurred during times when turbidity levels were lower.

In conclusion, there may be some threshold at which a higher turbidity levels during the right conditions is indicative of or corresponds with higher algae levels and/or limiting nutrients and minerals. However, above this threshold, elevated turbidity may reflect a high presence of material (e.g. sediments) which, by limiting sunlight penetration, inhibits algae growth.

7.3.4 Alkalinity

Alkalinity is a measure of the capacity of water to neutralize acids, as it measures how much acid can be added to water without causing a significant change in pH (i.e. buffering capacity). If any chemical changes are made to the water that could raise or lower the pH value, alkalinity acts as a buffer, protecting the water and its life forms from sudden shifts in pH.

Alkalinity is important in rivers and lakes because it buffers pH changes that occur naturally during photosynthetic cycles, or un-naturally by addition of acids to water via acid rain. The normal pH value of natural surface water bodies is usually between 6.5 and 8.5 but raising the alkalinity almost always raises the pH, which in turn affect aquatic life. If the alkalinity is too high, the water can become too cloudy and inhibit photosynthesis.

At the PVWC utility, as shown by Figures 36, 37 and 38, contradictory behavior was observed at the different stations. At Station 100, algae thrived during times when alkalinity was low. The highest alkalinity at this station was measured in July 2000 at 103 mg/l, and algae levels were correspondingly low. However, at Stations 101 and 612, higher algae levels generally occurred during periods of high alkalinity. The high alkalinity level of 98 mg/l in August 2002 at station 101 (highest at 106 mg/l in July) and the highest alkalinity level of 110 mg/l at stations 612 measured in July 2002, coincided with cyanobacteria bloom episodes at their respective stations. Moreover, at station 101, the highest chlorophytes counts occurred in July and August 2002, at exactly the same periods when alkalinity levels were highest. Another obvious coincidence between high chlorophytes and chrysophytes counts and high alkalinity occurred at this station in May 2001. At station 612, the highest chlorophytes counts occurred in May 2001 during relatively high alkalinity, while another cyanobacteria bloom episode in September 1999 at this station also coincide with high alkalinity above 70 mg/l.

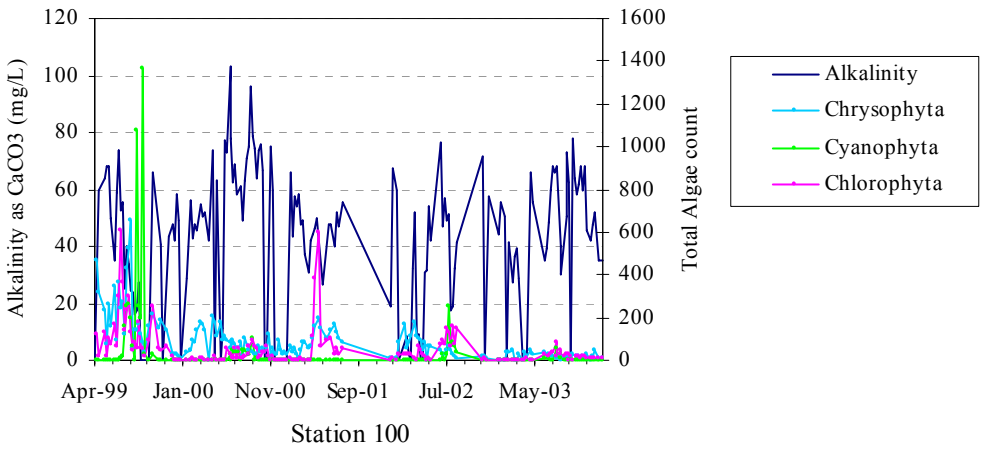


Figure 36. Total Algae counts against Alkalinity measured at Station 100

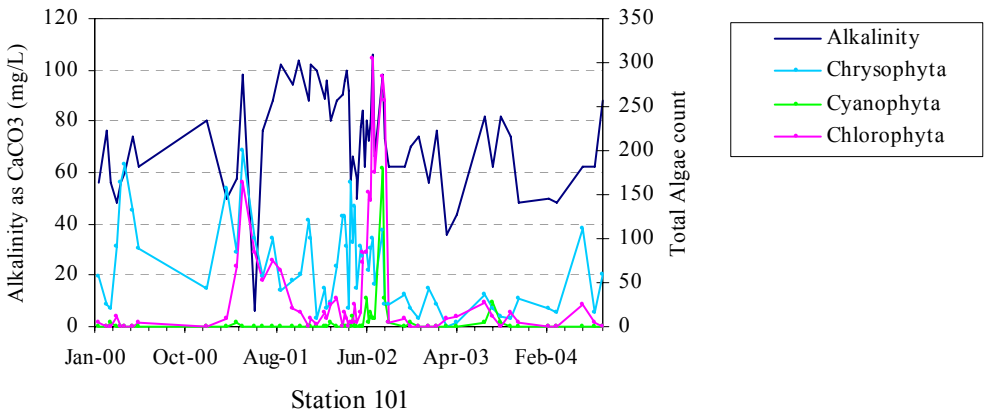


Figure 37. Total Algae counts versus Alkalinity measured at Station 101

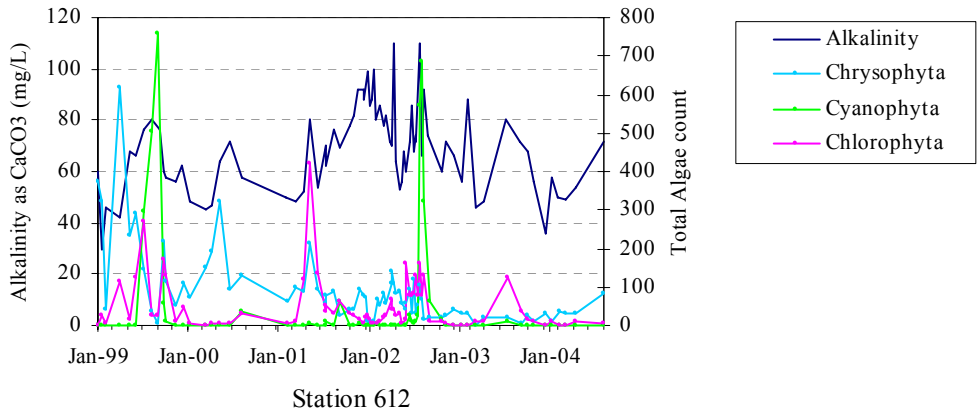


Figure 38. Total Algae counts versus Alkalinity measured at Station 612

7.3.5 Total Hardness

Hardness is a measure of the concentration of divalent cations dissolved in water, and the principal components in most natural water systems are typically calcium and magnesium ions. Hardness is generally defined by the following equation;

$$\text{Hardness} = 2.5(Ca^{2+}) + 4.1(Mg^{2+}) \quad \textbf{(6)}$$

where the Ca^{2+} and Mg^{2+} ion concentrations are measured in mg/l. The hardness represents the equivalent concentration of $CaCO_3$ that would produce an equivalent effect in terms of forming a soft precipitates or reacting in boilers to form a solid scale precipitate. The factors 2.5 and 4.1 represent the ratio of $CaCO_3$ formula mass to Ca and Mg atomic masses, respectively. Water with hardness below 75 mg/l is considered "soft" and water with hardness above 150 mg/l is considered hard.

At Station 100 as shown in Figure 39, the cyanobacteria bloom episodes in August and September 1999 occurred when corresponding total hardness was measured within the range 107 to 144 mg/l of $CaCO_3$, which by standard can be considered as moderately hard to hard water. The highest chrysophyta and chlorophyta counts occurred in the same year when water was hard (total hardness is above 150 mg/l of $CaCO_3$). Figure 40 depicts the comparison plot of different algae counts against total hardness at Station 101. As shown, the highest levels in all three algae types occurred during times when water was hard (above 120 mg/l of $CaCO_3$). As depicted by the figure, other higher chrysophyta concentrations coincided with moderately hard water as well. At Station 612, the two cyanobacteria bloom events and the highest chrysophyta and chlorophyta event coincided with moderately hard water (below 120 mg/l of $CaCO_3$). Figure 41 depicts these trends.

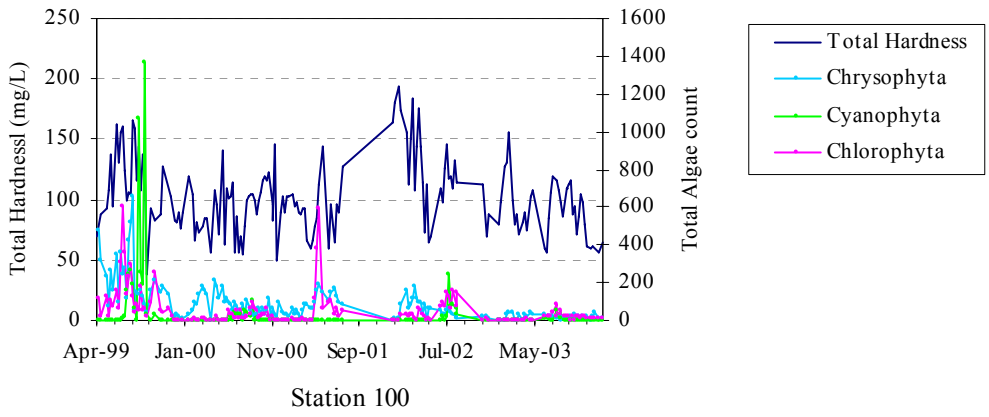


Figure 39. Total Algae counts versus Total Hardness measured at Station 100

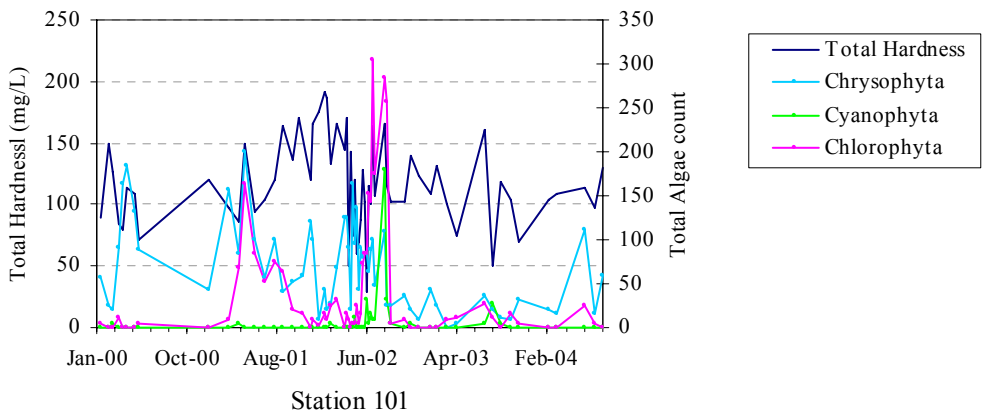


Figure 40. Total Algae counts versus Total Hardness measured at Station 101

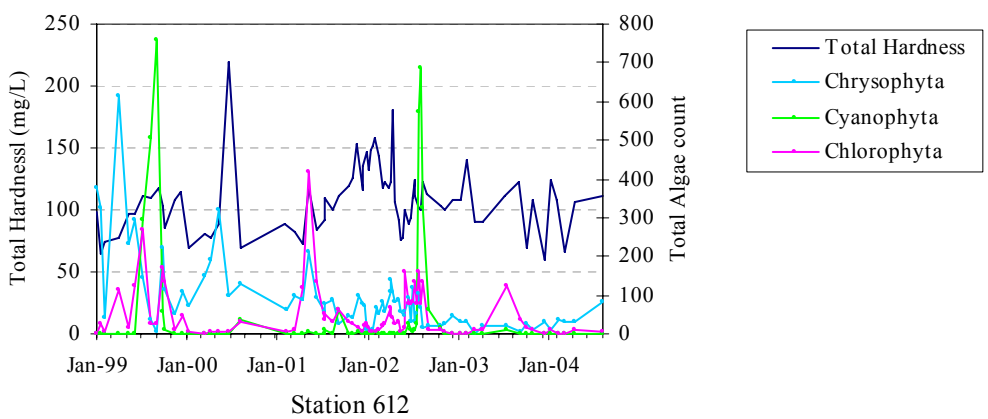


Figure 41. Total Algae counts versus Total Hardness measured at Station 612

7.3.6 Conductivity

Conductivity is a meaure of electrical current flow through a solution, is expressed in units of microSiemens (*u*S). Because conductivity increases nearly linearly with increasing ion concentration, it is generally found to be good measure of the concentration of total dissolved solids in water, which may contain nutrients available for algal growth, or other ions, such as chloride, which may inhibit it.

Figures 42 through 44 depict the algae counts against the conductivity measurements at the three sampling stations. All three stations exhibited the same distinct patterns: high algae levels corresponding with high conductivity measurement, and low algae levels with low conductivity measurements. The highest conductivity values measured at three stations occurred during the same measurement event, January 2002, at 1312 umhos/cm for Station 100, 1307 umhos/cm for Station 101, and 756 umhos/cm for Station 612.

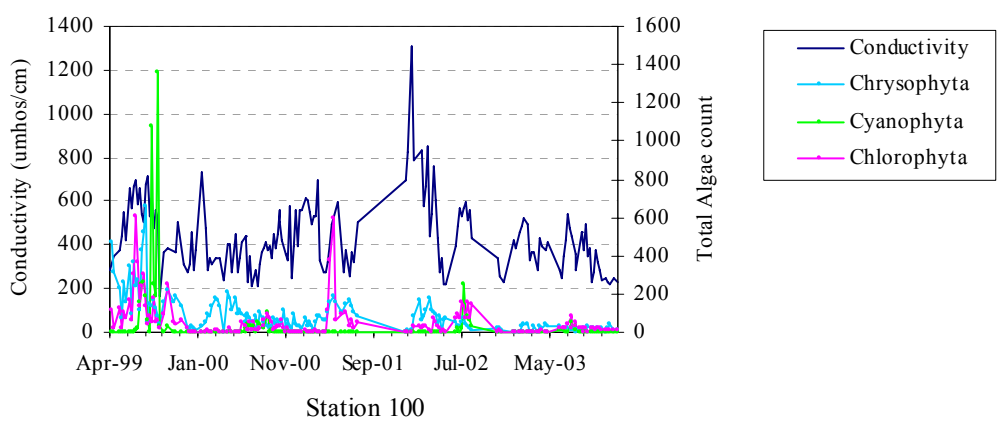


Figure 42. Total Algae counts versus Conductivity measured at Station 100

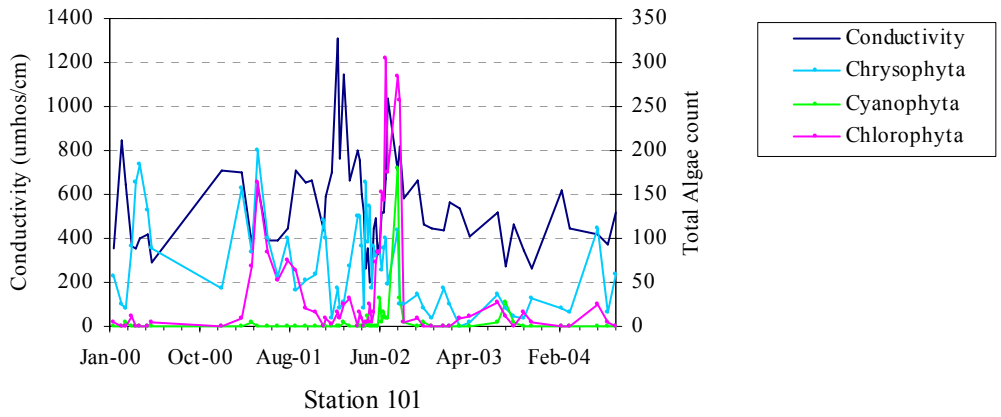


Figure 43. Total Algae counts versus Conductivity measured at Station 101

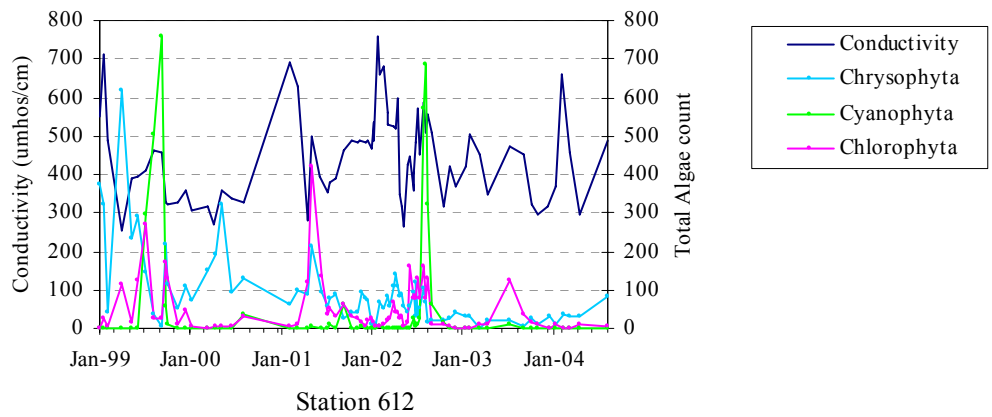


Figure 44. Total Algae counts versus Conductivity measured at Station 612

Algae levels during this event were correspondingly low at all three stations. At station 100, the cyanobacteria bloom episodes in August and September 1999, as well as the high chrysophytes and chlorophytes counts occurred during periods when conductivity were moderately high, from 593 to 717 756 umhos/cm. At Station 101, the single cyanobacteria bloom episodes in August 2002 coincide with conductivity level of 701 umhos/cm, while the highest chrysophytes counts that occurred in July to August 2002 occurred during periods when conductivity was considerably high, within the range of 637 to 1037 umhos/cm. High chlorophytes counts, on the other hand, coincide with low to moderate conductivity. At Station 612, the two cyanobacteria bloom episodes in September 1999 and August 2002 coincide with moderate conductivity level, from over 400 and over 500 umhos/cm, respectively.

7.3.7 Total Suspended Solids

Total Suspended Solids (TSS) consist of sand, silt and fine organic matters such as leaves, pieces of woods, etc. suspended in streams or lakes. High flows can increase TSS as water erodes banks and prevent the suspended solids from settling to the river bottom. High suspended solids can also exacerbate chemical degradation of water quality. Pesticides and bacteria that attach to them are more readily transportable, and their advection downstream can kill plants and animals, while making the water less safe or even undrinkable to humans and wildlife.

TSS data were available only for Station 100. As depicted by Figure 45, the four-year record at this station shows that the highest TSS at 47 mg/l was measured in March and April 2001. It was observed that the cyanobacteria bloom episodes that occurred in August and September 1999 coincide with higher TSS values measured at 16 and 34 mg/l, respectively. During lower periods of TSS, all three algae levels were correspondingly low.

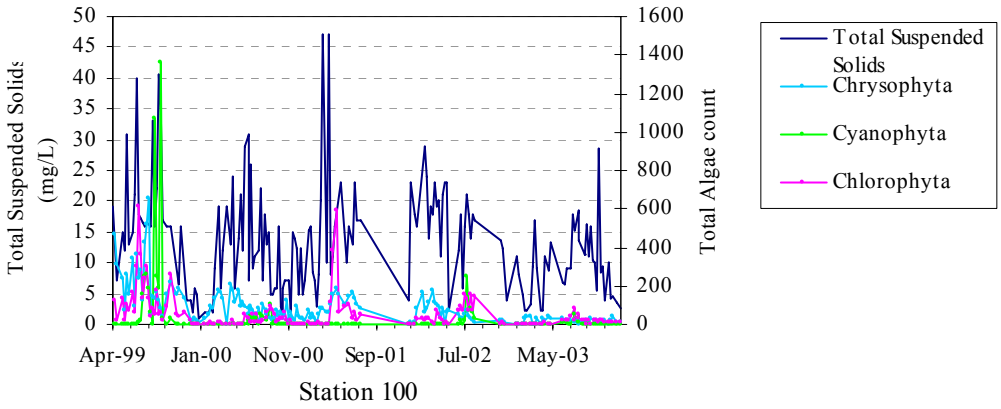


Figure 45. Total Algae counts versus Total Suspended Solids measured at Station 100

7.3.8 Total Amorphous Materials

Aggregate particles not passing through the 0.45 µm pore-size filter during rapid processing of water samples with materials along streams and rivers are more often

described as being amorphous. They consist of various unidentifiable fragments of organic and inorganic matter bound in an organic matrix. Sometimes the components are identifiable and may consist of diatom frustules or animal remain.

Particles passing the 0.45 μm pore-size filter are considered discrete materials and can be further classified into dissolved organic matter (DOM) and particulate organic matter (POM).

7.3.9 Color

Suspended sediments and organic matter (e.g. algae) affect the color of water in rivers or reservoirs. The green water that promotes fish production comes from billions of suspended microscopic algae. Eventually, the algae are consumed and/or simply die-off and the color of water will change. Sediments washed into rivers after heavy rains will also change the color of water, and as settling proceeds, the water color will return to normal, which may take several days. Obviously water that is too dark will inhibit photosynthesis necessary for algae to flourish.

There is no available data for color measurements at Station 100. At Station 101, the two highest color units were both recorded in 2002, at 96 Cu in June and at 153 Cu in April, while the lowest reading of 15 Cu, also in 2002, was recorded in August. As shown in Figure 46, high algae counts at this station occurred during periods of moderate color units, from 65 to 75 Cu. At Station 612 however, a different relationship was observed, where cyanobacteria bloom episodes in 1999 and 2002 corresponded with the two highest color measurements of 92 and 195 Cu, respectively. The two other algae types did not exhibit any consistent correlation with color levels. Plot of the three algae counts against the color measured at Station 612 is presented in Figure 47.

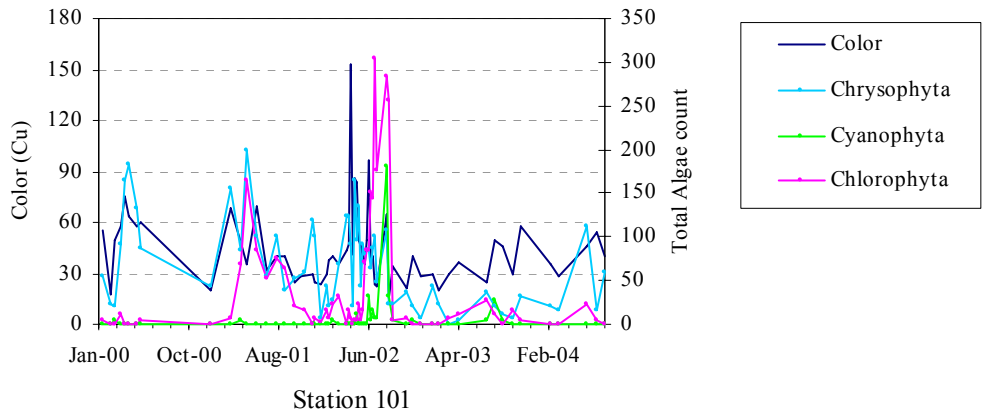


Figure 46. Total Algae counts against Color measured at Station 101

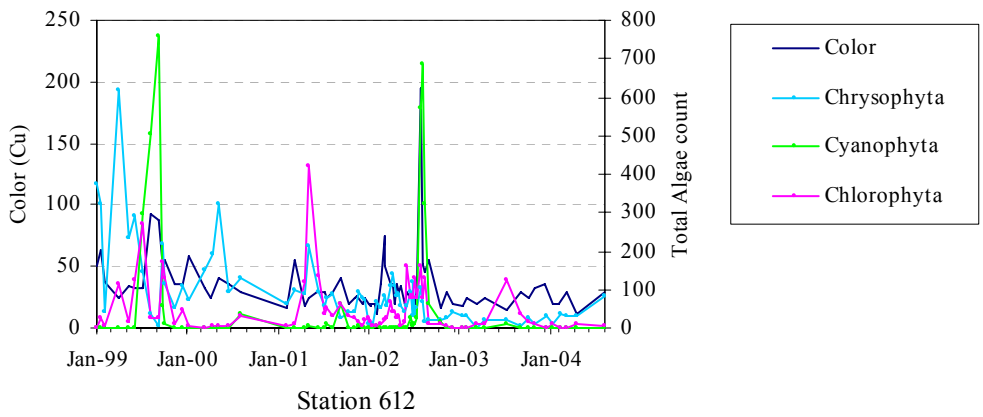


Figure 47. Total Algae counts against Color measured at Station 612

7.3.10 Odor

Odor in water is usually caused by organic compounds, inorganic salts, or dissolved gases as well as microscopic organisms such as algae. Seasonal occurrences of musty/moldy or earthy odors in rivers are due to naturally occurring algal and fungal by-products. Compounds known as Methyl-Isoborneol (MIB) and Geosmin are algal metabolites and can be released to the water during algae die off. These compounds are usually stable and difficult to remove.

7.4 Chemical Data

7.4.1 Dissolved Oxygen

Chrysophytes, chlorophytes and cyanobacteria like plants use the energy of sunlight to make their own food through the process called photosynthesis, and produce oxygen as byproduct of the process. Dissolved oxygen (DO) is consumed by algae through respiration and during decomposition as the algae are broken down by bacteria.

Figures 48, 49 and 50 depict DO measurements at the three sampling stations plotted against their corresponding algae levels. Station 100 exhibited a more distinct pattern in which generally higher DO levels, ranging from 13.8 to 16.2 mg/l, were measured from the end of the year to beginning of the following year. Most of the cyanobacteria blooms at this station, including the two particularly high count events in August and September 1999, coincided with period of lower DO levels. However, the bloom events in July and early August 1999 occurred during periods of relatively high DO levels, at 10.4 to 12.5 mg/l, respectively. Most of the higher counts of chrysophyta and chlorophyta also coincide with periods of relatively low DO levels. At Station 101 no distinct pattern between algae and DO levels emerges from the data, as shown by the figure. Higher algae levels occurred during both higher and lower DO levels. The highest DO level at this station was measured at 15.1 mg/l in February 2000, while the lowest at 5.34 and 5.52 mg/l were measured in August and June of the same year, respectively. At station 612, DO levels fluctuate from 4.8 to 13 mg/l during the years 1999 to 2000. However, at the beginning of 2001, DO levels were high and progressively increased towards the end of the year. A high spike (15.4 mg/l) in August 2002 coincided with a cyanobacteria bloom at this station. The other cyanobacteria bloom at Station 612, in 1999 coincide with high DO level, however high counts of chryosphyta and chlorophyta coincide with periods of relatively low DO levels.

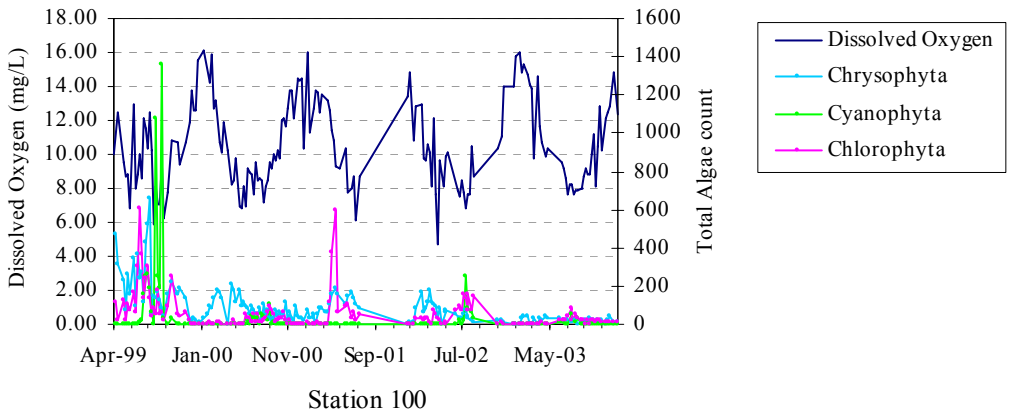


Figure 48. Total Algae counts versus Dissolved Oxygen measured at Station 100

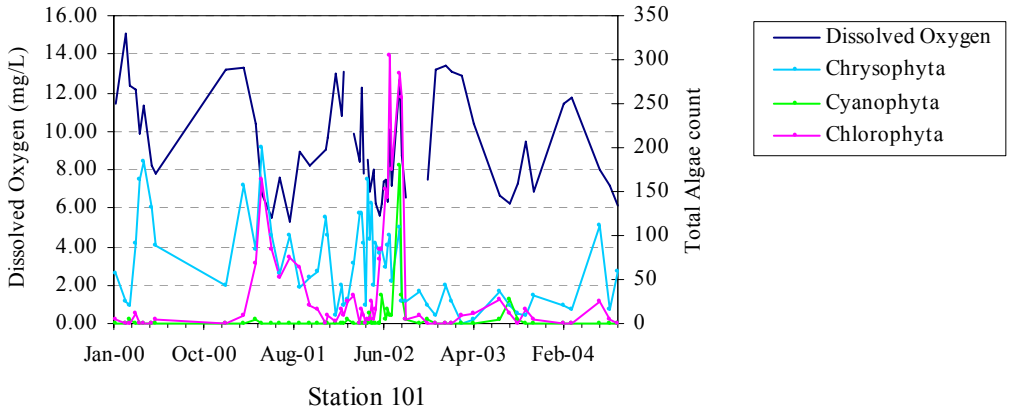


Figure 49. Total Algae counts versus Dissolved Oxygen measured at Station 101

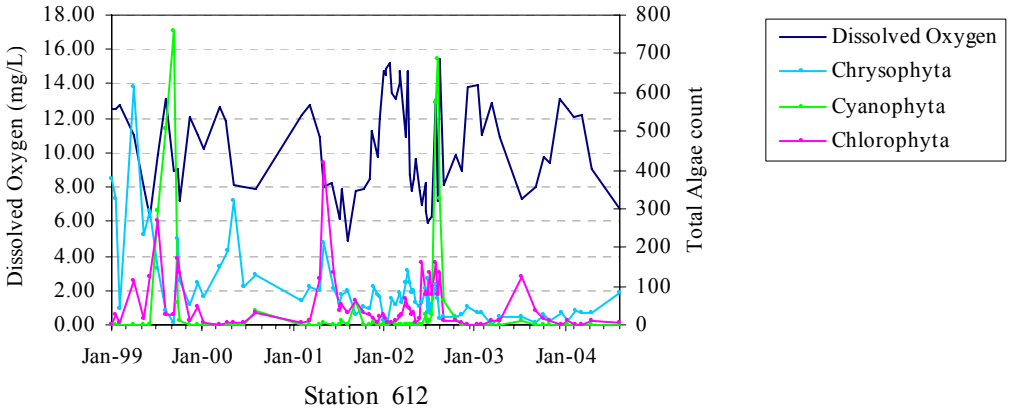


Figure 50. Total Algae counts versus Dissolved Oxygen measured at Station 612

7.4.2 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is a measure of the amount of dissolved oxygen in the water required by the aerobic organisms to breakdown organic matter. It is sometimes referred to biological oxygen demand. Higher amounts of organic material in the water body results in higher oxygen consumption by the organisms for aerobic oxidation. In extreme cases, an overabundance of organic material can result in depletion of DO, which can stress or kill other aquatic life.

As depicted by Figure 51, BOD levels at Station 100 ranged from 0.70 to 10.2 mg/l, and fluctuated on a weekly basis over the 4-year record. Algae levels do not appear to correlate either positively or negatively with BOD levels. Similarly, at Station 101, no obvious relationship between BOD and algae levels can be discerned as depicted by Figure 52. The BOD levels at this station ranged from 0.40 mg/l August 2004 to 8.10 mg/l in June 2001. Incidences of high algae concentrations occurred for all different levels of BOD. At Station 612 and shown in Figure 53, BOD levels over the 4-year record showed no distinct pattern, although relationships between BOD levels and algae counts do emerge.

The maximum level was measured at 10 mg/l in August 1999, while the lowest at 1.58 mg/l was measured in June 2002. At this station, high algae levels occurred mostly during the periods of high BOD. The two cyanobacteria bloom episodes that occurred in 1999 and 2002 as well as the highest chlorophyta levels in 2001 coincide with high BOD levels. The same positive correlation can be observed for chrysophyta, where higher counts correspond with higher BOD, with exception to April 1999, when the highest measured chrysophyta event occurred during a low BOD period.

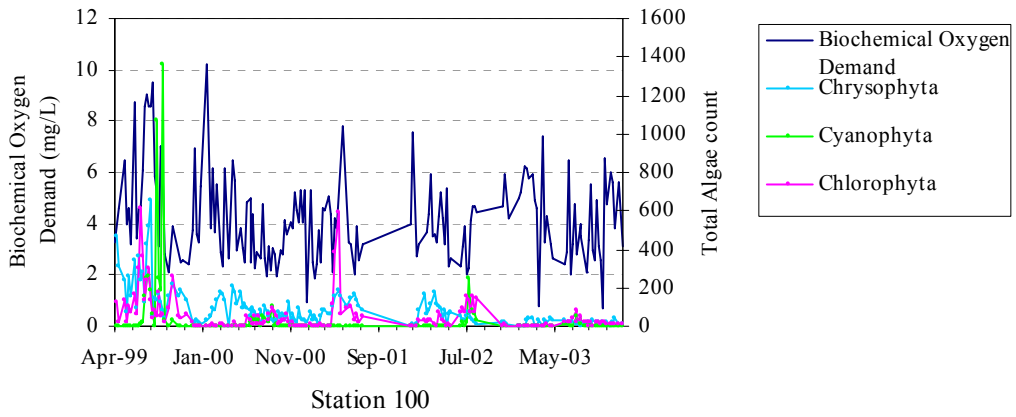


Figure 51. Total Algae counts versus Biochemical Oxygen Demand measured at Station 100

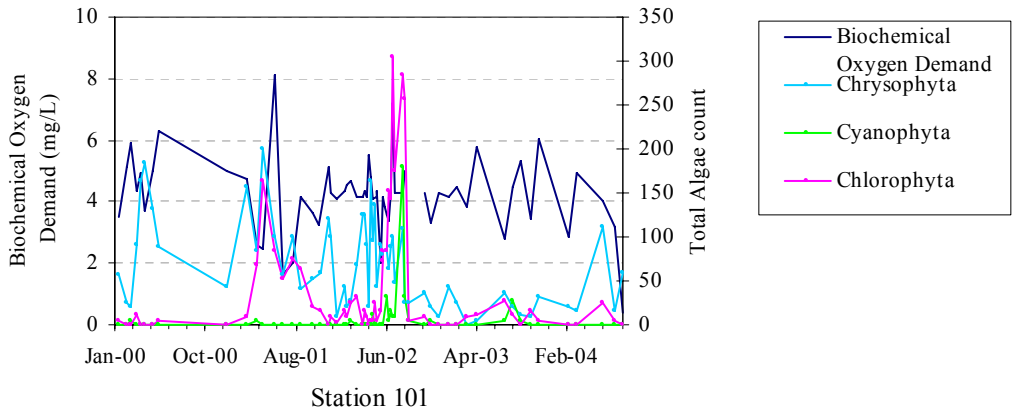


Figure 52. Total Algae counts versus Biochemical Oxygen Demand measured at Station 101

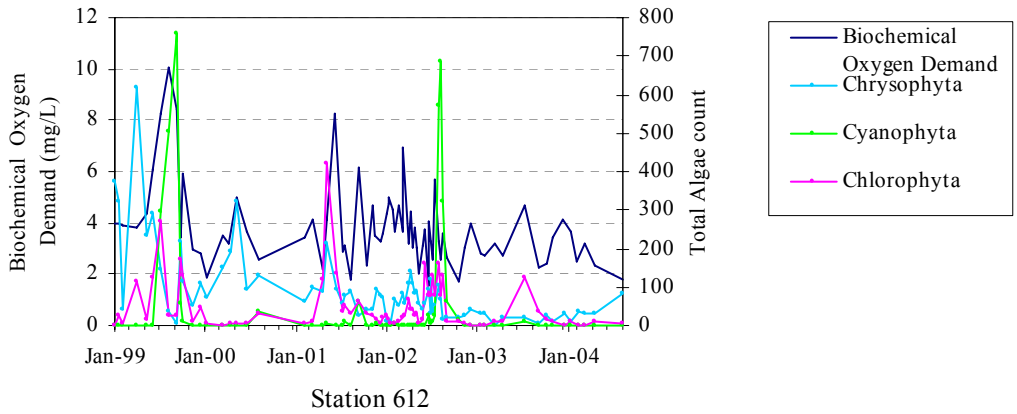


Figure 53. Total Algae counts versus Biochemical Oxygen Demand measured at Station 612

7.4.3 Nitrogen Compounds

Nitrogen, as an integral component of proteins and nucleic acids (like carbon), is required by all organisms to grow and reproduce. Dissolved nitrogen in water bodies may originate from a number of different sources. Organic forms may enter streams from surface runoff or groundwater sources, while proteins that contain organic nitrogen which are released by decomposing organic matters are broken down by bacteria to form ammonium (NH_4^+). Under very alkaline conditions (pH > 9), ammonium is converted to ammonia (NH_3). Inorganic forms of nitrogen, namely nitrate (NO_3), nitrite (NO_2), ammonia (NH_3) and nitrogen gas (N_2), are products of different nitrogen processes. Ammonium is the preferred nitrogen source for most algae.

Nitrite and nitrate are formed through the process of nitrification, in which ammonium is oxidized (combined with oxygen) by specialized bacteria and transformed into nitrate (NO_3) with nitrite (NO_2) as an intermediate product. The two steps of nitrification are performed by different bacterial species, the ammonium oxidizers and nitrate oxidizers, which convert ammonium to nitrite (NH_4^+ to NO_2) and nitrite to nitrate (NO_2 to NO_3), respectively. Nitrate is usually the most prevalent form of nitrogen in lakes that can be used by most aquatic plants and algae, as nitrite is relatively short-lived in water due to its rapid conversion to nitrate by bacteria. Nitrate and/or nitrite can be harmful to humans and wildlife at high concentration.

As depicted by Figure 54, no distinct pattern of ammonia concentrations can be observed at Station 100. High concentrations were measured four times over four different years; 0.43 mg/l in November 1999; 0.42 mg/l in December 2000; 0.41 mg/l in April 2002; and 0.33 mg/l in February 2003. The cyanobacteria bloom episodes in August and September 1999 as well as high cyanobacteria counts in July 2002, all coincide with low ammonia concentration below 0.05 mg/l. The same behavior was observed for chrysophyta and chlorophyta, that is, high algal counts occurred during low ammonia concentration periods usually below 0.05 mg/l.

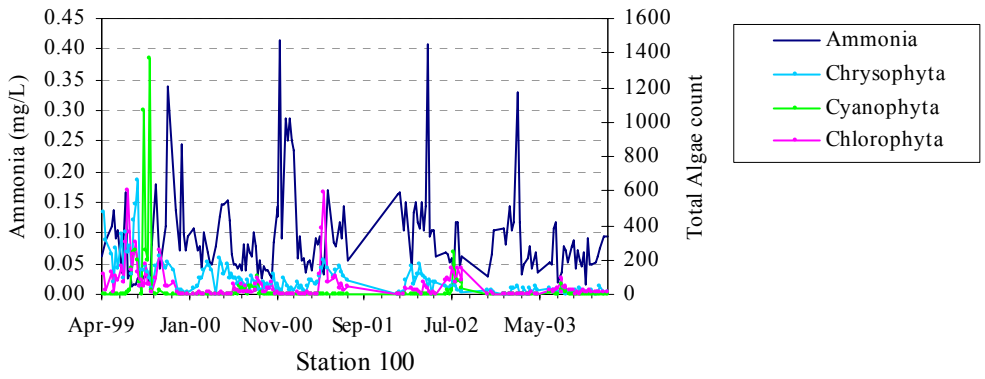


Figure 54. Total Algae counts versus Ammonia measured at Station 100

As depicted by Figure 55 below at Station 101, ammonia concentrations fluctuated over time, from a low 0.02 mg/l in July and August 2002 and November 2003 to a high of 0.43 mg/l in January 2002. The three algae classes behaved differently in response to ammonia concentration. The lone cyanobacteria bloom episode at this station occurred at the lowest ammonia concentration of 0.02 mg/l. Similarly, the highest chlorophytes counts also coincide with the lowest concentration. On the contrary several higher chlorophytes counts coincided with relatively high ammonia concentrations that ranged from 0.02 to 0.10 mg/l. Chrysophyta counts on the other hand, coincide with moderate ammonia concentrations ranging from 0.07 to more than 0.16 mg/l.

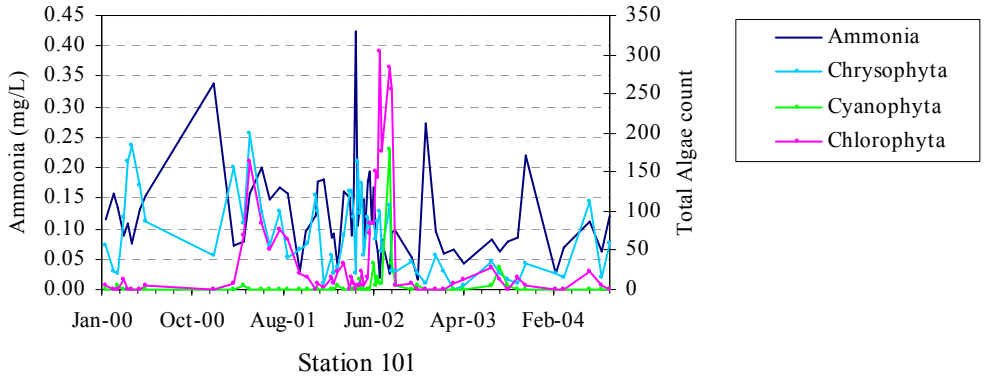


Figure 55. Total Algae counts versus Ammonia measured at Station 101

At Station 612, as with the other two stations, ammonia concentrations varied over time, ranging from a low of 0.01 mg/l in July and August 1999 to a high of 0.19 mg/l in January 2002. During 2000 and 2001, there were more dramatic weekly fluctuations as

compared to the years 1999, 2003, and 2004. Similar to the other two stations, the two cyanobacteria bloom episodes that occurred in July to September 1999 and July to August 2002 coincide with low ammonia levels less than 0.05 mg/l. As with cyanobacteria, the highest chrysophytes counts coincide with low ammonia levels below 0.05 mg/l, while the other higher counts occurred with ammonia levels above 0.05 and 0.17 mg/l. The highest chlorophytes counts occurred with ammonia concentrations at 0.05 mg/l. Comparison plot of nitrite/nitrate measured at Station 612 against the three algae counts is shown below in Figure 56.

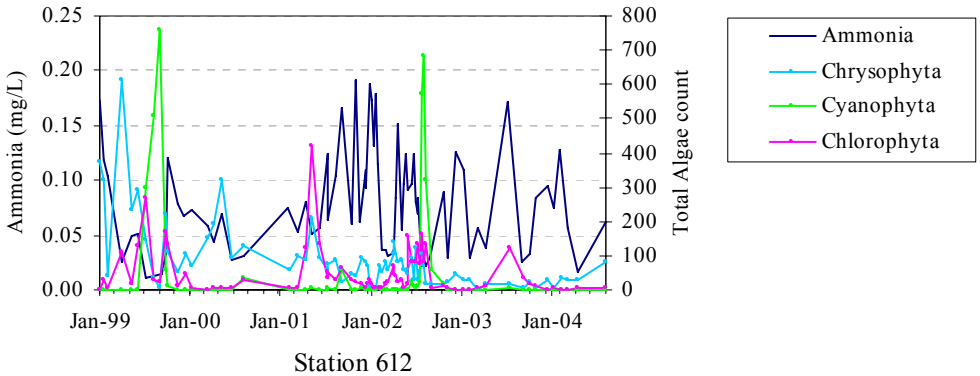


Figure 56. Total Algae counts versus Ammonia measured at Station 612

As also depicted by Figures 57 through 59, nitrite/nitrate concentrations, like ammonia, did not exhibit any consistent patterns at the three stations with respect to time or algae counts. At station 100, measured concentrations ranged from a low of 0.03 mg/l measured in November 2000 to a high of 5.34 mg/l measured in January 2002. Over the five-year record, particularly high nitrite/nitrate concentrations were observed in 1999, 2000 and 2002, during which the three algae types exhibited conflicting patterns. The highest nutrient concentrations in 1999 measured from June to September 1999 coincide with the highest counts of all three algae types. Similarly, the highest algal counts for 2000 also coincided with the highest concentrations, measured in December 2000. In contrast, all three algae classes had relatively low measured counts in January to April 2002 when nitrite/nitrate was again the highest during the year. In fact, measured cyanobacteria counts for this period were zero, chrysophyta counts were moderate and chlorophyta counts were relatively low.

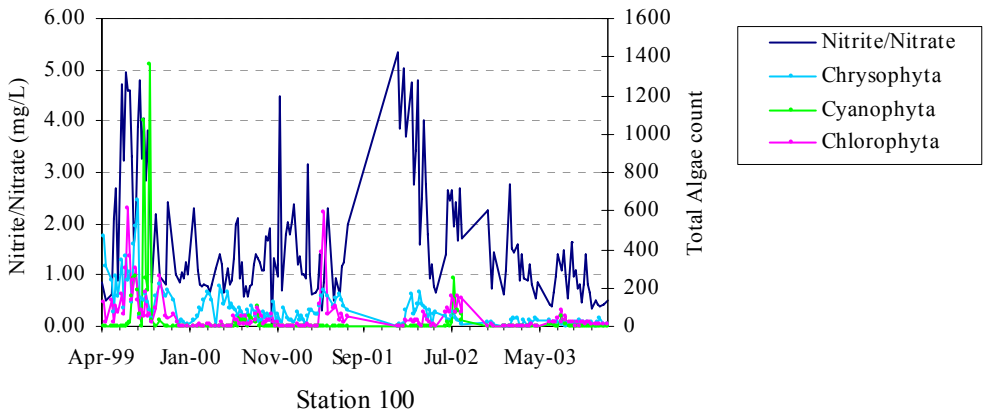


Figure 57. Total Algae counts versus Nitrite/Nitrate measured at Station 100

At Station 101, the sampling events in October 2001 and January 2002 yielded the two highest concentrations for this station with values measured at 5.94 and 6.15 mg/l, respectively. As depicted by the Figure 58, high algae levels coincide predominantly with low nitrite/nitrate concentrations. A notable exception occurred during the period July to September 2002, when the highest chlorophyta and cyanobacteria levels as well as moderate levels of chrysophyta coincide with fairly high nitrite/nitrate concentrations. Figure 59 shows that at Station 612, the highest nitrite/nitrate concentrations were measured in November 2001 at 3.70 mg/l, with moderately high concentrations also occurring in January, February and April of 2002. As can be seen in the figure, the three algae types behaved differently in response to variable nitrite/nitrate concentrations. High levels of chrysophyta occurred during lower concentration events, while high chlorophyta levels occurred during both lower and higher nitrite/nitrate concentration events. In contrast, Cyanobacteria bloom events in September 1999 and August 2002 coincide with moderate level of nitrite/nitrate concentrations.

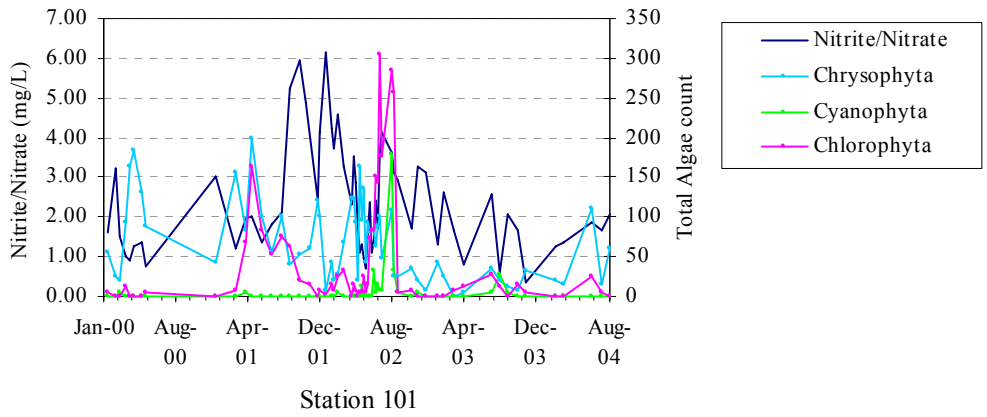


Figure 58. Total Algae counts versus Nitrite/Nitrate measured at Station 101

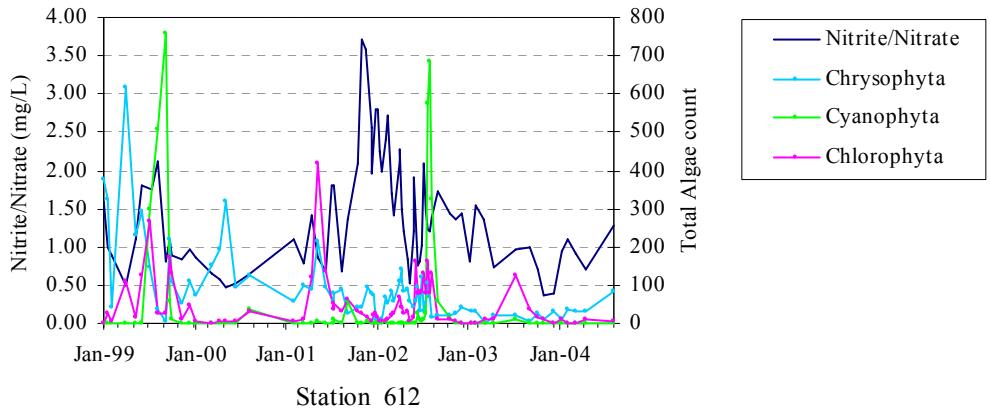


Figure 59. Total Algae counts versus Nitrite/Nitrate measured at Station 612

Because nitrogen compounds are important nutrients for algae growth, higher algae levels might be expected immediately following or during periods of nitrogen concentrations. However, the different observed relationships between the three types of algae types and the nitrite/nitrate levels at the three stations underscores the complex algae population dynamics that is certainly affected by multiple factors and conditions.

7.4.4 Total Phosphorus/Orthophosphate

Phosphorus as a structural component of nucleic acids and a key component of a cell's regulatory machinery (of signal transduction enzymes, nucleotides, factors and co-factors, etc.) is an essential nutrient that stimulates the growth of algae and aquatic plants.

It is considered as the limiting factor for algae and plants growth, as both will not grow if there is not enough phosphorus, even when plenty of other nutrients are present in water. The simplest form of phosphorus found in water is orthophosphate, which algae most readily consume.

Figure 60 shows that at station 100, no distinct pattern can be observed in the total phosphorous/orthophosphate concentrations over the study period. The measured total phosphorous/orthophosphate concentrations ranged from 0.003 to 1.71 mg/l. The three algae classes, all with the highest counts measured in 1999, behaved differently in terms of the nutrient concentrations. The two particularly high cyanobacteria counts in August and September 1999 coincide with moderately high nutrient concentrations from 0.7 to 0.82 mg/l. Similarly, the highest Chrysophyta count also coincides with moderate nutrient concentration of 0.84 mg/l. However, several higher chrysophyta counts also occurring during this year coincide with a range of concentrations for this variable, from a low 0.07 to as high as 1.27 mg/l. Chlorophyta showed somewhat more consistency; the highest count in 1999 and a fairly high count in 2001 both occurred when concentration were low, at 0.003 and 0.02 mg/l, respectively.

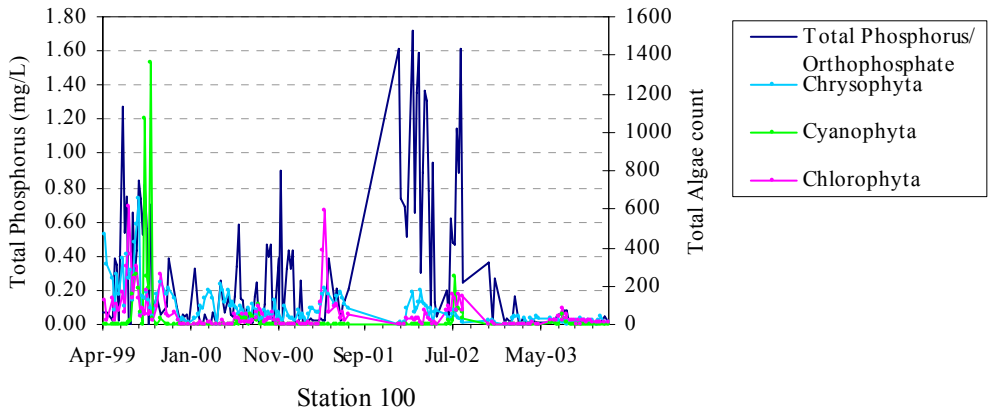


Figure 60. Total Algae counts versus Total Phosphorous/Orthophosphate measured at Station 100

As depicted by Figure 61, at station 101, a number of events of high total phosphorous/orthophosphate concentrations were measured from November 2001 (when the highest concentration was measured at 2.49 mg/l) to November 2002. Incidentally,

the highest chlorophyta levels, the cyanobacteria bloom episode and higher level of chrysophyta occurred simultaneously from July to September 2002, which coincide with the period of high total phosphorus/orthophosphate concentrations at this station. Station 612 also experienced several high total phosphorus/orthophosphate concentrations during the 4-year study period as shown by Figure 62. Among the peaks, the highest was in September 2001 at 1.58 mg/l. The two cyanobacteria bloom episodes in September 1999 and August 2002 at this station coincide with high total phosphorus/orthophosphate concentrations, while high levels of chrysophyta and chlorophyta occurred during periods of both low and high levels for this chemical.

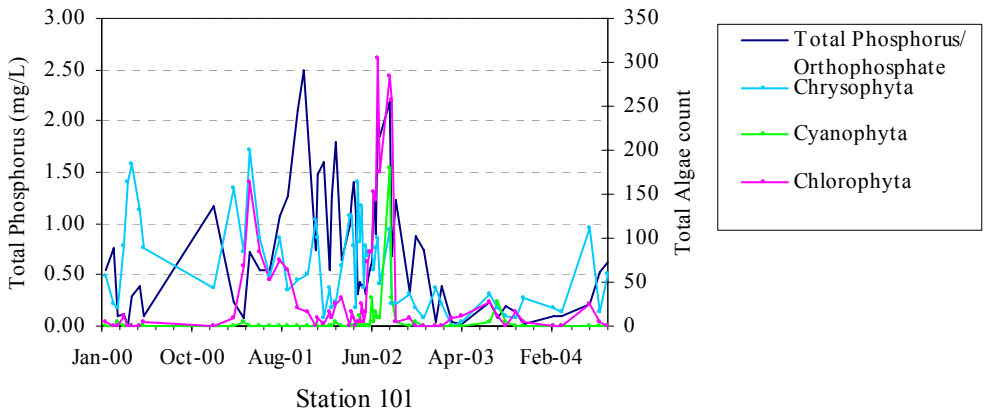


Figure 61. Total Algae counts versus Total Phosphorous/Orthophosphate measured at Station 101

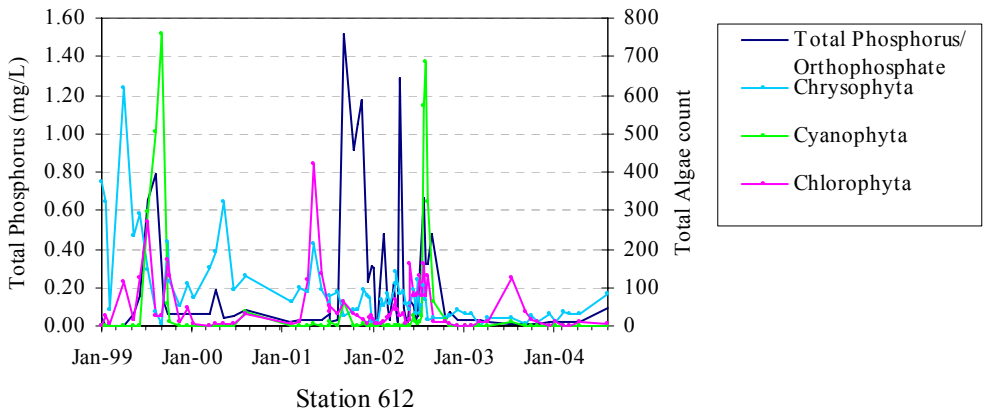


Figure 62. Total Algae counts versus Total Phosphorous/Orthophosphate measured at Station 612

7.4.5 Total Organic Carbon

Total Organic Carbon (TOC) is the total amount of organic matter found in natural water, including suspended particulate and dissolved organic carbon, which are essential components of the carbon cycle. Organic matter plays a major role in aquatic systems because it affects biogeochemical processes, nutrient cycling, biological availability, chemical transport and interactions. It also has direct implications in the planning of wastewater treatment and drinking water treatment. The TOC of a water body is affected by several factors, including vegetation, climate and treated sewage.

At station 100 as depicted by Figure 63 below, the four-year record showed no distinct pattern. There were several high TOC events, the highest of which was measured in May 2002 at 11.34 mg/l. High algae counts at this station coincide with TOC values between approximately 4 and 6 mg/l. Figure 64 below shows that at Station 101, the highest TOC level measured in August 2002 at 17.2 mg/l coincide with a cyanobacteria bloom episode and the second highest chlorophytes count. The highest chlorophytes counts as well as high chrysophytes counts occurred when TOC levels were below 6 mg/l. At station 612, there were little variations in TOC levels from January 1999 to October 2002. As depicted by Figure 65, the highest TOC was measured in August 2004 at 8.48 mg/l. Measured high counts of all three algae types occurred during periods when TOC was between 3 and 5 mg/l.

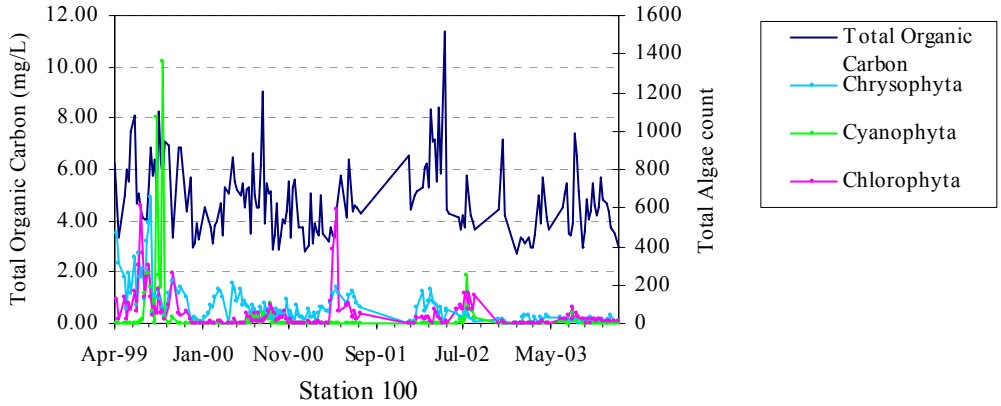


Figure 63. Total Algae counts versus Total Organic Carbon measured at Station 100

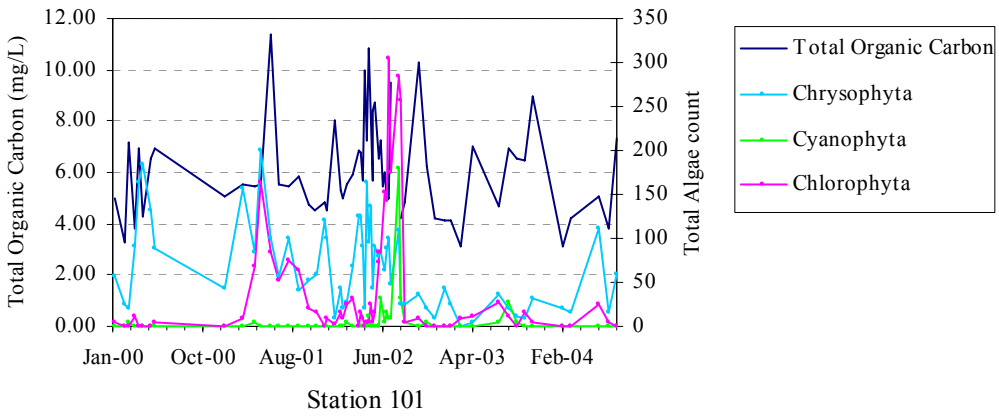


Figure 64. Total Algae counts versus Total Organic Carbon measured at Station 101

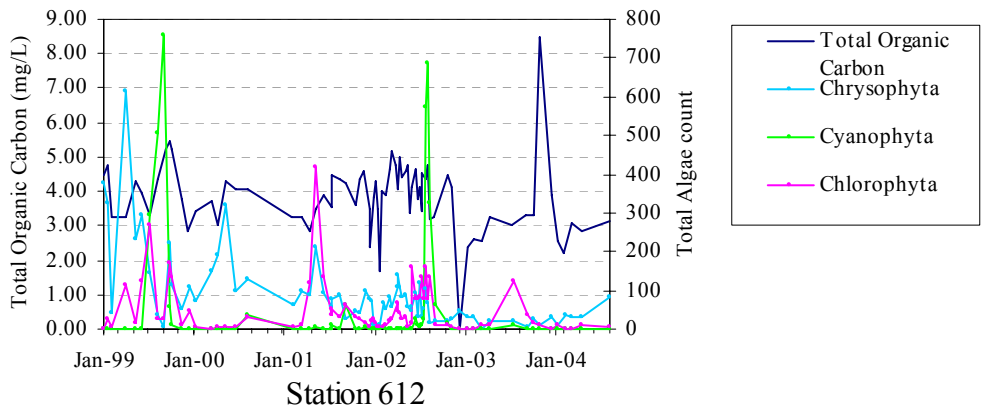


Figure 65. Total Algae counts versus Total Organic Carbon measured at Station 612

7.4.6 Chloride

Chlorides are binary compounds of chlorine chemically combined with a metal. The presence of chloride in water bodies where it does not occur naturally indicates possible pollution, along with excessive nutrients or bacteria. Sources of chloride include septic systems, wastewater treatment plant effluent, animal waste, potash fertilizer, and drainage from rock salt applied to roads, parking lots and sidewalks to lower the melting point of ice The normal range of chloride in fresh surface water systems is 45-155 mg/L, while USEPA has set a public drinking water standard of 250 mg/L.

Elevated chlorides can kill plants and wildlife, and may affect other organisms present in water including algae**.** Small amounts of chlorides are necessary for normal cell functions in plant and animal life. However, fish and aquatic animals can not live in high levels of chlorides.

Chloride concentrations over time at stations 100, 101 and 612 are shown in Figures 66, 67 and 68, respectively. At Station 100, a temporal pattern of chloride concentrations for the year 2000 to 2003 is evident, with peak concentrations occurring in late winter/early spring (January to March), after which concentrations decline and remain low through summer months. The highest chloride level at 283 mg/l was measured in January 2002. A notable exception to this otherwise consistent temporal pattern occurred in 1999, when the highest measured concentration of 164 mg/l occurred in July. High algae levels occurred mostly during moderate chloride concentrations. At Station 101, four high chloride events were measured from 2000 to 2002 with values ranging from 172 (February 2002) to 192 mg/l (February 2000). In 2000, another high chloride concentration occurred in August to September which coincides with the highest chlorophyta level and algal bloom incidence. Chrysophyta level on the other hand was moderate during this period. At Station 612, peak concentrations were observed in January to March with values ranging from 127 mg/l in March 2003 to 174 mg/l in January 2002. At this station however, most of high algae levels coincide with periods of moderate chloride concentrations.

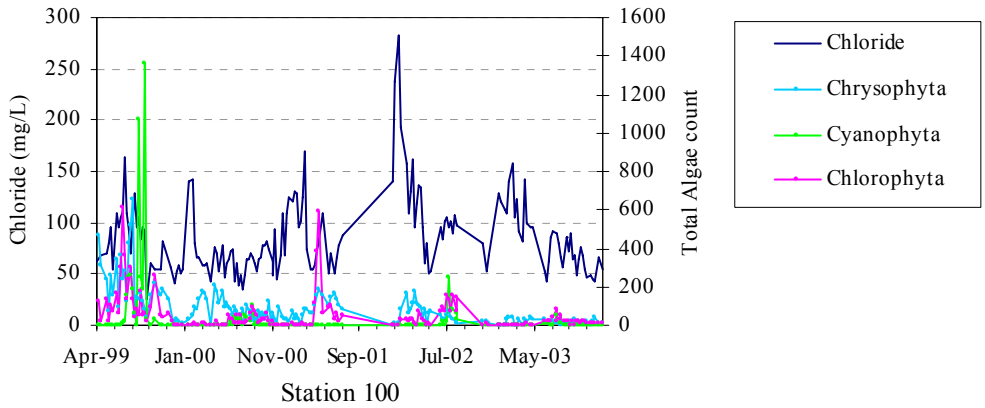


Figure 66. Total Algae counts versus Chloride measured at Station 100

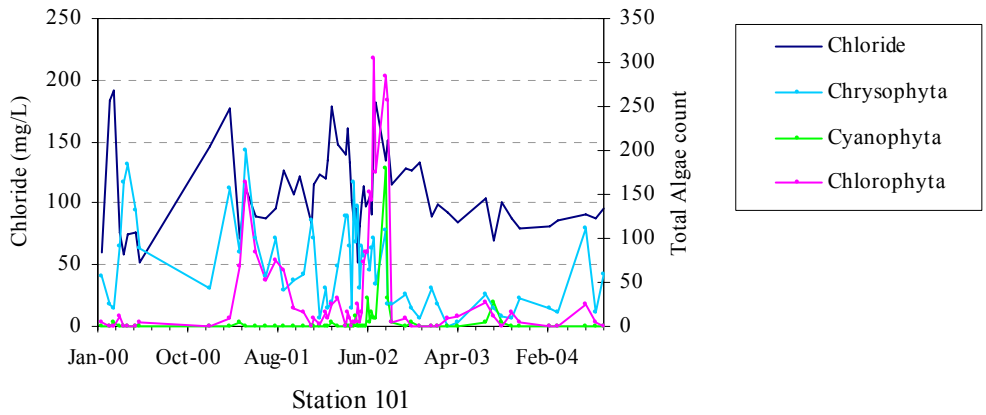


Figure 67. Total Algae counts versus Chloride measured at Station 101

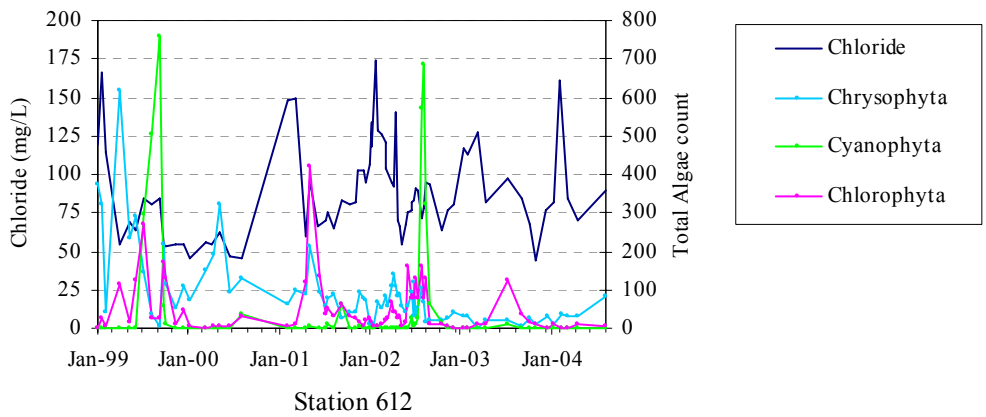


Figure 68. Total Algae counts versus Chloride measured at Station 612

7.5 Climate Data

7.5.1 Precipitation

In most algal bloom studies, precipitation is generally not considered one of the major controlling factors. However, as blooms occur in response to a variety of natural conditions, it is important that the potential affect of precipitation on these events not be excluded. During relatively high precipitation events, when run-off is generated, large amounts of nutrients are delivered to surface water bodies. This nutrient loading promotes the growth of aquatic plants and algae. Another impact due to precipitation, when it is minimal or absent, is a decline in surface water levels with an associated

decrease in flow rate. Low flow conditions increase the retention time of the water along any stretch of river, and thus increase the time available for algae to grow. Low flow conditions also promote water column stability, which enhances the ability of the algae to optimally locate themselves within the water column for photosynthesis.

Three weather stations located in proximity to the study area and operated by NOAA were used for the ANN development. These stations include Caldwell, located approximately 6 miles to the southwest, Newark, located 11.4 miles to the south, and Tetterboro, located 9 miles to the southeast. Data collected during the study period from 1999 to 2004, showed that distributions of average monthly precipitation totals from all three weather stations were similar. That is, the lowest precipitation of about 2 inches occurred in January and February, the highest precipitation of more than 5 inches occurred in June and September while the rest of the months, all stations received an average monthly precipitation totals of around 3 to 4 inches. For this study, the averages of daily precipitation totals from the three stations were used.

7.5.2 Wind Speed/Direction

Wind direction and speed have influence on the movement and/or mixing of water in the river or lake. As the wind become stronger, it creates waves and underwater currents below the waves. The underwater currents tend to move water particles horizontally and in irregular swirling motion known as turbulence. Nutrients are distributed vertically by turbulence, hence facilitating the recycling of nutrients from sediments and deeper water, which in turn will be available for algae suspended in water. At the other extreme, resuspension of sediments due to turbulence also increase the turbidity of the water and reduce light penetration which can affect the biochemical activity of algae such as photosynthesis.

Available wind speed and direction data used for developing the ANNs were taken from the three NOAA weather stations located in Caldwell, Newark and Tetterboro, all in proximity to the study area.

Computed average wind speeds over the week at the three stations were 7.4 miles per hour (mph) at station 100, 7.3 mph at station 101 and 7.6 mph at station 612. Based upon the data used in the modeling efforts, it was observed that most of high algae levels (all three) occurred during periods when wind speeds were around the average values between 6 to 8 mph. With exception to station 612 in April 1999, when the corresponding wind speed to the highest chrysophytes count was computed to 9.6 mph.

7.5.3 Heating degree days/Sky Cover/Length of Day

For any individual day, heating degree days indicate how far that day's average temperature departed from 65 degrees Fahrenheit, measuring heating energy demand. Sky cover indicates the total cloud cover throughout the entire day, 0.0 indicates a nearly clear sky, where high thin clouds may not be included in the total sky cover for some locations.

As in precipitation and wind direction/speed, data for heating degree days and sky cover used in this study were taken from the three weather stations maintained and operated by NOAA. Again, the stations used were Caldwell, Newark and Tetterboro.

Length of day is the time difference between sunrise and sunset. Sunrise and sunset are defined as instants in the morning/evening under ideal meteorological conditions, with a standard refraction of the sun's rays, when the upper edge of the sun's disk is coincident with an ideal horizon. Length of day has been shown to be an important variable for many higher plants that have “critical photoperiods”, during which growth regulators respond to length of day. The data used in this study was downloaded from a public domain provided as a public service by Horizon Network Security.

8. MODELING APPROACH AND RESULTS

Because the three water quality sampling stations each have distinct water quality and hydrologic conditions (e.g. unique watershed, etc.), each was modeled independently of the others. The validity of this approach was verified by preliminary ANN modeling results presented to DSR and PVWC during an October, 2004 meeting, showing superior modeling performance when each station was modeled individually rather than collectively. This finding was further verified with a comprehensive modeling effort, with the results for modeling all the stations collectively for each prediction period and algae type summarized in Appendix B-4. As previously discussed, many different ANN models were developed and tested for the PVWC, which evolved to address important modeling issues that emerged during this project, following submission of the first draft report to DEP for review.

After organizing the corresponding measurements for each variable by date, the values for the input and output variables were assigned or computed for each prediction event. For many variables, the input value is a single measurement, such as water temperature measured at a particular station on a particular date. For other variables, such as the prediction period's cumulative precipitation, daily values were summed over the period of interest. For other variables, such as wind direction and water temperature, the average daily values were used.

ANNs that explicitly predicted final measured count values constituted the great majority of forecasting models in this study, but eight RBF classification nets were also developed and assessed. Model forecast performances were assessed based upon a number of criteria, including standard statistical measures, such as absolute mean errors and correlation coefficients, statistical discrepancies between training and validation results, the ability of the models to forecast bloom and non-bloom events, the ability of the models to accurately predict relative changes in population counts, and visual comparison of time series. Again, the relatively few number of historical validation events limits the

strength with which conclusions can be drawn, particularly since there are relatively few events where populations change from bloom to non-bloom events, and vice versa. As a final benchmark of performance, LMs were also developed for comparison against ANN performance.

Sensitivity analyses was performed, using both the ratio and ranking method described in the water treatment modeling section, as well as the exclusion of select water quality and water extraction variables. The hope was that certain fundamental trends or tendencies would emerge that might help identify important predictor variables for improving future data collection and modeling strategies.

Most of the modeling results are presented in Appendices B-1 through B-6, with representative results for three test cases presented here. A detailed discussion of the original and revised modeling approaches is provided, followed by the systematic comparison of different modeling approaches that evolved out of the original modeling effort to address important data and modeling issues.

8.1 Original and Revised ANN Modeling Approaches

For the original modeling work, 27 different cases were modeled; the three stations, for the three different algal groups, for three prediction periods consisting of real-time, one-week ahead, and two-weeks ahead. As discussed previously, and presented in the appendices, the original set of ANN models developed for PVWC, which utilized all of the variables listed in Table 19, did not consistently perform well during validation, particularly for cases with smaller data sets. This finding was not unexpected, given the low number of data events, the relatively high number of input variables, and the complexity of algal population dynamics. Another potentially complicating factor considered was the original model inputs reflect conditions existing at or preceding the beginning of the prediction period, which may not be strongly causal and/or correlative factors of algal counts one-week or more into the future. That is, system changes (e.g.

precipitation event(s), hot spell, etc.) over the prediction period of interest, which is not captured or represented by the model inputs, could largely determine the algal populations as measured at the end of the prediction period. Lastly, the original models did not include length of day as an input variable, which ranked fairly high in importance for many of the models.

To further assess the possible disconnection between real-time system conditions and algal counts at some future date, the revised models were developed, with the measurement date of the input values generally corresponding to the prediction date. In a sense, then, these models are developed in a more correlative manner, though, as discussed in more detail later, for real-time operation, the modeler would have to forecast or predict final system conditions. Tables 20 and 21 below specify how the value for each model input type was computed/assigned for the original and revised models, respectively, using sample calendar dates. Again, the most recently developed original and revised models used forecasting periods of one-week and two-weeks ahead, but some three week models were developed in previous work, contained in the Appendices.

Table 20. Input Value Assignments/Computations for Three Prediction Periods for Original ANN Models

Model Variable Type	July 14 (one-week ahead)	July 21 (two-weeks ahead)	July 28 (three-weeks ahead)
Physical Water Parameters	Single Value Measured July 7	Single Value Measured July 7	Single Value Measured July 7
Water Quality Parameters	Single Value Measured July 7	Single Value Measured July 7	Single Value Measured July 7
Streamflows/ River Extractions	Mean Value July 1 – July 7	Mean Value July 1 – July 7	Mean Value July 1 – July 7
Prediction Period's Precipitation Two Week Lag	Total Cumulative June 24– June 30	Total Cumulative June 24 – June 30	Total Cumulative June 24 – June 30
Prediction Period's Precipitation One Week Lag	Total Cumulative July 1 – July 7	Total Cumulative July 1 – July 7	Total Cumulative July 1 – July 7
Other Weather Conditions	Mean Value July 1 – July 7	Mean Value July 1 – July 7	Mean Value July 1 – July 7
Initial Algae Count	July 7	July 7	July 7

Table 21. Input Value Assignments/Computations for Three Prediction Periods for Revised ANN Models

Model Variable Type	July 14 (one-week ahead)	July 21 (two-weeks ahead)	July 28 (three-weeks ahead)
Physical Water Parameters	Single Value Measured July 14	Single Value Measured July 21	Single Value Measured July 28
Water Quality Parameters	Single Value Measured July 14	Single Value Measured July 21	Single Value Measured July 28
Streamflows/ River Extractions	Mean Value July 7 – July 14	Mean Value July 7 – July 21	Mean Value July 7 – July 28
Prediction Period's Lagged Precipitation	Total Cumulative July 1 – July 7	Total Cumulative June 24 – July 7	Total Cumulative June 16 – July 7
Prediction Period's Precipitation	Total Cumulative July 7 – July 14	Total Cumulative July 7 – July 21	Total Cumulative July 7 – July 28
Other Weather Conditions	Mean Value July 7 – July 14	Mean Value July 7 – July 21	Mean Value July 7 – July 28
Initial Algae Count	July 7	July 7	July 7

As depicted by Tables 20 and 21, the major functional difference between the original and revised modeling approaches is the temporal correspondence of the input values with the final predicted algal counts. For the original models, the input values for future prediction periods are generally measured at the beginning of the prediction period, and hence, under real-time conditions, would be explicitly known a-priori. Thus, there is no uncertainty with regard to the values of the input variables. In contrast, for the revised models, input values generally correspond to the end of the prediction period, and hence, under real-time conditions, would have to be assumed or forecasted.

Another important distinction is that, unlike for the revised modeling approach, the original ANN models, for predicting algal counts n days into the future, use exactly the same input values, regardless of the forecast period (e.g. one-week ahead, two-weeks ahead, etc.). This may seem counterintuitive to use identical input values for different prediction periods, but a different model was developed for each different prediction period. It may be, as is discussed in more detail later, that there is a natural and therefore repeatable temporal transition of algal populations from initial state conditions, and thus

the one-week ahead ANN model would "learn" a different rate of algal population changes than the two-week ahead model.

The obvious limitation of the revised modeling approach is the uncertainty regarding model input values, each of which constitutes a prediction problem in itself. However, a number of these variables, such as water temperature, D.O., and conductivity, are related to seasons, and consequently, input values can be estimated or assumed with reasonable accuracy based upon measured historical conditions. Weather forecasts can be obtained from NOAA, and hydrologic and water use conditions, such as river flow and water extractions, can also be estimated or forecasted. Thus, using historical records and weather forecasts, uncertainty with regard to input values can be reduced.

Another factor that further reduces uncertainty is that some variables will generally not exhibit large changes over the relatively short prediction periods. Water, because of its high specific heat capacity, is characterized by gradual temperature changes. Exceptions may occur during freezing or thawing periods, but the modeler can combined historical records, weather forecast information, with physical intuition to estimate expected changes over prediction periods of interest. For example, if mean daily temperatures are expected to remain fairly constant over the next prediction period, relatively small water temperature changes may be expected. However, if a hot or cold spell is forecasted, the modeler may assume more dramatic change in water temperature.

To investigate at a very basic level the feasibility of this approach, the range and mean changes of representative input variables over one-week, two-weeks, and even three-weeks ahead forecast periods are presented below in Tables 22, 23, and 24 for Stations 100, 101, and 612, respectively. Both the actual and absolute value changes with respect to minimum, mean, maximum, and standard deviations are presented.

As the tables show, on average, relatively small absolute value changes in the values of the predictor variables occur over the three different periods. In some cases, even the

maximum observed changes for some variables is relatively small. What would be important in future modeling work is to more systematically quantify how algae counts predicted by the ANN models change in response to expected changes in input values over the prediction period of interest.

Table 22. Statistical Summary of Input Value Changes for Representative Variables for Three Prediction Periods at Station 100

Parameter	Statistics	One-week Interval Changes		Two-week Interval Changes		Three-week Interval Changes	
		Actual	Absolute	Actual	Absolute	Actual	Absolute
Temperature	Std. Dev.	2.80	1.85	3.29	2.19	3.86	2.52
	Min	-7.30	0.00	-9.10	0.00	-10.30	0.00
	Ave	0.08	2.10	0.28	2.46	0.43	2.95
	Max	9.40	9.40	11.00	11.00	11.80	11.80
pH	Std. Dev.	0.60	0.44	0.55	0.40	0.55	0.36
	Min	-2.60	0.00	-2.90	0.00	-2.30	0.00
	Ave	0.02	0.41	0.01	0.38	0.00	0.41
	Max	3.20	3.20	2.20	2.90	1.70	2.30
Turbidity	Std. Dev.	6.40	5.41	6.08	5.01	6.19	5.08
	Min	-34.90	0.00	-33.50	0.00	-33.50	0.00
	Ave	-0.15	3.42	-0.23	3.44	-0.25	3.55
	Max	30.33	34.90	37.86	37.86	38.44	38.44
Alkalinity	Std. Dev.	23.60	18.01	25.29	18.13	27.07	18.90
	Min	-86.08	0.00	-86.68	0.00	-89.00	0.00
	Ave	0.83	15.24	0.65	17.61	0.30	19.34
	Max	89.67	89.67	87.23	87.23	91.10	91.10
Hardness	Std. Dev.	25.14	16.94	29.00	17.97	32.15	19.71
	Min	-88.00	0.00	-109.00	0.00	-110.00	0.00
	Ave	-1.05	18.58	0.63	22.73	1.93	25.42
	Max	110.00	110.00	62.00	109.00	106.00	110.00
Conductivity	Std. Dev.	113.31	76.64	139.35	93.68	146.62	95.06
	Min	-558.00	0.50	-468.00	0.00	-472.50	3.50
	Ave	-7.87	83.67	1.63	102.97	2.17	111.40
	Max	324.50	558.00	675.50	675.50	436.50	472.50
Dissolved Oxygen	Std. Dev.	1.63	1.12	1.80	1.24	1.89	1.21
	Min	-6.56	0.00	-7.59	0.00	-7.32	0.02
	Ave	-0.01	1.18	-0.06	1.30	-0.12	1.45
	Max	7.57	7.57	6.62	7.59	4.99	7.32
Biochemical Oxygen Demand	Std. Dev.	2.19	1.32	2.20	1.41	2.45	1.52
	Min	-5.27	0.02	-5.83	0.00	-8.07	0.00
	Ave	-0.02	1.74	-0.10	1.68	-0.16	1.93
	Max	7.24	7.24	6.27	6.27	7.54	8.07
Chloride	Std. Dev.	23.24	16.77	26.74	18.17	31.77	21.92
	Min	-91.00	0.00	-111.00	0.00	-120.00	0.00
	Ave	0.21	16.06	0.65	19.59	1.39	22.98
	Max	128.00	128.00	86.00	111.00	116.00	120.00
Ammonia	Std. Dev.	0.06	0.04	0.06	0.05	0.07	0.05
	Min	-0.26	0.00	-0.28	0.00	-0.26	0.00
	Ave	0.00	0.04	0.00	0.04	0.00	0.05
	Max	0.36	0.36	0.31	0.31	0.32	0.32
Total Suspended Solids	Std. Dev.	24.85	23.36	18.66	17.12	20.53	18.90
	Min	-264.00	0.00	-41.00	0.00	-52.63	0.00
	Ave	-0.33	8.44	0.46	7.42	0.68	8.03
	Max	263.00	264.00	253.00	253.00	263.00	263.00
UV254	Std. Dev.	0.04	0.03	0.04	0.03	0.05	0.03
	Min	-0.11	0.00	-0.19	0.00	-0.16	0.00
	Ave	0.00	0.03	0.00	0.03	0.00	0.03
	Max	0.13	0.13	0.17	0.19	0.16	0.16
Total Organic Carbon	Std. Dev.	1.32	0.84	1.34	0.85	1.44	0.94
	Min	-4.15	0.00	-4.07	0.01	-4.35	0.02
	Ave	-0.05	1.02	-0.06	1.03	-0.05	1.10
	Max	3.90	4.15	5.35	5.35	3.99	4.35

Table 23. Statistical Summary of Input Value Changes for Representative Variables for Three Prediction Periods at Station 101

Parameter	Statistics	One-week Interval Changes		Two-week Interval Changes		Three-week Interval Changes	
		Actual	Absolute	Actual	Absolute	Actual	Absolute
Temperature	Std. Dev.	3.26	2.13	3.92	2.55	4.53	2.98
	Min	-8.24	0.00	-7.90	0.10	-7.54	0.20
	Ave	0.55	2.52	1.10	3.16	1.15	3.58
	Max	9.94	9.94	10.20	10.20	13.09	13.09
pH	Std. Dev.	0.56	0.40	0.58	0.40	0.49	0.32
	Min	-2.20	0.00	-1.70	0.00	-1.10	0.00
	Ave	0.02	0.39	0.00	0.41	0.05	0.37
	Max	1.70	2.20	1.60	1.70	1.30	1.30
Turbidity	Std. Dev.	5.50	4.31	6.01	4.59	5.87	4.55
	Min	-18.90	0.00	-18.20	0.00	-17.10	0.00
	Ave	-0.20	3.41	-0.33	3.86	-0.49	3.72
	Max	17.90	18.90	19.50	19.50	17.00	17.10
Alkalinity	Std. Dev.	14.21	8.30	17.41	11.74	22.91	15.83
	Min	-30.00	0.00	-52.00	0.00	-84.60	0.00
	Ave	2.28	11.70	6.78	14.45	5.48	17.33
	Max	39.60	39.60	53.60	53.60	62.60	84.60
Hardness	Std. Dev.	39.01	25.41	41.20	25.59	41.92	25.51
	Min	-120.00	0.00	-98.00	0.00	-96.00	0.00
	Ave	3.47	29.65	5.80	32.56	7.94	33.97
	Max	130.00	130.00	112.00	112.00	100.00	100.00
Color	Std. Dev.	28.36	19.80	31.41	20.81	30.19	20.97
	Min	-99.00	0.00	-84.00	0.00	-84.00	0.00
	Ave	0.12	20.20	-0.85	23.37	-4.32	21.99
	Max	106.00	106.00	97.11	97.11	79.00	84.00
Conductivity	Std. Dev.	121.14	79.67	136.98	71.57	169.29	105.53
	Min	-542.00	3.00	-271.00	3.00	-486.00	6.00
	Ave	9.14	91.24	35.31	121.17	46.79	139.52
	Max	219.00	542.00	265.00	271.00	506.00	506.00
Dissolved Oxygen	Std. Dev.	2.41	1.70	2.63	1.91	2.22	1.47
	Min	-7.38	0.01	-10.66	0.00	-5.08	0.03
	Ave	0.16	1.70	0.04	1.79	-0.12	1.66
	Max	6.73	7.38	8.60	10.66	8.44	8.44
Chloride	Std. Dev.	23.66	15.21	25.46	13.46	34.90	23.33
	Min	-92.00	0.00	-60.00	0.00	-88.00	0.00
	Ave	1.82	18.12	5.98	22.26	9.93	27.62
	Max	54.00	92.00	54.00	60.00	131.00	131.00
Ammonia	Std. Dev.	0.08	0.05	0.07	0.04	0.08	0.06
	Min	-0.15	0.00	-0.15	0.00	-0.27	0.00
	Ave	0.00	0.06	0.00	0.05	-0.01	0.06
	Max	0.32	0.32	0.13	0.15	0.25	0.27
UV254	Std. Dev.	0.06	0.04	0.08	0.06	0.08	0.06
	Min	-0.19	0.00	-0.25	0.00	-0.21	0.00
	Ave	0.00	0.04	0.00	0.05	0.00	0.06
	Max	0.15	0.19	0.28	0.28	0.29	0.29

Table 24. Statistical Summary of Input Value Changes for Representative Variables for Three Prediction Periods at Station 612

Parameter	Statistics	One-week Interval Changes		Two-week Interval Changes		Three-week Interval Changes	
		Actual	Absolute	Actual	Absolute	Actual	Absolute
Temperature	Std. Dev.	2.94	1.88	3.68	2.37	3.68	2.37
	Min	-8.20	0.00	-10.00	0.00	-10.00	0.00
	Ave	0.26	2.26	0.72	2.89	0.72	2.89
	Max	9.30	9.30	12.50	12.50	12.50	12.50
pH	Std. Dev.	0.36	0.26	0.39	0.29	0.39	0.29
	Min	-1.50	0.00	-1.50	0.00	-1.50	0.00
	Ave	-0.02	0.25	-0.03	0.27	-0.03	0.27
	Max	1.60	1.60	1.40	1.50	1.40	1.50
Turbidity	Std. Dev.	5.65	4.93	3.48	2.65	3.48	2.65
	Min	-14.00	0.00	-15.00	0.00	-15.00	0.00
	Ave	0.18	2.76	-0.35	2.26	-0.35	2.26
	Max	56.00	56.00	7.40	15.00	7.40	15.00
Alkalinity	Std. Dev.	11.18	7.68	12.12	7.20	12.12	7.20
	Min	-45.00	0.00	-36.00	0.00	-36.00	0.00
	Ave	0.37	8.11	1.26	9.79	1.26	9.79
	Max	40.00	45.00	28.00	36.00	28.00	36.00
Hardness	Std. Dev.	19.93	14.47	22.32	14.14	22.32	14.14
	Min	-80.00	0.00	-68.00	0.00	-68.00	0.00
	Ave	-0.82	13.68	0.84	17.23	0.84	17.23
	Max	84.00	84.00	80.00	80.00	80.00	80.00
Color	Std. Dev.	11.88	8.50	11.58	8.36	11.58	8.36
	Min	-49.00	0.00	-60.00	0.00	-60.00	0.00
	Ave	0.11	8.28	-0.87	8.03	-0.87	8.03
	Max	40.00	49.00	30.00	60.00	30.00	60.00
Conductivity	Std. Dev.	82.56	55.14	105.23	67.10	105.23	67.10
	Min	-328.00	0.00	-330.00	1.00	-330.00	1.00
	Ave	-3.35	61.36	-3.20	80.83	-3.20	80.83
	Max	249.00	328.00	310.00	330.00	310.00	330.00
Dissolved Oxygen	Std. Dev.	1.61	1.08	1.81	1.22	1.81	1.22
	Min	-4.78	0.00	-5.62	0.00	-5.62	0.00
	Ave	-0.09	1.20	-0.35	1.38	-0.35	1.38
	Max	7.16	7.16	4.43	5.62	4.43	5.62
Chloride	Std. Dev.	18.43	13.54	21.34	15.23	21.34	15.23
	Min	-58.00	0.00	-69.00	0.00	-69.00	0.00
	Ave	-0.45	12.47	-0.98	14.92	-0.98	14.92
	Max	79.00	79.00	88.00	88.00	88.00	88.00
Ammonia	Std. Dev.	0.09	0.08	0.10	0.09	0.10	0.09
	Min	-0.49	0.00	-0.47	0.00	-0.47	0.00
	Ave	0.00	0.05	0.01	0.05	0.01	0.05
	Max	0.81	0.81	0.70	0.70	0.70	0.70
UV254	Std. Dev.	0.60	0.59	0.62	0.61	0.62	0.61
	Min	-4.74	0.00	-4.76	0.00	-4.76	0.00
	Ave	0.00	0.10	-0.02	0.11	-0.02	0.11
	Max	4.79	4.79	4.76	4.76	4.76	4.76

8.2 Representative Modeling Results

Because of the large number of models previously developed, as well as the high possible number of prediction cases, for illustration purposes, six select cases are presented in this document for the single value algal count forecast models. The cases include each of the three different algal classes and stations, with each presenting different characteristics in terms of system conditions, algal populations, prediction periods, and the number of historical events. The general results are consistent with other modeling work performed, some of which is presented in the appendices. These case studies are considered sufficient for achieving the important objective of demonstrating the feasibility of using ANNs to accurately forecast algal blooms, and important modeling and data acquisition and processing issues are fully addressed. This is achieved with the comparisons between the original and revised modeling approaches, inclusion versus exclusion of select water quality inputs, inclusion versus exclusion of water volume extraction variables, and smaller versus larger number of data events. For the classification models, eight select test cases were used, which is discussed in detail in the corresponding section.

For the cyanobacteria forecasting example, Station 612, located on River A at the intake point for the Pumping Station 2, was selected. Not only is this the largest source of water for the utility for most time periods, but it also has the highest frequency of algal bloom events for this algae class. A two-week ahead prediction period was used for this location. For the chlorophytes class, Station 100 was selected, which is the location of the water intake point for the treatment facility. Based upon the available data, station 100 has the highest frequency of chlorophytes bloom incidences among the three sampling stations, and a one-week ahead prediction period was selected for this location. Lastly, for chrysophytes, Station 101, located just outside the mouth of the canal that connects the River B with the water treatment facility, was selected. A two-week ahead prediction period was selected for this modeling case**.** The other three modeling cases include the one-week ahead cyanobacteria predictions at Station 100, two-week ahead chlorophytes predictions at station 101 and lastly, the one-week ahead chrysophytes

predictions at Station 612. The figures, descriptive statistics and sensitivity analyses results of the six representative models are presented in the remainder of this section.

8.2.1 Original Modeling Paradigm – Larger Data Sets with Fewer Inputs versus Smaller Data Sets with More Inputs

Recognizing the inherent advantage of the original modeling approach, where input values are known a-priori, an effort was made to improve generalization capability of these models by simultaneously generating larger number of data events by reducing the number of input variables by excluding the following less frequently measured water quality variables: Biological Oxygen Demand (BOD), Total Phosphorous/Orthophosphate, Nitrite/Nitrate, Sulfate, and Total Organic Carbon (note BOD not excluded for Station 100). For Station 100, the increase in the number of data events increased on average approximately 1.6 times; for Station 101, data set sizes increased approximately 2 to 2.5 times; and for Station 612, the increase was approximately 2.4 to 3.5 times. At the same time, for all models, data set sizes for training fell short of the minimum computed value of 200 training events. This was most pronounced for Stations 101 and 612, when all input variables were included, with as little as 19 and 20 events available for training, respectively. Station 100, with by far the most historical data, was the only station that ever had more than 100 events available for training, with a maximum number of 136. However, even this station had less than 100 events available for training when its four less frequently water quality variables were included.

Thus, in general, training set sizes were on average one quarter to one half less than the minimum 200 required, computed in accordance with the number of input and output variables. As discussed in the ANN Background section, ANN generalization capability generally increases with larger training sets consisting of more historical events. Also, an ANN with a larger number of input variables will generally require more training patterns to effectively search the higher dimensional error surface during learning. In a complex

and non-linear system, it may be expected that even more data events are required for robust model development and validation.

A comparison between representative original ANN models, which included these water quality variables, and the models that excluded them, is shown below for the six representative cases. Tables 25 and 26 summarize the statistical performances of the models developed with complete and reduced input variable sets, respectively, including the number of data events available for model training and validation, the number of bloom events, and the number of false positive and false negatives with respect to algal blooms. In terms of mean absolute errors and correlation coefficients, there does not appear to be a significant discrepancy in overall model performance between the complete and reduced input models. A similar lack of discrepancy can be observed when comparing the occurrences of false positives and false negatives. However, it should also be noted that because the models that used the reduced input variable set had larger data sets, there was more variability in system conditions, or algal counts, as measured by the standard deviation. Thus, the reduced models were also subject to a greater range of conditions during validation.

As an additional measure of model performance, Table 27 compares the percentage accuracy of the models in terms of predicting relative increases or decreases from the initial to final measured counts. Please note that for cases where the initial and final measured counts were 0, ANN predictions less than 100 were deemed correct (i.e. non-bloom event). This was done to correct for what would otherwise require an exact prediction of 0, and as shown later in the figures, for most of these cases, the ANNs predicted counts significantly less than 100. Using this measure, all ANN models achieve 56% accuracy or higher in predicting increasing or decreasing counts. The original ANN models that included the less frequently measured water quality variables statistically outperformed the models that excluded these variables for four of the six cases, though advantages were relatively small, with average correct percentages of 78 and 71.5%, respectively, for the two methods. On the other hand, the models that

excluded the select water quality inputs on average achieved a higher correlation coefficient during validation; 0.80 versus 0.64 for the models that included these variables. Thus, the impact of excluding the five select water quality variables for the purpose of generating larger data sets is not clear in this case. At the same time, unlike Swimming River, it appears that excluding select water quality variables does not significantly compromise forecasting performance.

Table 25. Comparison of statistical performance of Original ANN Models for Predicting the three different algae classes at different modeling horizons using all inputs

	Station 612 – Two week Ahead Cyanobacteria Predictions			Station 100 - One week Ahead Chlorophytes Predictions			Station 101 – Two week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	52.000	45.143	104.000	45.455	54.910	38.667	75.400	73.000	77.600
Data S.D.	174.835	157.523	260.059	82.410	96.075	68.815	61.635	76.230	39.159
Error Mean	0.072	0.511	1.517	-4.433	-10.906	-1.519	-1.311	-4.838	-1.737
Error S.D.	72.343	11.389	145.360	65.237	81.245	54.315	47.906	59.438	30.982
Abs E. Mean	25.607	8.643	72.119	33.485	41.627	30.026	32.075	36.307	27.853
S.D. Ratio	0.414	0.072	0.559	0.792	0.846	0.789	0.777	0.780	0.791
Correlation	0.939	0.997	0.915	0.612	0.538	0.618	0.638	0.670	0.657
No. of Events	54	28	13	156	78	39	40	20	10
No. of Blooms	5	2	2	17	12	5	9	5	2
False Positives	0	0	0	3	2	1	4	1	2
False Negatives	1	0	1	5	7	3	2	2	0
	Station 100 – Two week Ahead Cyanobacteria Predictions			Station 101 - One week Ahead Chlorophytes Predictions			Station 612 – One week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	34.152	52.200	17.128	52.293	41.714	26.800	63.769	67.077	57.846
Data S.D.	144.995	196.960	45.363	76.158	70.260	25.111	55.032	65.636	38.769
Error Mean	5.133	2.349	21.386	5.034	2.735	10.720	-0.032	0.509	-0.926
Error S.D.	49.080	44.384	61.905	48.849	40.327	47.876	27.086	21.487	40.909
Abs E. Mean	20.457	20.251	28.864	35.939	26.729	42.159	19.529	15.147	31.480
S.D. Ratio	0.338	0.225	1.365	0.641	0.574	1.907	0.492	0.327	1.055
Correlation	0.944	0.974	0.903	0.780	0.828	0.640	0.871	0.945	0.122
No. of Events	158	80	39	41	21	10	52	26	13
No. of Blooms	11	7	2	7	3	0	9	5	2
False Positives	5	3	2	5	1	2	0	0	0
False Negatives	3	2	0	0	0	0	4	2	2

Table 26. Comparison of statistical performances of Original ANN Models for Predicting the three different algae classes at different modeling horizons excluding five water quality inputs.

	Station 612 – Two week Ahead Cyanobacteria Predictions			Station 100* - One week Ahead Chlorophytes Predictions			Station 101 – Two week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	34.849	20.000	28.941	49.455	48.515	44.939	69.736	59.037	74.615
Data S.D.	157.155	93.832	157.271	77.028	72.579	70.967	67.014	53.632	70.217
Error Mean	-1.414	0.855	2.074	3.697	-2.165	18.461	-0.300	6.022	-12.226
Error S.D.	32.336	22.685	16.580	52.465	40.655	68.847	54.353	40.884	52.119
Abs E. Mean	12.816	10.933	7.446	33.569	27.683	42.556	37.639	30.523	38.308
S.D. Ratio	0.206	0.242	0.105	0.681	0.560	0.970	0.811	0.762	0.742
Correlation	0.979	0.975	0.995	0.772	0.828	0.807	0.590	0.649	0.707
No. of Events	139	71	34	266	134	66	106	54	26
No. of Blooms	8	4	1	39	18	8	26	10	6
False Positives	0	0	0	11	4	4	7	4	0
False Negatives	2	2	0	19	6	4	7	4	1
	Station 100*– Two week Ahead Cyanobacteria Predictions			Station 101 - One week Ahead Chlorophytes Predictions			Station 612 – One week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	30.297	45.600	9.871	44.367	50.982	31.259	80.231	78.667	86.698
Data S.D.	121.847	162.598	34.542	75.159	83.132	49.556	82.210	82.743	83.477
Error Mean	6.100	-6.193	26.298	2.782	0.053	8.697	-2.623	-1.869	-5.852
Error S.D.	59.382	60.479	71.099	50.770	58.035	34.239	58.721	58.456	64.108
Abs E. Mean	31.144	33.885	31.982	30.809	32.441	28.385	39.477	37.550	44.684
S.D. Ratio	0.487	0.372	2.058	0.675	0.698	0.691	0.714	0.706	0.768
Correlation	0.873	0.937	0.847	0.738	0.716	0.789	0.700	0.708	0.656
No. of Events	249	125	62	109	55	27	173	87	43
No. of Blooms	19	14	1	15	8	3	46	20	15
False Positives	5	2	3	8	6	1	9	6	3
False Negatives	10	8	0	1	1	0	22	7	10

* - excluded only four less frequently measured water quality variables

Table 27. Percentage accuracy of the Original ANN Models for predicting the three different algae classes at different modeling horizons in terms of predicting relative increases or decreases from the validation data sets' Initial to Final measured counts

	Prediction Events	No. of Events	Accuracy			
			Correct	%	Incorrect	%
Original Models with All inputs	612-2wk Ahead Cyanobacteria	13	12	92	1	8
	100-1wk Ahead Chlorophyta	39	27	69	12	31
	101-2wk Ahead Chrysophyta	10	9	90	1	10
	100-2wk Ahead Cyanobacteria	39	37	95	2	5
	101-1wk Ahead Chlorophyta	10	6	60	4	40
	612-2wk Ahead Chlorophytes	13	8	62	5	38
Original Models with Fewer Inputs (exclude select water quality variables)	612-2wk Ahead Cyanobacteria	34	31	91	3	9
	100*-1wk Ahead Chlorophyta	66	37	56	29	44
	101-2wk Ahead Chrysophyta	26	16	62	10	38
	100*-2wk Ahead Cyanobacteria	62	58	94	4	6
	101-1wk Ahead Chlorophyta	27	17	63	10	37
	612-2wk Ahead Chlorophytes	43	27	63	16	37

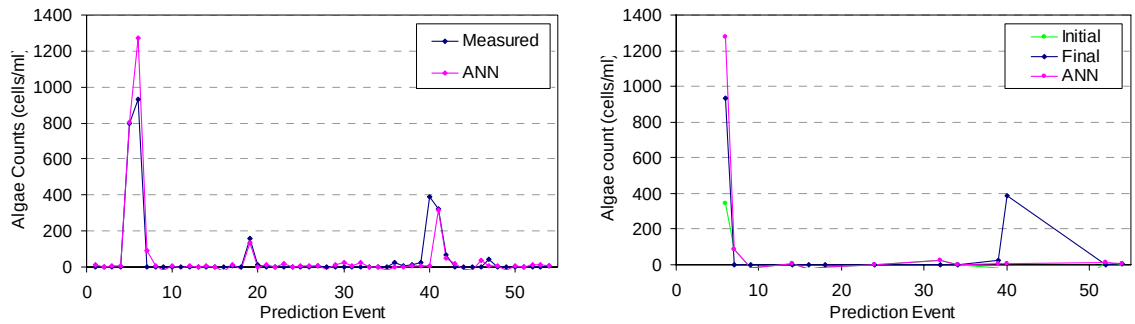
* - excluded only four less frequently measured water quality variables

This finding suggests that for this particular system, unlike Swimming River, the range of values under which the excluded variables exist over the modeling history, while having some influence, may not significantly affect the algal populations. Similar findings have been reported in the literature (Maier and others, 1997), and it may be that the constituents exist within a range of values that do not significantly diminish or propagate the organisms. Again, however, given the size deficiency of data sets, this possible explanation must be taken with guarded skepticism.

What does lend support, however, is the opposite result was found with the Swimming River Reservoir, where significantly smaller data sets that included nutrient variables significantly increased performance. There may even be a physical basis for these differences in model sensitivities to nutrient conditions in the two water utility systems. A reservoir, by nature a closed system, is hydraulically less dynamic, and short-term

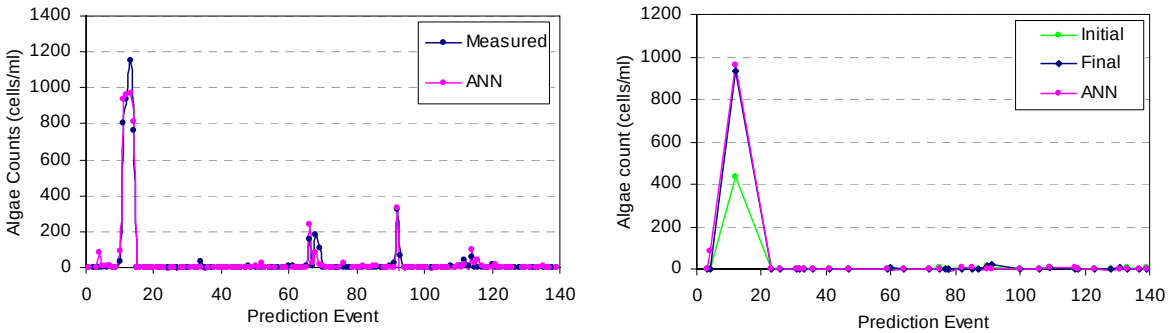
water quality changes may induce stronger influences over algal populations during relatively short time periods. A river system by its flowing nature is more dynamic hydraulically, and may comprise an algal ecosystem that is less influenced by nutrient changes over relatively short time periods.

In order to provide a visual comparison, Figures 69 through 80 below compare the overall and validation modeling results for the different models.



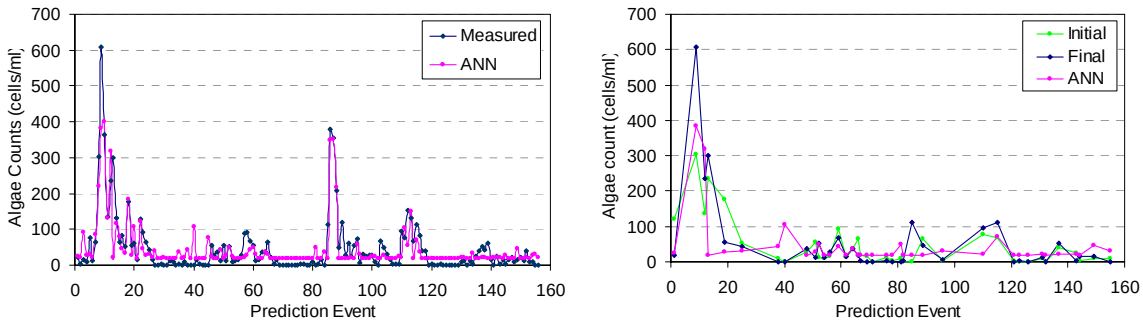
(a) (b)

Figure 69. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 612 (Original Model with all inputs)



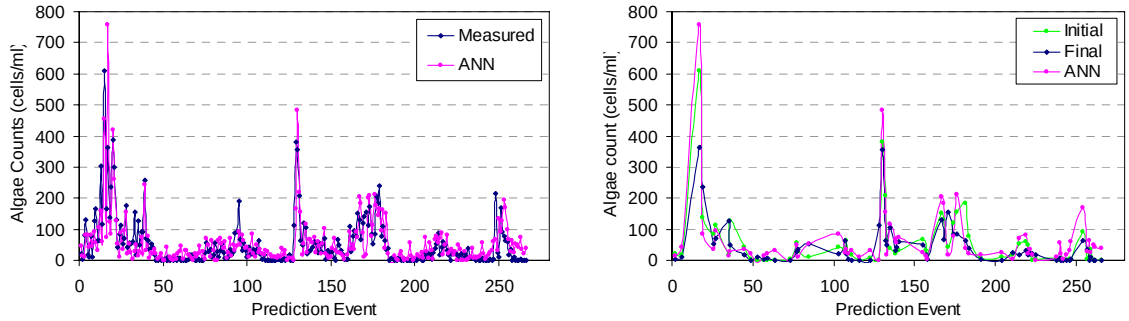
(a) (b)

Figure 70. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 12 (Original Model excluding five water quality inputs)



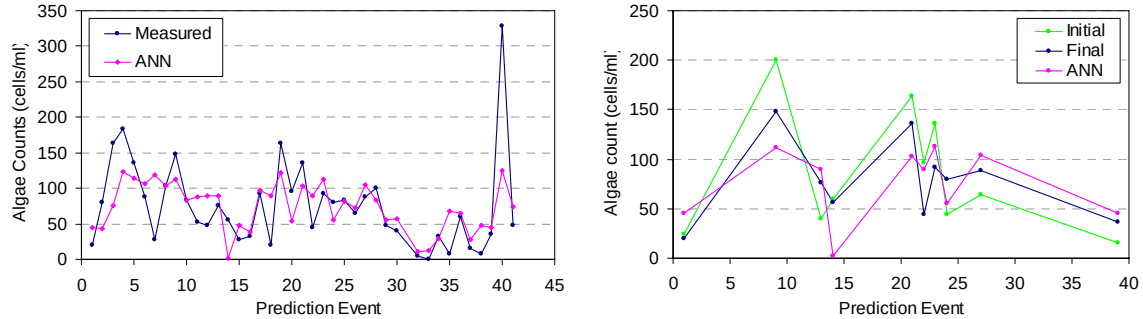
(a) (b)

Figure 71. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 100 (Original Model with all inputs)



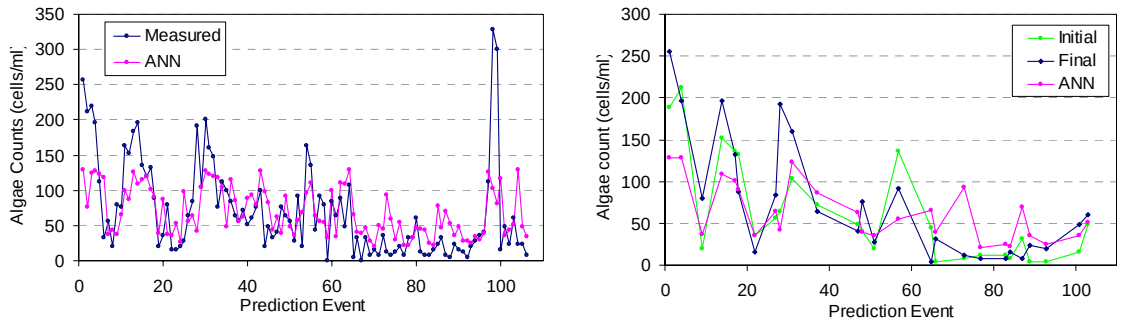
(a) (b)

Figure 72. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 100 (Original Model excluding five water quality inputs)



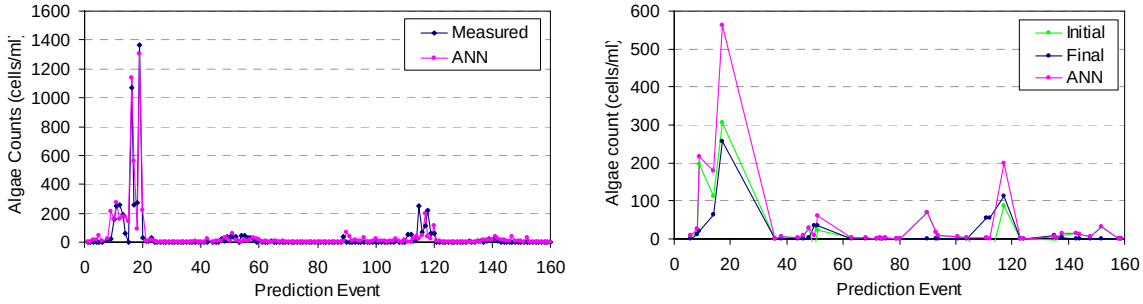
(a) (b)

Figure 73. Time-series plots of measured Chrysophytes counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 101 (Original Model using all inputs)



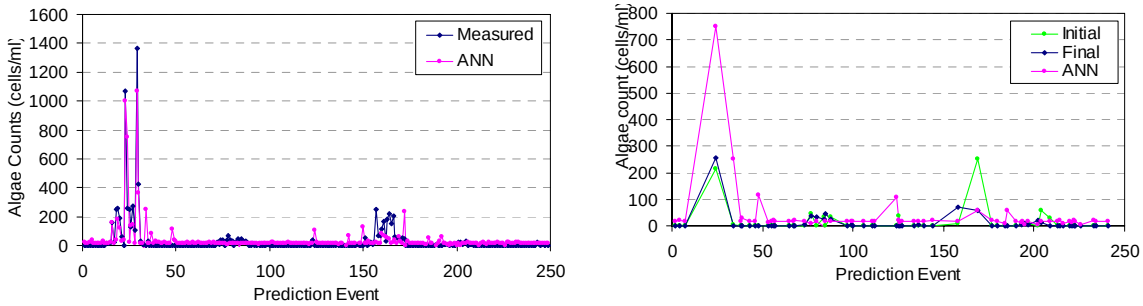
(a) (b)

Figure 74. Time-series plots of measured Chrysophytes counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 101 (Original Model excluding five water quality inputs)



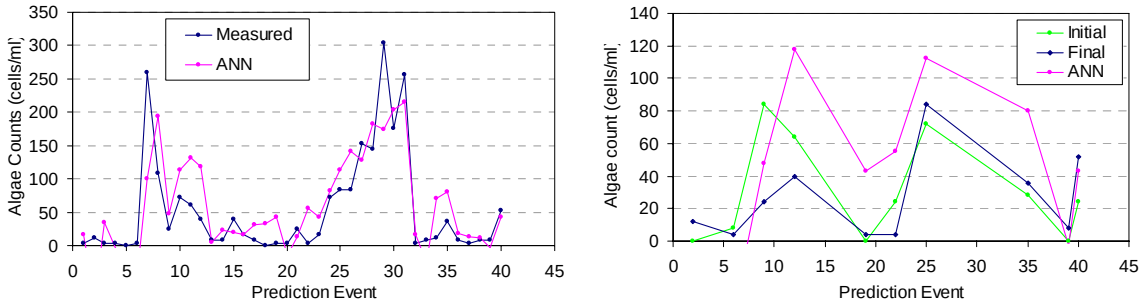
(a) (b)

Figure 75. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 100 (Original Model using all inputs)



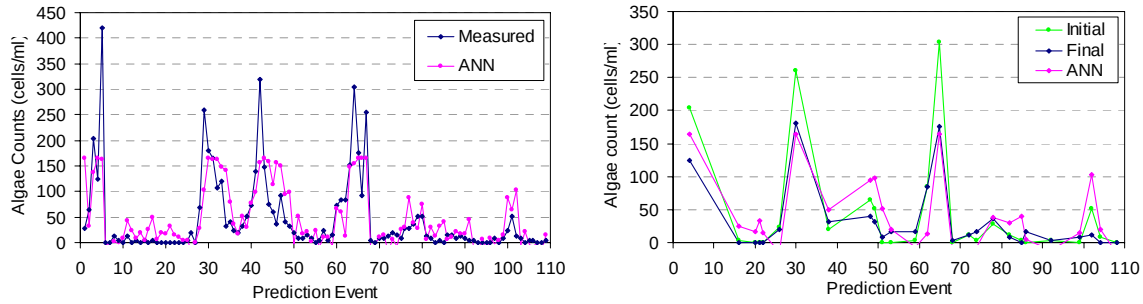
(a) (b)

Figure 76. Time-series plots of measured Cyanobactera counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 100 (Original Model excluding five water quality inputs)



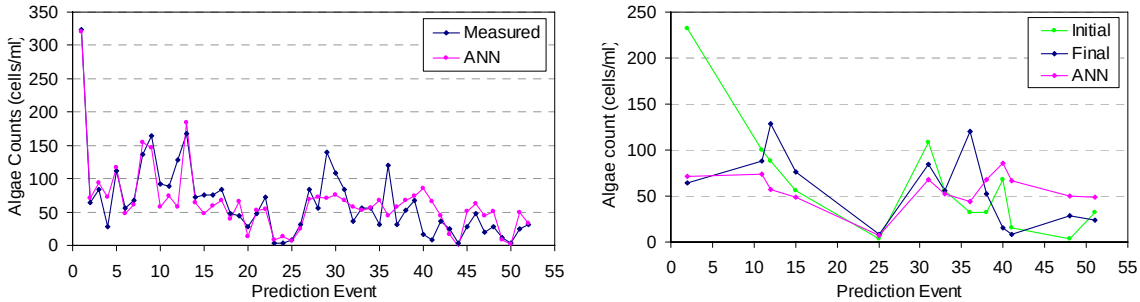
(a) (b)

Figure 77. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 101 (Original Model using all inputs)



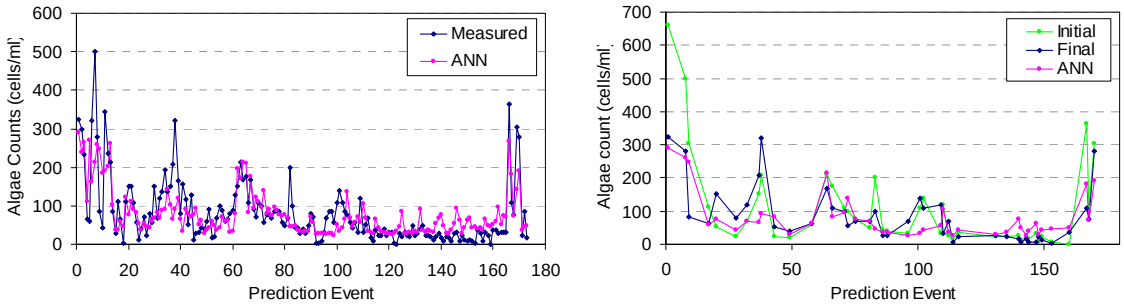
(a) (b)

Figure 78. Time-series plots of measured Chlrophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 101 (Original Model excluding five water quality inputs)



(a) (b)

Figure 79. Time-series plots of measured Chrysophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 612 (Original Model using all inputs)



(a) (b)

Figure 80. Time-series plots of measured Chrysophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 612 (Original Model excluding five water quality inputs)

A visual comparison of the model predictions, particularly the validation figures, is helpful for assessing ANN performance. For depicting validation results, the initial algal counts measured at the beginning of the prediction period are plotted along with the measured and ANN predicted final counts so as to provide a more transparent assessment of forecasting performance. For example, on Figure 80b, the first validation event had an initial chrysophytes algal count around 680 organisms (i.e. cells). At the end of the corresponding one-week prediction event, the final measured count was just over 300 organisms, while the ANN predicted a count just below 300.

Overall, given the sparse data, many models perform surprisingly well in predicting dramatic changes in algal populations during validation. For example, for the two-week ahead prediction period for cyanobacteria at Station 612 using all inputs (Figure 69b), the ANN model accurately predicted a 600 count increase for this organism. The ANN model developed for predicting chlorophytes at Station 101 one-week ahead (Figure 77b) using all inputs validated extremely well, accurately predicting relative increases and decreases in counts. The same was achieved with the mode developed for predicting chrysophytes counts one week ahead for Station 612 with the reduced inputs. The model accurately predicted very large decreases in algal counts (i.e. 200 or more) for three events, and generally reproduced higher and lower count events. Even a model trained with very few data events (Chrysophytes two-week ahead predictions at Station 101 with

complete inputs) accurately predicted relative increases and decreases in algal counts during validation (Figure 73b). Interestingly, the corresponding model that used the reduced input set for the same prediction problem did not predict relative changes as well, as shown by Figure 74b, and seems to be "keying" off the initial counts. In this case, it suggests that at least some of the water quality variables may have been important for this prediction problem.

As inferred from statistical measures, the figures do not reveal an obvious superiority between the complete and reduced input models. Thus, increasing the number of historical events did not significantly improve ANN forecasting ability, although the models developed with more data events generally achieved higher correlation coefficients (0.80 versus 0.64). By extension, excluding the five select water quality variables may not generally compromise development of robust ANN forecasting models, although there appears to be at least one exception.

Perhaps most importantly, the modeling results suggest that on average, the initial system conditions measured at the beginning of the prediction period capture the dynamics that govern algal population changes over the prediction periods of interest. This could be due to relatively small changes in system conditions over the short prediction periods, and/or natural and consistent transitions from initial system conditions, measured at the beginning of the period, to end of the prediction period, when final algal counts are predicted. In other words, there may be a natural and consistent time lag in algal population responses to system conditions that, except under extreme conditions (e.g. sudden and dramatic temperature change), evolve in a fairly consistent. The extremely important implication is that development of robust ANN models that use input values measured at the beginning of the prediction period appears to be quite feasible.

8.2.2 Sensitivity Analysis Results – Original Model Paradigms

This section compares the sensitivity analyses results obtained for the two original modeling approaches. The analysis is done using both the ratio and ranking method, described previously in the water treatment modeling section.

Table 28 below presents the sensitivity analysis results for the original model that included all input variables for the two-week ahead prediction of cyanobacteria at Station 612. As depicted by the table, odor and total algal counts ranked first and second in terms of importance, respectively, both with ratio value over 1.2. Other variables that ranked highly in terms of importance with ratio value over 1.1. These variables include length of day, total amorphous materials and Reservoir A extraction. At the other extreme, a total of 14 of the 34 variable inputs achieved low ratio values of less than 1.0. The three lowest ranking were pH, sky cover, and BOD.

Table 28. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 612 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Odor	1.530	1	Total Hardness	1.010	18
Total Algal Count	1.214	2	Nitrite/Nitrate	1.008	19
Temperature	1.129	3	Pumping Station 1 Extraction	1.004	20
Length of Day	1.109	4	Chloride	0.998	21
Total Amorphous Material	1.108	5	Initial Cyanobacteria counts	0.998	22
Reservoir A Extraction	1.097	6	River A Extraction	0.993	23
Wind Direction	1.088	7	Dissolved Oxygen	0.991	24
Sulfate	1.063	8	UV254	0.989	25
Initial Chrysophytes counts	1.046	9	Turbidity	0.983	26
Heating Degree Days	1.035	10	Prediction Period's Precipitation Total	0.975	27
Ammonia	1.032	11	Color	0.975	28
Alkalinity	1.031	12	TotalPhosphorus/Orthophosphate	0.967	29
Conductivity	1.029	13	River B Extraction	0.964	30
River A Streamflow	1.028	14	Prediction Period's Lagged Precipitation Total	0.946	31
Initial Chlorophytes counts	1.025	15	Biochemical Oxygen Demand	0.938	32
Wind Speed	1.024	16	Sky Cover	0.936	33
Total Organic Carbon	1.012	17	pH	0.864	34

For the original model with reduced input variables for the two-week ahead prediction of cyanobacteria at Station 612, as presented in Table 29, extraction from Reservoir A was the most important variable with a ratio value of 2.89. Odor and extraction from River A also ranked high in importance, both with ratio values over 1.8. At the other extreme, a number of low ranking variables had ratio values below 1.0, five of which had ratio values of 0.89 and below, including total hardness, dissolved oxygen, alkalinity, pH and conductivity.

Table 29. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 612 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Reservoir A Extraction	2.895	1	Total Algal counts	1.025	16
Odor	1.835	2	River A Streamflow	1.024	17
River A Extraction	1.802	3	Initial Chlorophytes counts	1.023	18
Length of Day	1.602	4	Initial Chrysophytes counts	1.010	19
River B Extraction	1.451	5	UV254	0.998	20
Turbidity	1.278	6	Pump Station 1 Extraction	0.992	21
Sky Cover	1.229	7	Prediction Period's Precipitation Total	0.984	22
Prediction Period's Lagged Precipitation	1.189	8	Initial Cyanobacteria counts	0.974	23
Heating Degree Days	1.133	9	Chloride	0.933	24
Wind Direction	1.091	10	Conductivity	0.895	25
Total Amorphous Material	1.068	11	pH	0.893	26
Ammonia	1.064	12	Alkalinity	0.873	27
Wind Speed	1.044	13	Dissolved Oxygen	0.818	28
Temperature	1.033	14	Total Hardness	0.818	29
Color	1.032	15			

The sensitivity analyses results for the original ANN model with all the variable inputs for one-week ahead prediction of chlorophytes counts at Station 100 is shown below in Table 30. Initial chlorophytes counts ranked first in importance, followed by heating degree days and length of day. Ratio values, however, were relatively low. That is, most of the variables on top of the ranking including the highest ranking initial chlorophytes counts had ratio values of just a little over 1.0. At the other extreme, several variables

achieved ratio values of less than 1.0, with the three lowest ranking being odor, ammonia and initial cyanobacteria counts.

Table 30. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chlorophytes at Station 100 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.043	1	UV-254	1.002	18
Heating Degree Days	1.024	2	Total Suspended Solids	1.001	19
Length of Day	1.020	3	pH	1.001	20
Wind Direction	1.017	4	River B Extraction	1.001	21
River A Extraction	1.017	5	Dissolved Oxygen	1.000	22
Total Algal counts	1.013	6	River A Streamflow	1.000	23
Temperature	1.011	7	Pumping Station 1 Extraction	1.000	24
Nitrite/Nitrate	1.010	8	Prediction Period's Lagged Precipitation Total	1.000	25
Wind Speed	1.010	9	Conductivity	1.000	26
Total Organic Carbon	1.008	10	Total Hardness	0.999	27
Initial Chrysophytes counts	1.006	11	Chloride	0.999	28
Sulfate	1.006	12	Reservoir A Extraction	0.999	29
T.Phosphorus/Orthophosphate	1.005	13	Alkalinity	0.998	30
Prediction Period's Precipitation Total	1.005	14	Initial Cyanobacteria counts	0.996	31
Sky Cover	1.004	15	Ammonia	0.991	32
Turbidity	1.003	16	Odor	0.964	33
Biochemical Oxygen Demand	1.002	17			

Table 31 below presents the sensitivity analysis results for the similar model with reduced inputs. Initial chlorophytes counts ranked first in terms of importance with a ratio value of 1.3, followed by odor, and then extractions from Rivers A and B. At the bottom of the ranking, a total of seven variables had ratios less than 1.0. Among these lower ranking variables were initial chrysophytes counts, previous and current week's precipitation totals, and dissolved oxygen.

Table 31. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chlorophytes at Station 100 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes	1.304	1	Conductivity	1.006	16
Odor	1.241	2	River A Streamflow	1.004	17
River A Extraction	1.181	3	Total Organic Carbon	1.004	18
River B Extraction	1.181	4	Initial Cyanobacteria counts	1.002	19
Biochemical Oxygen Demand	1.059	5	Alkalinity	1.001	20
Sky Cover	1.045	6	Reservoir A Extraction	1.001	21
Turbidity	1.036	7	pH	1.001	22
Chloride	1.029	8	Heating Degree Days	0.999	23
Ammonia	1.026	9	UV254	0.999	24
Total Algal Counts	1.022	10	Pump Station 1 Extraction	0.999	25
Wind Direction	1.018	11	Dissolved Oxygen	0.998	26
Temperature	1.017	12	Prediction Period's Precipitation Total	0.998	27
Wind Speed	1.011	13	Prediction Period's Lagged Precipitation Total	0.995	28
Length of Day	1.009	14	Initial Chrysophytes counts	0.994	29
Total Hardness	1.008	15			

Table 32 below presents the sensitivity analysis results for the original model that included all input variables for the two-week ahead prediction of chrysophytes at Station 101. As with the other original models developed and assessed with the complete input set, variables achieved relatively low ratio values, including most of the top ranked variables with ratio values of just over 1.0. A number of variables at the bottom of the ranking had ratio values of less than 1.0, and the three lowest ranking variables were extraction from Pumping Station 1, conductivity, and chloride.

Table 32. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Chrysophytes at Station 101 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chrysophytes count	1.091	1	Prediction Period's Precipitation Total	1.004	18
Color	1.067	2	River A Streamflow	1.003	19
Length of Day	1.043	3	Nitrite/Nitrate	1.003	20
Wind Direction	1.035	4	Wind Speed	1.002	21
Ammonia	1.016	5	Turbidity	1.001	22
Total Algal Counts	1.012	6	T.Phosphorus/Orthophosphate	1.000	23
Alkalinity	1.010	7	Reservoir A Extraction	1.000	24
Initial Cyanobacteria counts	1.010	8	Biochemical Oxygen Demand	1.000	25
pH	1.009	9	UV254	1.000	26
River B Extraction	1.009	10	Dissolved Oxygen	0.999	27
River A Extraction	1.009	11	Sulfate	0.999	28
Initial Chlorophytes counts	1.008	12	Total Hardness	0.998	29
Heating Degree Days	1.006	13	Temperature	0.997	30
Odor	1.006	14	Prediction Period's Lagged Precipitation Total	0.997	31
Total Organic Carbon	1.005	15	Chloride	0.994	32
Total Amorphous Material	1.005	16	Conductivity	0.994	33
Sky Cover	1.005	17	Pumping Station 1 Extraction	0.992	34

Similar to the ANN model for two-week ahead chrysophytes predictions at Station 101 using the complete input set, the sensitivity analysis result for the model with reduced inputs exhibited low overall ratio values, as shown in Table 33 below. In particular, the four highest ranking variables, total algal counts, initial chrysophytes counts, length of day, and pH, had ratio values of just over 1.0. . Most of the remaining variables had ratio values around 1.0, and the seven lowest ranking variables all had ratio values less than 1.0, with the three lowest ranking being total amorphous materials, turbidity and previous week's precipitation.

Table 33. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Chrysophytes at Station 101 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal counts	1.026	1	Color	1.002	16
Initial Chrysophytes counts	1.022	2	UV254	1.001	17
Length of Day	1.014	3	Chloride	1.001	18
pH	1.010	4	Sky Cover	1.001	19
Pump Station 1 Extraction	1.009	5	Heating Degree Days	1.000	20
Reservoir A Extraction	1.008	6	River A Streamflow	1.000	21
Prediction Period's Precipitation Total	1.007	7	Ammonia	1.000	22
Initial Cyanobacteria counts	1.005	8	River B Extraction	0.999	23
Conductivity	1.004	9	Initial Chlorophytes counts	0.999	24
Alkalinity	1.004	10	Total Hardness	0.999	25
Odor	1.003	11	River A Extraction	0.998	26
Dissolved Oxygen	1.003	12	Prediction Period's Lagged Precipitation Total	0.995	27
Temperature	1.002	13	Turbidity	0.994	28
Wind Direction	1.002	14	Total Amorphous Material	0.990	29
Wind Speed	1.002	15			

The sensitivity analysis result for original modeling for two-week ahead cyanobacteria counts at station 100 with the complete input set is shown in Table 34. In terms of importance, the two highest ranking variables were pH and nitrite/nitrate, both with ratio value over 1.6. Oother variables that ranked highly with ratio values above 1.3 include odor, sky cover, total organic carbon, River B extractions and intial chrysophytes counts. At the other extreme, a total of nine variables achieved ratio values less than 1.0, with the lowest ranking being total suspended solids, wind speed, and length of day.

Table 34. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 100 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
pH	1.667	1	Total Algal Counts	1.043	18
Nitrite/Nitrate	1.638	2	Prediction Period's Lagged Precipitation Total	1.034	19
Odor	1.430	3	UV-254	1.030	20
Sky Cover	1.396	4	Chloride	1.020	21
Total Organic Carbon	1.362	5	Biochemical Oxygen Demand	1.009	22
River B Extractions	1.321	6	Reservoir A Extractions	1.006	23
Initial Chrysophyta counts	1.301	7	Initial Cyanophytes counts	1.004	24
T.Phosphorus/Orthophosphate	1.240	8	Prediction Period's Precipitation Total	0.999	25
Wind Direction	1.227	9	Alkalinity	0.984	26
Sulfate	1.217	10	Pumping Station 1 Extractions	0.981	27
Heating Degree Days	1.206	11	Conductivity	0.978	28
River A Extractions	1.203	12	River A Streamflow	0.953	29
Turbidity	1.194	13	Temperature	0.943	30
Dissolved Oxygen	1.170	14	Length of Day	0.941	31
Total Hardness	1.116	15	Wind Speed	0.927	32
Initial Chlorophytes counts	1.101	16	Total Suspended Solids	0.896	33
Ammonia	1.092	17			

The sensitivity analysis results for the similar prediction model but with the reduced input set are presented in Table 35. Extractions from River B ranked first in terms of importance with ratio value of 1.52, followed by sky cover, total organic carbon, and biochemical oxygen demand, all with ratio values of over 1.2. The lower ranking variables, all with ratio values less than 1.0, include the prediction period's precipitation total, water temperature, and extractions from Pumping Station 1.

Table 35. Sensitivity Analysis for Original ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 100 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
River B Extraction	1.519	1	Prediction Period's Lagged Precipitation Total	1.136	16
Sky Cover	1.327	2	Ammonia	1.119	17
Total Organic Carbon	1.299	3	River A Streamflow	1.062	18
Biochemical Oxygen Demand	1.297	4	Length of Day	1.051	19
Initial Chrysophytes counts	1.292	5	Initial Cyanobacteria counts	1.051	20
Wind Direction	1.281	6	Total Hardness	1.043	21
Turbidity	1.269	7	Total Algal Counts	1.029	22
Heating Degree Days	1.233	8	UV254	1.020	23
River A Extraction	1.220	9	Chloride	1.019	24
Dissolved Oxygen	1.213	10	Total Suspended Solids	1.010	25
Initial Chlorophytes counts	1.196	11	Conductivity	1.009	26
pH	1.182	12	Reservoir A Extraction	1.005	27
Odor	1.171	13	Pump Station 1 Extraction	0.995	28
Alkalinity	1.168	14	Temperature	0.994	29
Wind Speed	1.162	15	Prediction Period's Precipitation Total	0.952	30

The overall sensitivity analysis results for one-week ahead chlorophytes predictions with complete input set at Station 101 are summarized in Table 36. The three highest ranking variables were the initial chlorophytes counts, wind speed, and direction, and all input variables exhibited low ratio values, with only the initial chlorophytes counts having a ratio value above 1.07 (1.2). Most of the variables had ratio values just over 1.0, with and 13 having ratio values less than 1.0. The three lowest ranking variables were odor, heating degree days, and water temperature.

Table 36. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chlorophytes at Station 101 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.211	1	Reservoir A Extractions	1.001	18
Wind Speed	1.070	2	Conductivity	1.000	19
Wind Direction	1.069	3	Dissolved Oxygen	1.000	20
River A Extraction	1.047	4	Chloride	1.000	21
Total Organic Carbon	1.035	5	Biochemical Oxygen Demand	0.999	22
Total Hardness	1.027	6	Total Amorphous Material	0.996	23
River A Streamflow	1.025	7	Length of Day	0.994	24
Initial Cyanobacteria counts	1.022	8	Ammonia	0.993	25
Sulfate	1.018	9	River B Extractions	0.992	26
Total Algal Count	1.014	10	Pumping Station 1 Extractions	0.992	27
UV254	1.012	11	Alkalinity	0.990	28
Color, Cu	1.007	12	T.Phosphorus/Orthophosphate	0.990	29
Turbidity	1.006	13	Sky Cover	0.989	30
Prediction Period's Lagged Precipitation Total	1.006	14	Initial Chrysophytes counts	0.987	31
pH	1.005	15	Temperature	0.970	32
Nitrite/Nitrate	1.001	16	Heating Degree Days	0.966	33
Prediction Period's Precipitation Total	1.001	17	Odor	0.961	34

As with the previous model, the one-week ahead chlorophytes predictions at Station 101 with reduced input set exhibited low sensitivity ratio values, as presented in Table 37. Even the highest ranking variable achieved a value of little just over 1.0 and six low ranking variables have ratio value less than 1.0. In terms of importance, initial chlorophytes counts, total algal counts, and the prediction period's precipitation ranked first, second and third, respectively, while the three lowest ranking variables were sky cover, wind speed and wind direction.

Table 37. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chlorophytes at Station 101 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.110	1	River B Extraction	1.002	16
Total Algal counts	1.093	2	Turbidity	1.001	17
Prediction Period's Precipitation Total	1.050	3	Conductivity	1.001	18
River A Extraction	1.021	4	Ammonia	1.001	19
Total Hardness	1.009	5	UV254	1.001	20
Initial Chrysophytes counts	1.007	6	Chloride	1.001	21
Temperature	1.006	7	Pump Station 1 Extraction	1.000	22
Dissolved Oxygen	1.006	8	pH	1.000	23
Reservoir A Extraction	1.006	9	Length of Day	0.999	24
Color	1.005	10	Prediction Period's Lagged Precipitation Total	0.997	25
Heating Degree Days	1.005	11	Odor	0.997	26
River A Streamflow	1.004	12	Sky Cover	0.996	27
Alkalinity	1.004	13	Wind Speed	0.995	28
Initial Cyanobacteria counts	1.003	14	Wind Direction	0.990	29
Total Amorphous Material	1.002	15			

The sensitivity analysis results for the original ANN model for one-week ahead chrysophytes predictions at Station 612 with complete inputs is shown below in Table 38. Initial chrysophytes counts was the highest ranking variable, with a ratio value of 1.65. Other variables that also ranked highly were length of day, wind speed, and total amorphous materials. Of the seven low ranking variables that achieved ratio value of less than 1.0, the three lowest ranking were initial cyanobacteria counts, total algal counts, and turbidity.

Table 38. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chrysophytes at Station 612 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chrysophytes counts	1.658	1	Reservoir A Extractions	1.013	18
Length of Day	1.295	2	Sky Cover	1.013	19
Wind Speed	1.104	3	Temperature	1.013	20
Total Amorphous Material	1.100	4	Biochemical Oxygen Demand	1.009	21
UV254	1.094	5	pH	1.008	22
TotalPhosphorus/Orthophosphate	1.088	6	Chloride	1.002	23
River B Extractions	1.078	7	Total Organic Carbon	1.000	24
Initial Chlorophytes counts	1.075	8	Prediction Period's Precipitation Total	1.000	25
Conductivity m	1.062	9	River A Streamflow	1.000	26
Total Hardness	1.059	10	Prediction Period's Lagged Precipitation Total	1.000	27
Alkalinity	1.051	11	Nitrite/Nitrate	0.998	28
River A Extractions	1.046	12	Color	0.997	29
Odor	1.031	13	Wind Direction	0.994	30
Ammonia	1.022	14	Pumping Station 1 Extractions	0.994	31
Dissolved Oxygen	1.020	15	Turbidity	0.993	32
Heating Degree Days	1.017	16	Total Alga Count	0.991	33
Sulfate	1.013	17	Initial Cyanobacteria counts	0.965	34

Table 39 presents the sensitivity analysis results for one-week ahead predictions of Chrysophytes at Station 612 with the reduced input set. As with the similar model with complete input set, initial chrysophytes counts was the highest ranking variable; however, this variable achieved a relatively low ratio value of only 1.1, as compared with the 1.6 with the other model. Other variables that ranked near the top, with low ratio value just over 1.0, include odor, temperature and chloride. The three lowest ranking variables, all with ratio values below 1.0, were sky cover, pH, and initial chlorophytes counts.

Table 39. Sensitivity Analysis for Original ANN Model for One-week Ahead Predictions of Chrysophytes at Station 612 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chrysophytes counts	1.146	1	Turbidity	1.005	16
Odor	1.046	2	UV254	1.003	17
Temperature	1.029	3	Pump Station 1 Extraction	1.002	18
Chloride	1.021	4	River A Extraction	1.002	19
Heating Degree Days	1.018	5	Conductivity	1.000	20
Length of Day	1.017	6	Alkalinity	1.000	21
Total Hardness	1.014	7	Reservoir A Extraction	1.000	22
Total Algal counts	1.014	8	Prediction Period's Precipitation Total	1.000	23
Color	1.009	9	River B Extraction	0.999	24
Ammonia	1.008	10	Prediction Period's Lagged Precipitation	0.998	25
Dissolved Oxygen	1.006	11	River A Streamflow	0.997	26
Wind Direction	1.006	12	Initial Chlorophytes counts	0.997	27
Wind Speed	1.006	13	pH	0.995	28
Total Amorphous Material	1.005	14	Sky Cover	0.986	29
Initial Cyanobacteria counts	1.005	15			

8.2.3 Revised Modeling Paradigm – Larger Data Sets with Fewer Inputs versus Smaller Data Sets with More Inputs

As was done with the original modeling approach, a comparison between the larger number of historical data events that excluded the select water quality variables versus inclusion of these variables with fewer events was performed with the revised models. As was found with the original modeling approach, increasing the number of data events by excluding the five select water quality variables did not necessarily produce superior results. Tables 40 and 41 summarize the statistical results for these two data sets for the six representative forecasting cases. Half of the models that excluded the five select water quality variables achieved higher correlations during validation, and half did not. What is interesting is that the revised models, regardless of the set of input variables, generally avoided false positives and false negatives.

Table 40. Comparison of statistical performances of Revised ANN Models for Predicting the three different algae classes at different modeling horizons using all inputs

	Station 612 – Two week Ahead Cyanobacteria Predictions			Station 100 - One week Ahead Chlorophytes Predictions			Station 101 – Two week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	11.900	21.400	4.400	55.582	70.630	31.467	75.771	78.316	70.500
Data S.D.	51.244	70.782	10.651	95.147	113.067	49.750	52.424	44.016	61.284
Error Mean	-1.194	0.160	-5.419	3.204	1.584	7.182	-4.116	-0.314	-28.581
Error S.D.	8.324	7.853	11.346	51.870	57.877	28.108	31.599	7.393	53.261
Abs E. Mean	4.019	4.313	6.539	33.123	39.016	21.007	19.655	5.488	52.268
S.D. Ratio	0.162	0.111	1.065	0.545	0.512	0.565	0.603	0.168	0.869
Correlation	0.987	0.994	0.342	0.839	0.860	0.825	0.824	0.986	0.581
No. of Events	40	20	10	182	92	45	35	19	8
No. of Blooms	1	1	0	30	21	4	10	5	2
False Positives	0	0	0	9	5	1	2	0	1
False Negatives	0	0	0	11	9	0	3	1	1
	Station 100 – Two week Ahead Cyanobacteria Predictions			Station 101 - One week Ahead Chlorophytes Predictions			Station 612 – One week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	31.760	44.988	17.171	53.277	39.360	90.545	81.020	98.815	38.333
Data S.D.	140.813	189.279	47.124	77.348	64.693	88.087	67.909	76.824	37.003
Error Mean	-0.773	-3.300	0.211	9.530	-1.356	39.375	15.904	9.073	46.659
Error S.D.	54.234	63.786	43.339	36.275	11.082	61.744	39.417	43.281	21.648
Abs E. Mean	24.456	28.531	19.361	19.995	9.176	51.255	34.964	35.164	48.131
S.D. Ratio	0.385	0.337	0.920	0.469	0.171	0.701	0.580	0.563	0.585
Correlation	0.923	0.942	0.393	0.908	0.985	0.803	0.814	0.826	0.842
No. of Events	167	85	41	47	25	11	51	27	12
No. of Blooms	12	6	3	7	2	4	15	9	2
False Positives	8	2	0	1	0	1	2	2	0
False Negatives	2	4	2	0	0	0	5	3	0

Table 41. Comparison of statistical performances of Revised ANN Models for Predicting the three different algae classes at different modeling horizons excluding five water quality inputs

	Station 612 – Two week Ahead Cyanobacteria Predictions			Station 100* - One week Ahead Chlorophytes Predictions			Station 101 – Two week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	28.886	33.829	10.857	51.167	57.360	32.537	80.606	77.529	64.250
Data S.D.	142.553	143.274	53.858	83.488	85.256	52.854	72.390	64.389	72.477
Error Mean	0.540	1.876	-2.077	1.810	0.561	9.598	-2.259	0.854	-3.943
Error S.D.	26.645	23.973	36.732	49.504	51.883	44.289	36.326	15.916	51.068
Abs E. Mean	10.973	12.160	12.131	34.560	36.144	29.930	26.909	12.983	41.603
S.D. Ratio	0.187	0.167	0.682	0.593	0.609	0.838	0.502	0.247	0.705
Correlation	0.983	0.987	0.897	0.805	0.794	0.603	0.865	0.969	0.722
No. of Events	140	70	35	270	136	67	66	34	16
No. of Blooms	7	4	1	40	23	6	21	8	5
False Positives	0	0	0	6	2	1	2	1	0
False Negatives	2	1	0	23	13	3	3	0	1
	Station 100* – Two week Ahead Cyanobacteria Predictions			Station 101 - One week Ahead Chlorophytes Predictions			Station 612 – One week Ahead Chrysophytes Predictions		
	Overall	Training	Validate	Overall	Training	Validate	Overall	Training	Validate
Data Mean	29.921	44.635	17.143	47.542	49.417	49.333	79.885	81.636	75.814
Data S.D.	121.225	165.547	40.938	83.662	86.946	84.614	82.099	90.686	61.425
Error Mean	2.015	-0.605	5.752	-1.505	0.717	-2.126	-1.291	1.208	-5.225
Error S.D.	36.711	42.937	34.892	38.167	31.260	57.128	47.770	45.794	46.045
Abs E. Mean	19.328	22.188	19.558	21.032	18.116	28.920	35.973	34.487	34.685
S.D. Ratio	0.303	0.259	0.852	0.456	0.360	0.675	0.582	0.505	0.750
Correlation	0.954	0.966	0.793	0.891	0.933	0.761	0.814	0.867	0.684
No. of Events	252	126	63	96	48	24	174	88	43
No. of Blooms	20	13	3	14	8	4	46	23	12
False Positives	4	3	1	1	0	1	12	6	1
False Negatives	8	5	1	1	0	1	17	7	5

* - excluded only four less frequently measured water quality variables

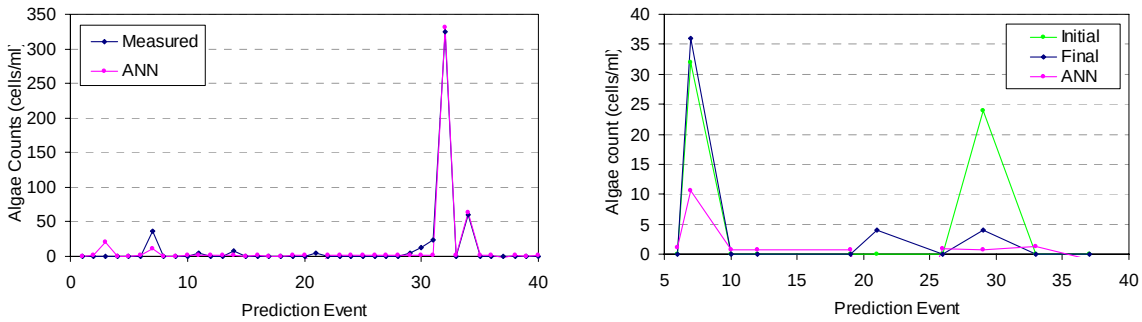
As done for the original models, the percentage accuracy for predicting relative increases or decreases from the initial to final measured counts were compared between the revised models with complete and reduced input sets, shown below in Table 42 below. Unlike the original models, the revised ANN models that excluded the five select input variables slightly outperformed the models that included them, with average correct forecast percentages of 77.5% and 75%, respectively. In a head to head comparison, it was a draw, with three of each outperforming the corresponding model. In terms of average correlation coefficient, the discrepancy between the revised models that excluded and included the select variables was larger, with computed values of 0.74 and 0.63, respectively.

Table 42. Percentage accuracy of the Revised ANN Models for predicting the three different algae classes at different modeling horizons in terms of predicting relative increases or decreases from the validation data sets' Initial to Final measured counts

	Models	No. of Events	Accuracy			
			Correct	%	Incorrect	%
Revised Models with All inputs	612-2wk Ahead Cyanobacteria Predictions	10	8	80	2	20
	100-1wk Ahead Chlorophyta Predictions	45	34	76	11	24
	101-2wk Ahead Chrysophyta Predictions	8	5	62	3	38
	100- 2wk Ahead Cyanobacteria Predictions	41	38	93	3	7
	101- 2wk Ahead Chlorophyta Predictions	8	5	62	3	0.38
	612-1wk Ahead Cyanobacteria Predictions	12	9	75	3	25
Revised Models with Fewer Inputs (exclude select water quality variables)	612-2wk Ahead Cyanobacteria Predictions	35	33	94	2	6
	100*-1wk Ahead Chlorophyta Predictions	67	52	78	15	22
	101-2wk Ahead Chrysophyta Predictions	16	9	56	7	44
	100*- 2wk Ahead Cyanobacteria Predictions	63	57	90	6	10
	101- 2wk Ahead Chlorophyta Predictions	16	12	75	4	25
	612-1wk Ahead Cyanobacteria Predictions	43	31	72	12	28

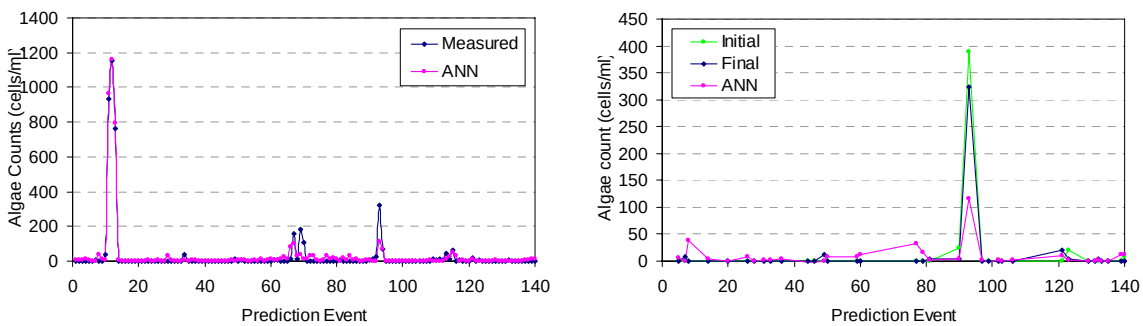
* - excluded only four less frequently measured water quality variables

Figures 81 through 92 depicting the various models are presented below for all representative test cases, showing both the overall and validation results.



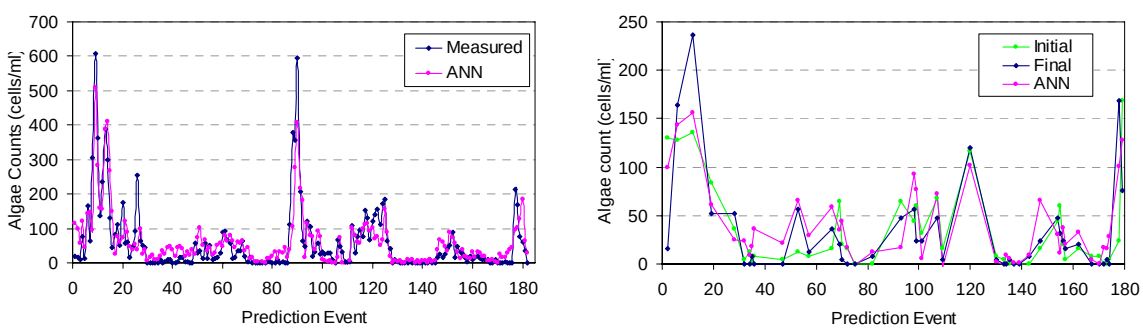
(a) (b)

Figure 81. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 612 (Revised Model using all inputs)



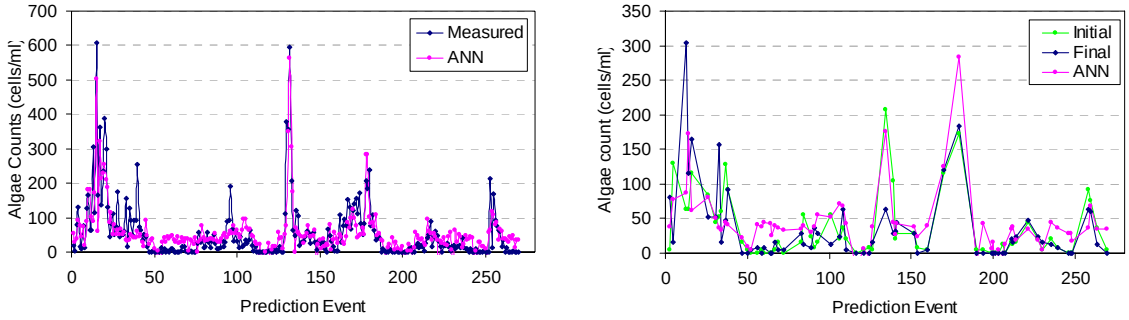
(a) (b)

Figure 82. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 612 (Revised Model excluding five water quality inputs)



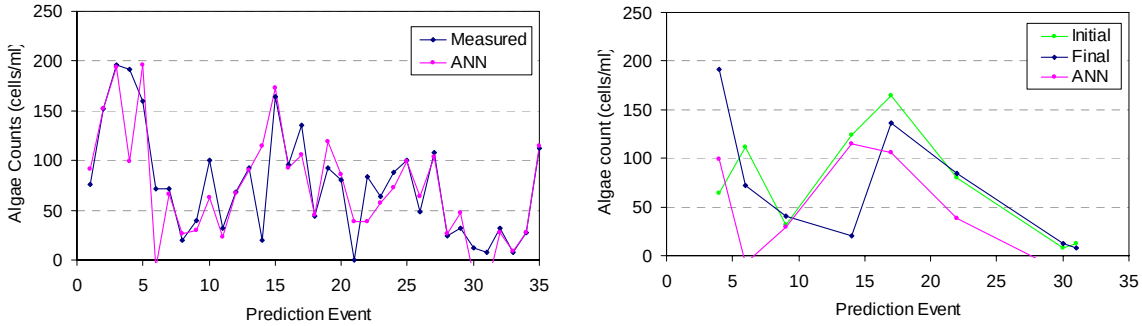
(a) (b)

Figure 83. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data sets at Station 100 (Revised Model using all inputs)



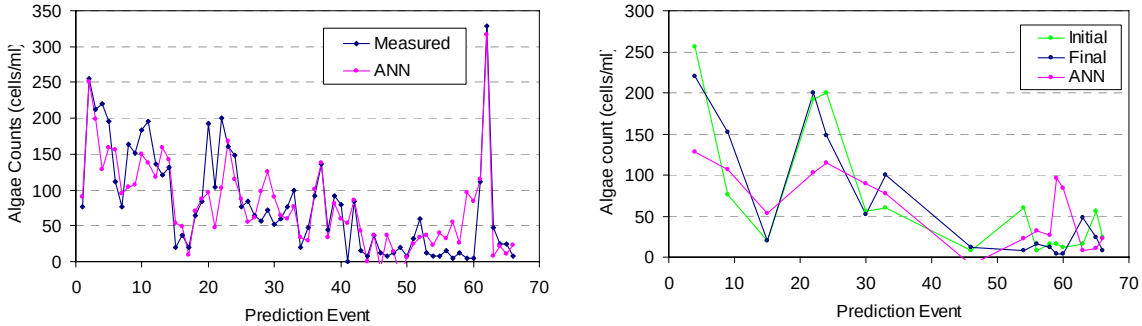
(a) (b)

Figure 84. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 100 (Revised Model excluding four water quality inputs)



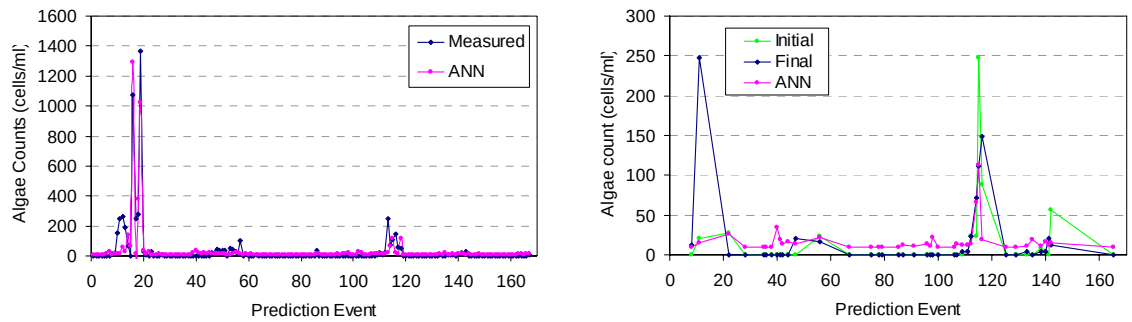
(a) (b)

Figure 85. Time-series plots of measured Chrysophytes counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 101 (Revised Model using all inputs)



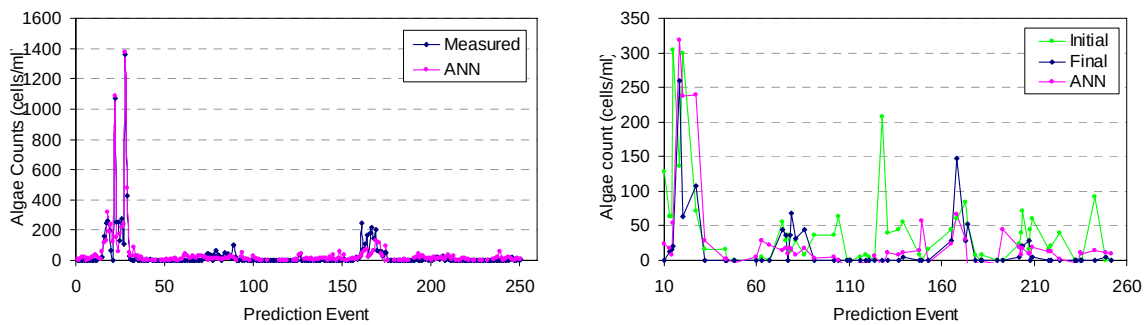
(a) (b)

Figure 86. Time-series plots of measured Chrysophytes counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 101 (Revised Model excluding five water quality inputs)



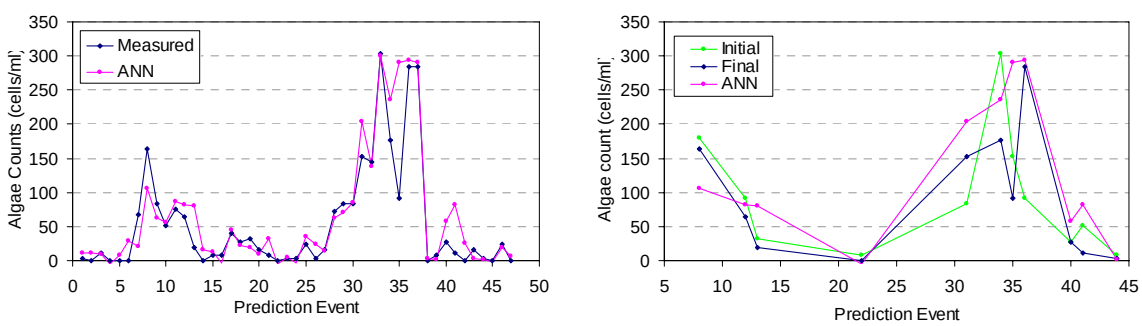
(a) (b)

Figure 87. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 100 (Revised Model using all inputs)



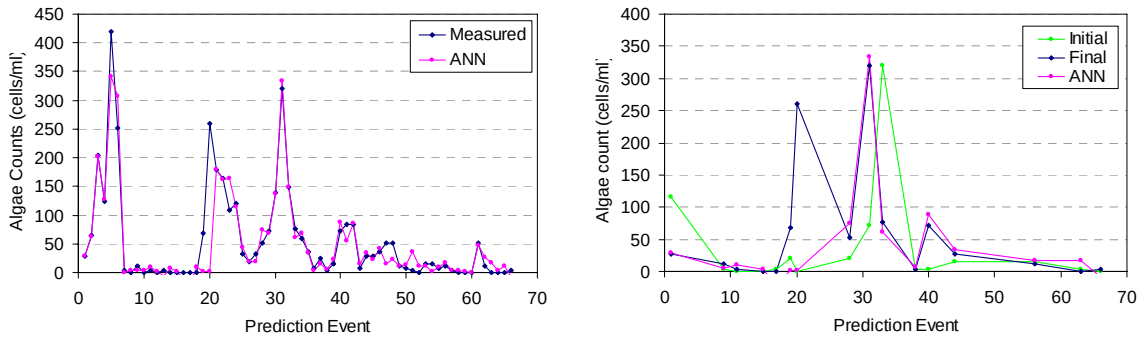
(a) (b)

Figure 88. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data sets at Station 100 (Revised Model excluding four water quality inputs)



(a) (b)

Figure 89. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data sets at Station 101 (Revised Model using all inputs)



(a) (b)

Figure 90. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data sets at Station 101 (Revised Model excluding five water quality inputs)

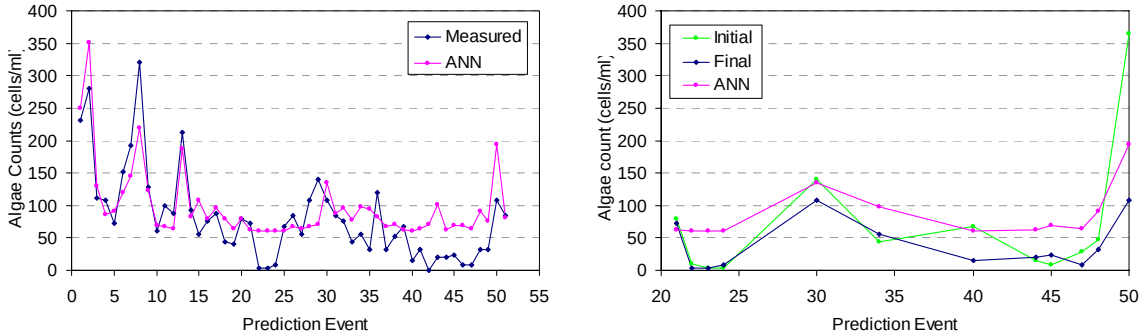
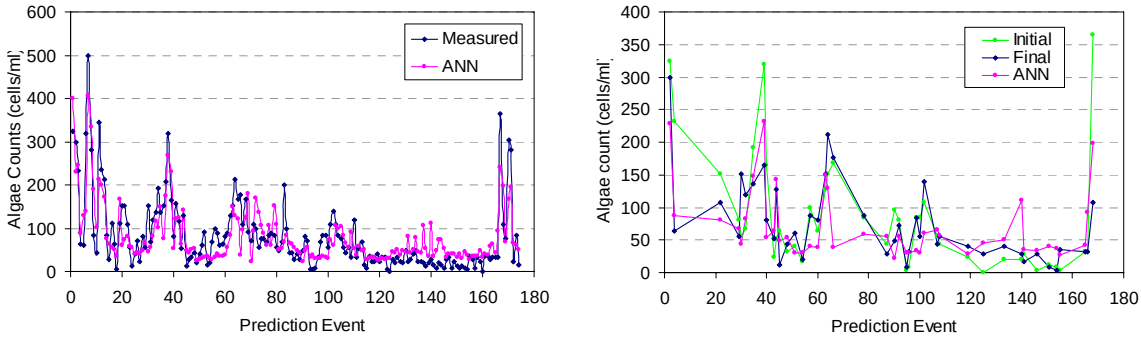


Figure 91. Time-series plots of measured Chrysophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data sets at Station 612 (Revised Model using all inputs)



(a) (b)

Figure 92. Time-series plots of measured Chrysophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data sets at Station 612 (Revised Model excluding five water quality inputs)

Compared to the original models, the validation performance of the revised models are similar, but perhaps slightly less accurate (coefficient value of 0.69 is slightly below the 0.72 value achieved with the former model type). There are some examples where the models during validation accurately predicted very large algal count changes, from bloom to non-bloom events, and vice-versa. For example, the revised model developed with the reduced inputs for predicting chlorophytes one-week ahead at Station 101 (Figure 90b) accurately predicted the evolution of a bloom to non-bloom condition of with a count below 50 for the first validation event. Around event 30, the model accurately forecasted the evolution from an initial non-bloom condition of 60 counts to a bloom condition of approximately 300 counts. Impressively, the model then predicts dissipation of this bloom condition to a non-bloom condition of approximately 60 counts. The model did fail to predict one significant bloom event during validation, but overall, it performed extremely well.

The model developed for predicting chrysophytes one-week ahead at Station 612 with reduced inputs also performed well during validation, accurately forecasting large increases and decreases in algal counts (Figure 92b). Other models performed reasonably well; for example, predicting chlorophytes one-week ahead at Station 100 with all inputs, where evolution from a non-bloom to bloom condition and other relatively large changes were accurately predicted (Figure 83b). For this same prediction problem, the revised model with reduced inputs did not perform quite as well, but did generally manage to predict relative changes (Figure 84b). At the same time, there were models that while correctly predicting a certain condition, may have underestimated or overestimated the magnitude by a fairly large number. The ANN model developed for predicting cyanobacteria two-weeks ahead at Station 612 using the reduced input set is an excellent example (Figure 82b). From an initial count close to 400, it accurately predicts a decrease, but significantly undershoots the measured final value of approximately 270 counts to around 110 counts (Figure 82b).

For the revised models, exclusion of the five select water quality variables at the benefit of larger data sets for ANN development appears to have slightly improved forecasting performance. It is likely that for some conditions, however, inclusion of at least some of these variables would be important, but this needs to be assessed with larger data sets. Again, ideally, the utility will continue to monitor these variables at some regular and perhaps increased frequency, and perhaps, in the future, their potential contribution under a variety of conditions can be more fully investigated.

8.2.4 Sensitivity Analyses Results – Revised Model Paradigm

Table 43 presents the sensitivity analysis result for two-week ahead cyanobacteria predictions with complete set at Station 612. Extraction from PVWC ranked first in terms of importance with relatively high ratio value of 3.7, followed by sky cover and initial cyanobacteria counts, both with ratio values over 2.9. Other variables that ranked near the top also had high ratio values exceeding 2.0. These variables include turbidity, heating degree days, prediction period's precipitation, and total phosphorus/orthophosphate. At the bottom of the ranking, a number of variables achieved low ratio values of less than 1.0, with the three lowest ranking variables being extraction from River B, length of day, and temperature.

Table 43. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 612 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Reservoir A Extraction	3.662	1	Prediction Period's Precipitation Total	1.076	18
Sky Cover	2.915	2	Sulfate	1.075	19
Initial Cyanobacteria counts	2.901	3	Initial Chlorophytes counts	1.065	20
Turbidity	2.637	4	Total Hardness	1.051	21
Heating Degree Days	2.557	5	Chloride	1.050	22
Prediction Period's Lagged Precipitation Total	2.275	6	Wind Direction	1.036	23
T.Phosphorus/Orthophosphate	2.201	7	Alkalinity	1.014	24
Biochemical Oxygen Demand	1.732	8	Conductivity	0.999	25
Wind Speed	1.537	9	Total Organic Carbon	0.991	26
pH	1.381	10	Initial Chrysophytes	0.989	27
Initial Total Algal Counts	1.356	11	River A Streamflow	0.987	28
River A Extraction	1.320	12	Total Amorphous Materials	0.979	29
UV254	1.308	13	Pumping Station 1 Extraction	0.974	30
Color	1.287	14	Odor	0.949	31
Dissolved Oxygen	1.123	15	Temperature	0.947	32
Nitrite/Nitrate	1.112	16	Length of Day	0.935	33
Ammonia	1.078	17	River B Extraction	0.922	34

The overall sensitivity analysis result for the similar revised models but with reduced input variables is shown below in Table 44. As shown, color, turbidity and initial cyanobacteria counts were the three highest ranking, all with ratio values over 2.5. Extraction from Reservoir A and odor also rank high with ratio values around 2.0. At the other extreme, three variables achieved a ratio value less than 1.0, and were total amorphous materials, initial cholorophytes counts, and sky cover.

Table 44. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 612 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Color	2.614	1	Initial Chrysophytes counts	1.091	15
Turbidity	2.601	2	Prediction Period's Lagged Precipitation Total	1.061	16
Initial Cyanobacteria counts	2.581	3	Alkalinity	1.058	17
Heating Degree Days	2.352	4	Prediction Period's Precipitation Total	1.058	18
Reservoir A Extraction	2.241	5	Length of Day	1.052	19
Odor	1.960	6	Total Hardness	1.045	20
River A Streamflow	1.452	7	Conductivity	1.038	21
Wind Direction	1.353	8	Chloride	1.038	22
River A Extraction	1.269	9	Initial Total Algal Counts	1.029	23
pH	1.199	10	Pumping Station 1 Extraction	1.002	24
Wind Speed	1.187	11	Ammonia	1.000	25
Dissolved Oxygen	1.180	12	UV254	1.000	26
River A Extraction	1.093	13	Sky Cover	0.991	27
Temperature	1.092	14			

Table 45 below presents the overall results of sensitivity analysis for one-week ahead prediction of chlorophytes at Station 100. As depicted by the table, initial chlorophytes counts and odor ranked first and second in importance, respectively, with ratio values above1.2, with total organic carbon ranking third with a ratio value of 1.1. All other variables exhibited relatively low ratio values, ranging from just less than 1.0 to just greater than 1.0. Turbidity, wind direction, and extraction from Pumping Station 1 were the three lowest ranking variables.

Table 45. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chlorophytes at Station 100 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.268	1	Wind Speed	1.010	18
Odor	1.212	2	Biochemical Oxygen Demand	1.009	19
Total Organic Carbon	1.104	3	Sulfate	1.008	20
Sky Cover	1.050	4	Dissolved Oxygen	1.007	21
Heating Degree Days	1.045	5	Prediction Period's Precipitation Total	1.006	22
T.Phosphorus/Orthophosphate	1.044	6	Chloride	1.006	23
UV-254	1.038	7	River A Extraction	1.005	24
Temperature	1.025	8	Prediction Period's Lagged Precipitation Total	1.003	25
Initial Total Algal Counts	1.024	9	Initial Chrysophytes counts	1.003	26
Ammonia	1.022	10	Reservoir A Extraction	1.003	27
Initial Cyanobacteria counts	1.020	11	pH	1.002	28
Length of Day	1.020	12	River A Streamflow	1.002	29
Total Hardness	1.018	13	Total Suspended Solids	1.001	30
Conductivity	1.016	14	Pumping Station 1 Extraction	1.000	31
River B Extraction	1.014	15	Wind Direction	0.999	32
Nitrite/Nitrate	1.013	16	Turbidity	0.984	33
Alkalinity	1.011	17			

Table 46 below presents the overall sensitivity analysis result for the ANN revised model with reduced inputs for one-week ahead chlorophytes predictions at Station 100. As shown, heating degree days ranked first in terms of importance, with a ratio value of 1.2, followed by initial chlorophytes counts, odo,r and initial total algal counts, all with ratio values around 1.1 For the lower ranking variables, several variables achieved ratio values less than 1.0, with the three lowest ranking being River A streamflow, wind direction, and UV254.

Table 46. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chlorophytes at Station 100 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Heating Degree Days	1.224	1	Total Organic Carbon	1.015	16
Initial Chlorophytes Counts	1.163	2	Prediction Period's Lagged Precipitation Total	1.014	17
Odor	1.118	3	Ammonia	1.012	18
Initial Total Algal Counts	1.100	4	Turbidity	1.011	19
River A Extractions	1.099	5	Alkalinity	1.006	20
Total Hardness	1.095	6	Reservoir A Extraction	1.005	21
Length of Day	1.080	7	Initial Cyanobacteria Counts	1.003	22
Biochemical Oxygen Demand	1.048	8	Total Suspended Solids	1.000	23
Initial Chrysophytes Counts	1.045	9	Sky Cover	1.000	24
Dissolved Oxygen	1.041	10	pH	1.000	25
Temperature	1.033	11	Wind Speed	0.998	26
Conductivity	1.024	12	Pump Station 1 Extraction	0.997	27
River B Extraction	1.022	13	UV254	0.995	28
Prediction Period's Precipitation Total	1.017	14	Wind Direction	0.994	29
Chloride	1.015	15	River A Streamflow	0.993	30

As for the two-week chryosphytes predictions at Station 101, Table 47 below presents the the sensitivity analysis results. As shown by the table, extraction from River B ranked as the most important predictor variable, with a ratio value of 1.7. Other variables that ranked near the top include odor, color, sulfate, and dissolved oxygen. At the other extreme, only three variables had ratio values less than 1.0, and they were extraction from Pumping Station 1, wind speed and biochemical oxygen demand.

Table 47. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Chrysophytes at Station 101 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
River B Extraction	1.725	1	T.Phosphorus/Orthophosphate	1.081	18
Odor	1.424	2	pH	1.078	19
Color	1.270	3	River A Streamflow	1.077	20
Sulfate	1.239	4	Sky Cover	1.075	21
Dissolved Oxygen	1.229	5	Prediction Period's Lagged Precipitation	1.063	22
Ammonia	1.218	6	Total Amorphous Materials	1.057	23
UV254	1.206	7	Length of Day	1.038	24
Heating Degree Days	1.200	8	Wind Direction	1.028	25
Conductivity	1.187	9	Nitrite/Nitrate	1.028	26
Prediction Period's Precipitation	1.166	10	Initial Cyanobacteria counts	1.025	27
Initial Total Algal Counts	1.162	11	Initial Chlorophytes counts	1.024	28
Turbidity	1.134	12	Reservoir A Extraction	1.012	29
Initial Chrysophytes	1.129	13	Total Organic Carbon	1.007	30
River A Extraction	1.123	14	Total Hardness	1.003	31
Alkalinity	1.121	15	Biochemical Oxygen Demand	1.000	32
Temperature	1.102	16	Wind Speed	0.978	33
Chloride	1.081	17	Pumping Station 1 Extraction	0.924	34

The result of sensitivity analysis for the similar revised model but with reduced input is shown in Table 48. Length of day ranked first with a ratio value of 1.45, followed by total algal counts and odor, both with ratio values over 1.2. At the bottom of the ranking, three variables achieved ratio values less than 1.0, indicating that they were the least important predictor variables in this particular prediction case. These variables include DO, wind direction, and initial chrysophytes counts.

Table 48. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Chrysophytes at Station 101 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Length of Day	1.450	1	pH	1.050	15
Initial Total Algal Count	1.279	2	Turbidity	1.047	16
Odor	1.220	3	Color	1.042	17
Wind Speed	1.172	4	Temperature	1.036	18
Prediction Period's Lagged Precipitation Total	1.152	5	Conductivity	1.016	19
Alkalinity	1.145	6	UV254	1.014	20
River B Extraction	1.134	7	River A Extraction	1.010	21
Initial Cyano Counts	1.092	8	Pump Station 1 Extraction	1.003	22
Chloride	1.089	9	Total Amorphous Materials	1.003	23
Ammonia	1.078	10	Initial Chlorophytes Counts	1.002	24
River A Streamflow	1.065	11	Total Hardness	1.002	25
Prediction Period's Precipitation Total	1.061	12	Initial Chrysophytes Counts	0.997	26
Heating Degree Days	1.052	13	Wind Direction	0.978	27
Sky Cover	1.051	14	Dissolved Oxygen	0.971	28

Table 49 presents the sensitivity analysis results for the revised ANN model two-week ahead cyanobacteria predictions with complete inputs at Station 100. River A extractions and turbidity were the two highest ranking variables in terms of importance, with ratio value of 1.94 and 1.9, respectively. Other high ranking variables achieved high ratio values of from 1.3 to over 1.6, including River B extractions, wind direction, and heating degree days. Several low variables attained ratio values of less than 1.0, including dissolved oxygen, UV254, and length of day.

Table 49. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 100 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
River A Extraction	1.940	1	Initial Cyanobacteria counts	1.033	18
Turbidity	1.905	2	Total Hardness	1.019	19
River B Extraction	1.637	3	Prediction Period's Precipitation Total	1.016	20
Wind Direction	1.375	4	Alkalinity	1.012	21
Heating Degree Days	1.368	5	Sulfate	1.009	22
Odor	1.280	6	Initial Chrysophytes counts	1.008	23
Wind Speed	1.223	7	Biochemical Oxygen Demand	1.006	24
Initial Total Algal Counts	1.197	8	Chloride	1.003	25
Initial Chlorophytes counts	1.190	9	Pumping Station 1 Extraction	1.002	26
Total Suspended Solids	1.166	10	Reservoir A Extraction	0.998	27
Temperature	1.164	11	Conductivity	0.995	28
Ammonia	1.140	12	pH	0.995	29
River A Streamflow	1.076	13	Nitrite/Nitrate	0.995	30
Total Organic Carbon	1.066	14	Length of Day	0.991	31
Prediction Period Lagged Precipitation Total	1.053	15	UV-254	0.988	32
Sky Cover	1.047	16	Dissolved Oxygen	0.973	33
T.Phosphorus/Orthophosphate	1.040	17			

As for the similar model with the complete input set, input variables for the ANN model with the reduced inputs achieved relatively high ratio values, as presented in Table 50. It is interesting that both models have the same three highest ranking variables, though in different orders; turbidity and extractions from Rivers A and B. For the reduced input set model, the first two variables had ratio value just over 2.0 and the third had a ratio value of 1.92. Other high ranking variables include wind speed, wind direction, and dissolved oxygen. At the other extreme, five variables at the bottom of the ranking attained ratio values less than 1.0, with the three lowest ranking being initial chrysophytes counts, biochemical oxygen and total organic carbon.

Table 50. Sensitivity Analysis for Revised ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 100 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Turbidity	2.494	1	River A Streamflow	1.026	16
River A Extractions	2.101	2	Alkalinity	1.023	17
River B Extraction	1.920	3	Temperature	1.014	18
Wind Speed	1.429	4	Prediction Period's Precipitation Total	1.014	19
Wind Direction	1.407	5	pH	1.007	20
Dissolved Oxygen	1.386	6	Chloride	1.006	21
Odor	1.386	7	Total Hardness	1.002	22
Initial Total Algal Counts	1.248	8	Pump Station 1 Extraction	1.002	23
Heating Degree Days	1.205	9	Reservoir A Extraction	1.001	24
Initial Chlorophytes Counts	1.190	10	Total Suspended Solids	1.000	25
Ammonia	1.187	11	UV254	0.999	26
Initial Cyanobacteria Counts	1.155	12	Conductivity	0.997	27
Length of Day	1.070	13	Total Organic Carbon	0.997	28
Sky Cover	1.040	14	Biochemical Oxygen Demand	0.992	29
Prediction Period's Lagged Precipitation Total	1.035	15	Initial Chrysophytes Counts	0.987	30

For the ANN developed for two-week ahead chlorophytes predictions at Station 101, Table 51 below shows that initial cyanobacteria counts and Reservoir A extractions were the two highest ranking variables, with ratio values of 1.8 and 1.65, respectively. The next two highest ranking variables were initial chlorophytes counts and conductivity, both with ratio values just over 1.1. At the other extreme, the three lowest ranking variables were heating degree days, temperature, and ammonia. These three variables were among the ten low ranking variables that achieved ratio values less than 1.0.

Table 51. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chlorophytes at Station 101 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Cyanobacteria counts	1.810	1	Chloride	1.006	18
Reservoir A Extraction	1.650	2	Initial Chrysophytes counts	1.004	19
Initial Chlorophytes counts	1.189	3	pH	1.004	20
Conductivity	1.109	4	Turbidity	1.003	21
Wind Speed	1.094	5	Prediction Period's Lagged Precipitation Total	1.002	22
Prediction Period's Precipitation Total	1.060	6	Total Hardness	1.001	23
Initial Total Algal Counts	1.040	7	Sky Cover	1.001	24
UV254	1.037	8	Sulfate	0.996	25
Colro	1.026	9	Dissolved Oxygen	0.995	26
Biochemical Oxygen Demand	1.025	10	Total Amorphous Materials	0.994	27
River A Extraction	1.021	11	Pump Station 1 Extraction	0.992	28
Wind Direction	1.020	12	Odor	0.990	29
Total Organic Carbon	1.019	13	T.Phosphorus/Orthophosphate	0.984	30
River A Streamflow	1.018	14	Nitrite/Nitrate	0.977	31
River B Extraction	1.016	15	Ammonia	0.975	32
Length of Day	1.015	16	Temperature	0.968	33
Alkalinity	1.015	17	Heating Degree Days	0.954	34

Table 52 below presents the overall sensitivity analysis results for one-week ahead predictions of Chlorophytes a at Station 101 with reduced inputs. In terms of importance, alkalinity, wind direction, and length of day were the three highest ranking variables, all with ratio values just over 1.1. Other variables near the top of the ranking include pH, initial chlorophytes counts, and sky cover. At the bottom of the ranking, four variables achieved ratio values of less than 1.0, including extraction from Pumping Station 1, color, conductivity, and turbidity.

Table 52. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chlorophytes a at Station 101 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Alkalinity	1.188	1	Prediction Period's Precipitation Total	1.014	15
Wind Direction	1.184	2	Heating Degree Days	1.013	16
Length of Day	1.162	3	Initial Total Algal Count	1.012	17
pH	1.127	4	Initial Cyano Counts	1.012	18
Initial Chlorophytes Counts	1.120	5	Ammonia	1.009	19
Sky Cover	1.089	6	Chloride	1.007	20
Odor	1.077	7	Total Amorphous Materials	1.007	21
River A Streamflow	1.069	8	Prediction Period's Lagged Precipitation Total	1.005	22
Temperature	1.064	9	Initial Chrysophytes Counts	1.001	23
Wind Speed	1.048	10	River A Extraction	1.000	24
Total Hardness	1.036	11	Turbidity	0.999	25
UV254	1.022	12	Conductivity	0.998	26
Dissolved Oxygen	1.019	13	Color	0.997	27
River B Extraction	1.018	14	Pumping Station 1 Extraction	0.997	28

As for the one-week chryosphytes predictions at Station 612, Table 53 below presents the overall results for the sensitivity analysis. As shown, the prediction period's lagged precipitation total, extraction from River A, and temperature were the first three top ranking variables. The first had a ratio value of 1.2 while the other two had ratio values just over 1.1. A total of eleven variables achieved ratio values of less than 1.0, and the three lowest ranking variables were total amorphous material, pH, and heating degree days.

Table 53. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chrysophytes at Station 612 with complete input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Prediction Period's Lagged Precipitation Total	1.201	1	Length of Day	1.005	18
River A Extractions	1.124	2	Prediction Period's Precipitation Total	1.002	19
Temperature	1.109	3	Biochemical Oxygen Demand	1.001	20
Odor	1.084	4	T.Phosphorus/Orthophosphate	1.001	21
Initial Chlorophytes counts	1.082	5	Conductivity	1.000	22
UV254	1.037	6	Sulfate	1.000	23
Wind Speed	1.027	7	Nitrate/Nitrite	0.999	24
Pumping Station Extraction	1.027	8	Turbidity	0.999	25
River A Streamflow	1.026	9	Initial Cyanobacterial counts	0.995	26
Chloride	1.022	10	Ammonia	0.994	27
Sky Cover	1.018	11	River B Extractions	0.992	28
Total Organic Carbon	1.016	12	Reservoir A Extractions	0.992	29
Color	1.016	13	Total Algal Counts	0.987	30
Initial Chrysophytes counts	1.014	14	Dissolved Oxygen	0.986	31
Total Hardness	1.013	15	Heating Degree Days	0.985	32
Alkalinity	1.012	16	pH	0.984	33
Wind Direction	1.008	17	Total Amorphous Materials	0.970	34

The sensitivity analysis result for revised ANN model for one-week ahead predictions of chrysophytes at Station 612 with reduced input set is presented in Table 54. Initial chrysophytes counts ranked first with a ratio value of 1.28, followed by length of day and odor, both with ratio value just over 1.1. At the other extreme, only sky cover achieved a ratio value of less than 1.0. Other low ranking variables were wind direction, total algal counts, and ammonia.

Table 54. Sensitivity Analysis for Revised ANN Model for One-week Ahead Predictions of Chrysophytes at Station 612 with reduced input set

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chrysophytes counts	1.282	1	Chloride	1.014	16
Length of Day	1.162	2	Turbidity	1.008	17
Odor	1.130	3	Pumping Station 1	1.007	18
River A Extractions	1.075	4	Dissolved Oxygen	1.006	19
UV254	1.058	5	Wind Speed	1.006	20
Color	1.054	6	Total Hardness	1.006	21
Temperature	1.037	7	Conductivity	1.005	22
Total Amorphous Materials	1.034	8	pH	1.005	23
Prediction Period's Precipitation Total	1.030	9	Reservoir A Extractions	1.003	24
River B Extractions	1.027	10	Prediction Period's Lagged Precipitation	1.002	25
River A Streamflow	1.023	11	Ammonia	1.002	26
Alkalinity	1.016	12	Total Algal Counts	1.001	27
Initial Cyanobacteria counts	1.015	13	Wind Direction	1.000	28
Initial Chlorophytes counts	1.015	14	Sky Cover	0.999	29
Heating Degree Days	1.015	15			

8.2.5 ANN Models without Water Extraction Input variables

A concern that emerged during the study was whether the ANN models were at least partly biased by operational input variables of a more correlative relationship with algal counts, rather than causal. This correlative relationship or bias would be problematic for a real-time forecasting method that is assumed to capture the mechanistic processes that govern algal population dynamics. The variables in question, water extractions from the rivers and reservoir, often reflect operational decisions made in response to formation and/or dissipation of bloom events, and except for Station 100, a mixing point, may not have significant causative effects on algal counts at the water quality river stations. As the example given previously, during an algal bloom event on River A, the utility may discontinue use of this source and make up the deficit with reservoir extraction. Because the reservoir extraction may have relatively little effect on the algae counts on River A,

unlike a weather or chemical variable, but can be correlated with this variable, there is the possibility that the ANN model is "keying" off this relationship. A simple relationship or correlation that the ANN might learn is: "If River A extraction drops to 0, algal counts are relatively high at Station 612, and if River A extraction is high, algal counts are relatively low at Station 612."

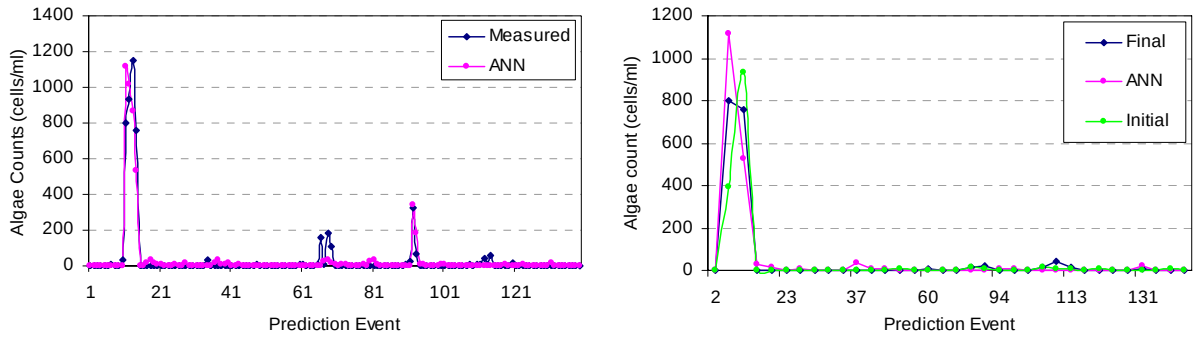
Ideally, the real-time forecasting method should be based upon variables that are independent of any operational actions that the utility may implement in response to measured algal counts, such as water extraction from the reservoir. It should be qualified, however, that river extractions may induce some causal effect on river algal populations. For example, a lower extraction from River A during a bloom event is expected to produce different hydrodynamic and chemical conditions on the river that may effect populations, such as higher turbulence and sediment suspension (i.e. less sunlight penetration). Some overlap between causal and correlative is naturally present for other variables; for example, some water quality parameters were observed to correlate to some degree with measured algal counts. The difference is that these variables are not direct human responses to algal counts, although the human responses manifested in water extraction rates may also influence these variables (e.g. lower river extraction may produce lower dissolved oxygen levels).

To assess the possible influence of these so-called correlative extraction variables on model performance, they were eliminated as inputs for select modeling cases. In consultant with NJDEP and PVWC, the four following forecasting cases were selected, using the original data sets (inputs generally measured at beginning of prediction period); one-week ahead chlorophytes counts predictions for both Stations 100 and 101; two-week ahead cyanobacteria predictions for Stations 100 and 612.

The statistical summaries for these four models are shown in Table 55, with accompanying figures 93 though 96 that depict measured versus predicted values for both the overall and validation data sets.

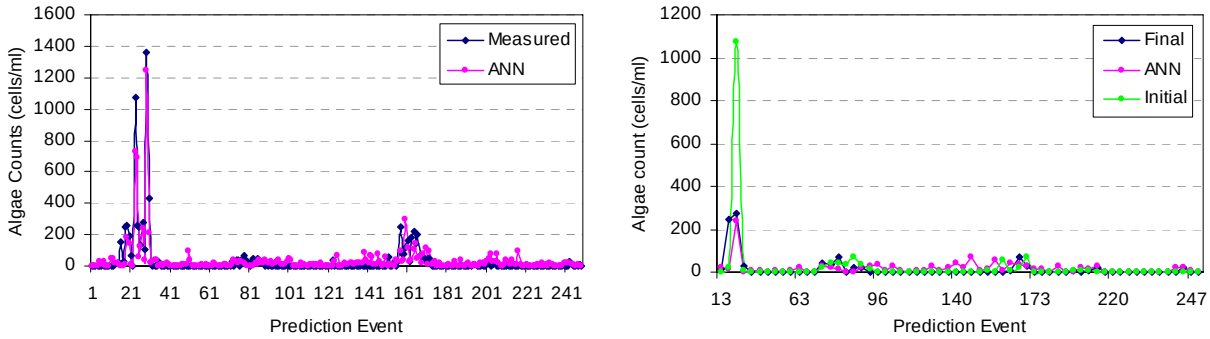
Table 55. Comparison of statistical performances of ANN Models for predicting the two different algae classes at different modeling horizons excluding water extraction inputs

	Station 612 – Two week Ahead Cyanobacteria Predictions			Station 100 - Two week Ahead Cyanobacteria Predictions		
	Overall	Training	Validation	Overall	Training	Validation
Data Mean	34.849	27.380	49.294	30.297	43.360	14.710
Data S.D.	157.155	118.630	182.950	121.847	162.515	47.664
Error Mean	-2.985	-2.476	2.218	1.913	1.255	2.262
Error S.D.	48.151	33.808	68.044	55.346	65.822	35.942
Abs E. Mean	16.479	14.335	24.108	25.473	28.838	17.157
S.D. Ratio	0.306	0.285	0.372	0.454	0.405	0.754
Correlation	0.952	0.964	0.945	0.891	0.915	0.657
No. of Events	139	71	34	249	125	62
No. of Blooms	8	5	2	19	13	2
False Positives	1	1	0	1	0	0
False Negatives	3	3	0	7	3	1
	Station 100 – One week Ahead Chlorophytes Predictions			Station 101 - One week Ahead Chlorophytes Predictions		
	Overall	Training	Validation	Overall	Training	Validation
Data Mean	49.455	51.552	51.848	44.367	55.200	37.185
Data S.D.	77.028	75.136	73.359	75.159	75.743	64.165
Error Mean	5.518	-0.780	13.493	3.651	-0.942	7.800
Error S.D.	50.863	44.149	62.370	47.343	42.079	40.628
Abs E. Mean	32.425	29.475	39.456	27.709	25.155	27.723
S.D. Ratio	0.660	0.588	0.850	0.630	0.556	0.633
Correlation	0.783	0.811	0.788	0.778	0.833	0.775
No. of Events	266	134	66	109	55	27
No. of Blooms	39	23	10	15	11	2
False Positives	21	7	7	4	2	1
False Negatives	17	8	5	1	1	0



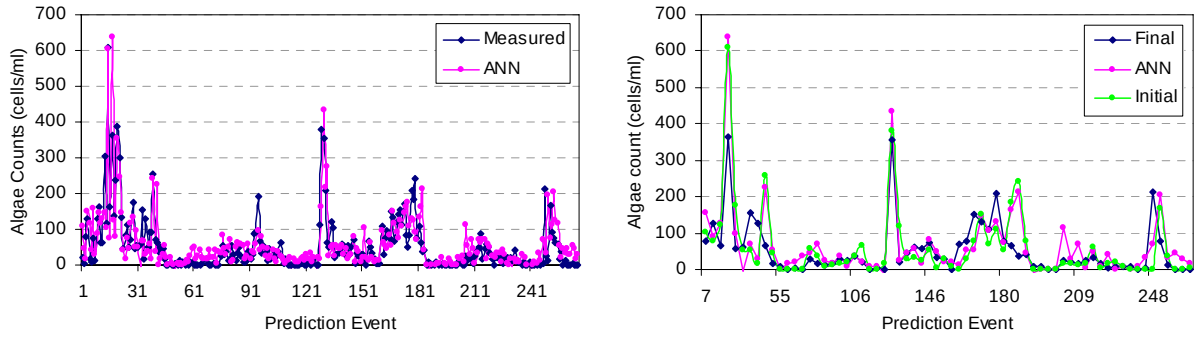
(a) **(b)**

Figure 93. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 612



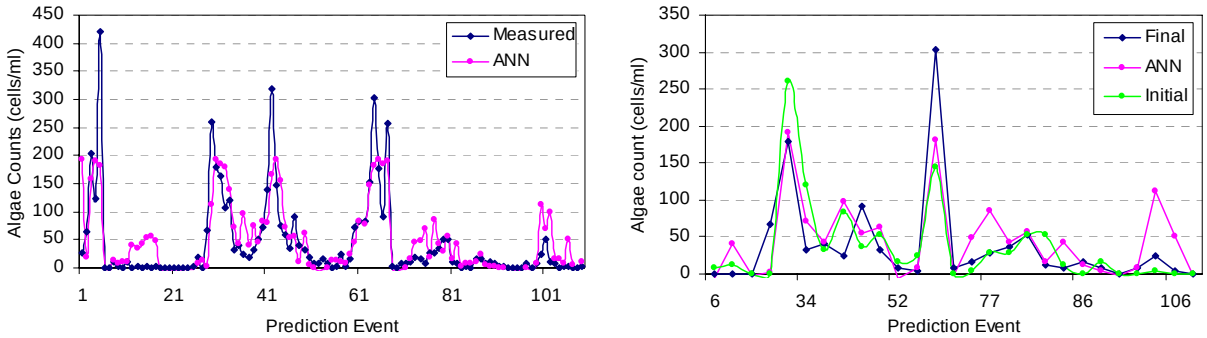
(a) **(b)**

Figure 94. Time-series plots of measured Cyanobacteria counts against ANN Two-week Ahead predicted values for (a) complete and (b) validations data set at Station 100



(a) **(b)**

Figure 95. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 100



(a) **(b)**

Figure 96. Time-series plots of measured Chlorophytes counts against ANN One-week Ahead predicted values for (a) complete and (b) validations data set at Station 101

As expected, the models performed best for Stations 101 and 612, given that mixing of various source waters does not occur, and extractions are not assumed to be strongly causative mechanisms on algal populations. In comparison, there was relatively larger diminishment in forecasting performance for Station 100, where mixing of various source waters does occur, and hence extractions are considered more causal. For the two-week ahead forecasting problem for cyanobacteria at Station 612, the ANN model correctly predicted blooms during both validation events, with no false positives. Similarly for predicting chlorophytes one-week ahead at Station 101, the model correctly forecasted both blooms during validation, with just one false positive. For both stations, the statistical measure for the models that excluded extractions compare favorably with the models that included extractions, with slightly lower correlation coefficients for the former (0.945 versus 0.985 for Station 612, and 0.775 versus 0.788 for Station 101).

For predicting chlorophytes one-week ahead at Station 100, the ANN model clearly appears to have keyed off the initial chlorophytes counts, which as presented further below, had the highest sensitivity ratio for the model. The two-week ahead cyanobacteria forecasting model for Station 100 performed better, and correctly forecasted one of the two validation algal bloom events. However, this model had a relatively large discrepancy in its correlation coefficient between training (0.915) and validation (0.657).

In contrast, the model for this forecasting problem that included extraction as an input achieved a correlation coefficient of 0.847 during validation.

The sensitivity analyses for the four models are presented below in Tables 56 through 59.

Table 56. Sensitivity Analysis for ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 612 without water extraction inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Turbidity	2.840	1	Conductivity	1.022	14
Initial Cyanobacteria counts	1.802	2	Sky Cover	1.011	15
Total Algal counts	1.521	3	Dissolved Oxygen	1.010	16
Color	1.331	4	Alkalinity	1.000	17
Odor	1.228	5	Chloride	0.999	18
Wind Direction	1.186	6	Prediction Period's Lagged Precipitation Total	0.994	19
River A Streamflow	1.129	7	Prediction Period's Precipitation Total	0.991	20
Total Amorphous Material	1.120	8	Initial Chlorophytes counts	0.990	21
Heating Degree Days	1.104	9	pH	0.982	22
Wind Speed	1.089	10	Total Hardness	0.982	23
Ammonia	1.063	11	Length of Day	0.980	24
UV254	1.034	12	Temperature	0.972	25
Initial Chrysophytes counts	1.029	13			

Table 57. Sensitivity Analysis for ANN Model for Two-week Ahead Predictions of Cyanobacteria at Station 100 without water extraction inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Odor	1.752	1	Temperature	1.026	14
Total Algal Counts	1.268	2	UV254	1.021	15
Initial Cyanobacteria counts	1.238	3	Alkalinity	1.021	16
Sky Cover	1.200	4	Chloride	1.020	17
Wind Direction	1.188	5	Initial Chrysophytes counts	1.009	18
Total Organic Carbon	1.182	6	Initial Chlorophytes counts	1.007	19
Biochemical Oxygen Demand	1.150	7	Total Hardness	1.004	20
Dissolved Oxygen	1.141	8	Wind Speed	1.003	21
Conductivity	1.135	9	Prediction Period's Precipitation Total	1.001	22
River A Streamflow	1.124	10	Length of Day	0.999	23
Ammonia	1.078	11	Total Suspended Solids	0.997	24
Prediction Period's Lagged Precipitation Total	1.029	12	Turbidity	0.997	25
pH	1.028	13	Heating Degree Days	0.997	26

Table 58. Sensitivity Analysis for ANN Model for Two-week Ahead Predictions of Chlorophytes couts at Station 100 without water extraction inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.261	1	UV254	1.002	14
Odor	1.216	2	Total Suspended Solids	1.001	15
Chloride	1.200	3	Turbidity	1.000	16
Conductivity	1.152	4	Length of Day	0.995	17
Biochemical Oxygen Demand	1.065	5	Prediction Period's Lagged Precipitation Total	0.995	18
River A Streamflow	1.044	6	pH	0.994	19
Sky Cover	1.039	7	Total Hardness	0.991	20
Dissolved Oxygen	1.016	8	Temperature	0.991	21
Wind Speed	1.015	9	Alkalinity	0.990	22
Ammonia	1.012	10	Prediction Period's Precipitation Total	0.989	23
Total Organic Carbon	1.008	11	Heating Degree Days	0.987	24
Wind Direction	1.006	12	Initial Chrysophytes counts	0.985	25
Initial Cyanobacteria counts	1.006	13	Total Algal Counts	0.972	26

Table 59. Sensitivity Analysis for ANN Model for Two-week Ahead Predictions of Chlorophytes couts at Station 101 without water extraction inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.183	1	Initial Cyanobacteria counts	0.999	14
Prediction Period's Precipitation Total	1.092	2	Total Hardness	0.998	15
Total Algal counts	1.084	3	Length of Day	0.997	16
Ammonia	1.037	4	River A Streamflow	0.997	17
pH	1.026	5	Wind Direction	0.997	18
Alkalinity	1.021	6	Initial Chrysophytes counts	0.996	19
Prediction Period's Lagged Precipitation Total	1.019	7	Heating Degree Days	0.995	20
Color	1.010	8	Total Amorphous Material	0.994	21
Turbidity	1.004	9	Sky Cover	0.991	22
Temperature	1.003	10	Dissolved Oxygen	0.989	23
Wind Speed	1.002	11	Chloride	0.988	24
UV254	1.000	12	Conductivity	0.985	25
Odor	1.000	13			

While there is some similarity, there is some marked inconsistency between the earlier comparable ANN models and these. For example, length of day ranked consistently high for the previous models, but for this case, ranked near the bottom, in all cases having a ratio value < 1.0. Again, given the relatively few events available for ANN development, the sensitivity analyses must be regarded with skepticism.

Excluding volumetric water extractions considered to be correlative variables did not significantly decrease forecasting performance for the two models developed for Stations 101 and 612. In contrast, overall there was more diminishment in performance for the two models developed for Station 100. This supports the conclusion that the previously developed ANN models appear to be learning the underlying system behavior, and for Stations 101 and 612, are not overly biased in correlating extractions with counts. The results also agree with physical intuition, and indeed was anticipated that extraction variables would be more relevant for Station 100, where the mixing of various source waters occurs. Thus, despite the limited data sets, the ANN models appear to have

learned the general underlying behavior in this complex system for the range of conditions measured. This is further supported by the classification modeling results presented in the following section.

8.2.6 ANN Classification Models

As an alternative to developing ANN models that explicitly predict final measured algal counts, RBF nets were developed to predict the pre-specified bins or classification ranges in which the final measured algal counts fall. For this exercise, the following four bins or classification ranges were selected: 0 to 10 counts, 11 to 50 counts, 51 to 200 counts, and 201 and above counts. The original model input sets were used and included both the complete and reduced parameter sets, and as only Stations 101 and 612 were used, water volume extraction variables were excluded as inputs. Station 101 was used for predicting chlorophytes bins one-week ahead and chrysophytes bins two-weeks ahead. Station 612 was selected for predicting chrysophytes bins one-week ahead and chlorophytes bins two-weeks ahead. The four classification bins and stations/algae classes and eight modeling exercise were selected in consultation with NJDEP and PVWC.

Below in Tables 60 and 61 are the tabulated results for two representative cases, comparing the measured versus class predicted values for the entire data set for the models that included and excluded the select water quality variables. Overall, the ANNs did surprisingly well in accurately classifying algal counts into their classification bins. The other results can be found in Appendix B-5.

Table 60. Comparison of measured Chrysophytes counts against ANN One-week Ahead Class-predicted values at Station 101 without Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1*	76	51-200	Correct	34	20	11-50	Correct
2	256	>200	Correct	35	48	11-50	Correct
3	212	>200	Correct	36	92	51-200	Correct
4	220	>200	Correct	37	136	51-200	Correct
5*	196	51-200	Correct	38	44	11-50	Correct
6	112	51-200	Correct	39	92	51-200	Correct
7*	76	51-200	Correct	40	80	51-200	Correct
8	164	51-200	Correct	41	0	0-10	Correct
9	152	51-200	Correct	42	84	51-200	Correct
10	184	51-200	Correct	43*	16	0-10	Incorrect
11	196	51-200	Correct	44	8	0-10	Correct
12	136	51-200	Correct	45	36	11-50	Correct
13	120	51-200	Correct	46	12	11-50	Correct
14	132	51-200	Correct	47	8	0-10	Correct
15	20	11-50	Correct	48	12	11-50	Correct
16	36	11-50	Correct	49	20	11-50	Correct
17	20	11-50	Correct	50	8	0-10	Correct
18	64	51-200	Correct	51	32	11-50	Correct
19	84	51-200	Correct	52	60	51-200	Correct
20	192	51-200	Correct	53	12	11-50	Correct
21*	104	51-200	Correct	54*	8	11-50	Incorrect
22	200	>200	Correct	55	8	0-10	Correct
23	160	51-200	Correct	56	16	11-50	Correct
24	148	51-200	Correct	57	4	0-10	Correct
25	76	51-200	Correct	58	12	11-50	Correct
26	84	51-200	Correct	59	4	0-10	Correct
27	64	51-200	Correct	60	4	0-10	Correct
28	56	51-200	Correct	61	112	51-200	Correct
29	72	51-200	Correct	62	328	>200	Correct
30	52	51-200	Correct	63	48	11-50	Correct
31	60	51-200	Correct	64	24	11-50	Correct
32	76	51-200	Correct	65	24	11-50	Correct
33	100	51-200	Correct	66	8	0-10	Correct

* - validation event

Table 61. Comparison of measured Chrysophytes counts against ANN One-week Ahead Class-predicted values at Station 101 with Chemical Inputs

Event	Measured	Bin	Accuracy
1	76	51-200	Correct
2	152	51-200	Correct
3	196	51-200	Correct
4	192	51-200	Correct
5	160	51-200	Correct
6	72	51-200	Correct
7	72	51-200	Correct
8	20	11-50	Correct
9	40	11-50	Correct
10	100	51-200	Correct
11	32	11-50	Correct
12	68	51-200	Correct
13	92	51-200	Correct
14	20	11-50	Correct
15	164	51-200	Correct
16	96	51-200	Correct
17	136	51-200	Correct
18	44	11-50	Correct
19	92	51-200	Correct
20	80	51-200	Correct
21	0	0-10	Correct
22	84	51-200	Correct
23	64	51-200	Correct
24	88	51-200	Correct
25	100	51-200	Correct
26	48	11-50	Correct
27	108	51-200	Correct
28	24	11-50	Correct
29	32	11-50	Correct
30	12	11-50	Correct
31	8	11-50	Correct
32	32	11-50	Correct
33	8	0-10	Correct
34	28	11-50	Correct
35	112	51-200	Correct

As the two representative cases demonstrate, the models correctly predicted the classification range or bin for the final measured algal counts with high accuracy. In the few cases that the classification was incorrect, it always occurred with an adjacent class. For example, for event 54 (a validation) shown in Table 60 above, the ANN model predicted the final measured algae count of 8 would fall into the bin or classification range of 11 to 50 counts. Given the impreciseness of the measured algal counts, where previous researchers estimate a measurement error of approximately ±20% (excludes spatial variability), the classification performance is high.

Table 62 below summarizes the overall performance of the different classification models by percentage classification accuracy, with the number of events provided, and the inclusion or exclusion of the five select water quality variables indicated.

Table 62. Overall Percentage Accurary for the Eight RBF Nets

Station	Organism	Select Chemical Inputs	Total Number Correct	Total Number Events	Percentage Classification Accuracy (%)
101	Chrysophyta	Included	35	35	100.0
101	Chrysophyta	Excluded	64	66	97.0
101	Chlorophyta	Included	47	47	100.0
101	Chlorophyta	Excluded	95	96	99.0
612	Chrysophyta	Included	51	51	100.0
612	Chrysophyta	Excluded	144	174	82.8
612	Chlorophyta	Included	38	44	86.4
612	Chlorophyta	Excluded	125	140	89.3

Note: Original Input Structure Used for All Models, and extraction variables excluded.

On average, the models that included the five select chemical inputs slightly outperformed those that did not, with correct classification percentages of 96 and 92 percent, respectively. However, the models that excluded these five water quality variables had approximately three times the number of events, and hence had more events that bordered on two classification bins. Three of the eight models, which included all

chemical inputs, achieved 100 percent classification accuracy. The lowest performing net correctly classified 83 percent of the events, and all incorrect classifications for all models occurred within an adjacent bin (e.g. measured count of 8, predicted range of 11 to 50).

Finally, as described in the ANN section, RBF models excluded variables that reduced classification accuracy during learning. Table 63 below presents the forecasting problems and corresponding variables that were excluded by the various RBF nets.

Table 63. List of Input variables excluded by various RBF nets during Training

Station	Organism	Prediction Horizon	Select Chemical Inputs	Variables Excluded by the Nets
101	Chrysophyta	Two-week Ahead	Included	Conductivity
101	Chrysophyta	Two-week Ahead	Excluded	Ammonia
101	Chlorophyta	One-week Ahead	Included	Total Phosphorus/ Orthophosphate, Initial Chlorophytes counts, Odor, Total Amorphous Materials
101	Chlorophyta	One-Week Ahead	Excluded	Chloride, Odor, Total Amorphous Materials
612	Chrysophyta	One-Week Ahead	Included	pH, Heating Degree Days, Length of Day, Total Amorphous Material, Initial Cyanobacteria counts, Initial Chlorophytes counts
612	Chrysophyta	One-Week Ahead	Excluded	All variables ***except*** Alkalinity, Conductivity, Wind Speed, Length of Day, Total Algal Counts, Initial Chrysophytes counts, Initial Chlorophytes counts
612	Chlorophyta	Two-week Ahead	Included	All variables ***except*** Dissolved Oxygen, UV254, Heating Degree Days, Sky Cover, Length of Day
612	Chlorophyta	Two-week Ahead	Excluded	No variable excluded

Again, because of the sparse data sets, it is difficult to draw conclusions with high confidence. It is, however, interesting to note that three of the four ANNs that initially included the select water quality parameters generally eliminated these as inputs. In addition, length to day was included for seven of eight models, including the two models that eliminated most variables, and two nets for Station 612 eliminated most inputs.

8.2.7 Linear Models versus ANNs

In order to further assess the performance of the ANN technology, as was done in the preliminary research for Swimming River, linear models were also applied to the PVWC site. Although transformation of the data, for example, logarithmically, may have improved LM performance, the main objective of this analysis was to provide an objective assessment of ANN performance with an alternative model paradigm using the identical data sets. The linear models used in this research are analogous to traditional linear regression equations, but utilize a superior algorithm to find the "best fitting" coefficients. As with the ANN modeling, the software Statistica was used to perform this work.

Linear models were developed to predict the three algae types at the three stations used as representative models. Of the twelve prediction problems, the ANN models provided a lower MAE error eleven times, often significantly smaller. The only time the LM model provided lower MAE's was for predicting chrysophytes two week-ahead at Station 101 with reduced input set measured primarily at the beginning of the prediction period.

Tables 64 and 65 provide a statistical comparison between the two model types for the two modeling approaches and data sets as presented by the three representative models.

With respect to a model's ability to accurately predict the incidence and magnitude of algal blooms while avoiding false positives, the discrepancy between the ANNs and the LMs is often quite significant. The ANNs were generally able to reproduce the rising and falling algae count levels, predicting the incidence and magnitude of algal blooms, while minimizing false positives. In contrast, the LMs sometimes fail in both measures, particularly for cyanophyta.

Table 64. Statistical Measure Comparison between ANN and LM for Original Models with two types of input variables

		Complete Input Set		Reduced Input Set	
		ANN	LM	ANN	LM
Station 612: Two-week Ahead Cyanobacteria Prediction	Mean Absolute Error	25.607	110.536	12.816	44.179
	Correlation Coefficient	0.939	0.592	0.979	0.823
Station 100*: One-week Ahead Chlorophytes Prediction	Mean Absolute Error	33.485	67.271	33.569	34.755
	Correlation Coefficient	0.612	0.139	0.772	0.719
Station 101: Two-week Ahead Chrysophytes Prediction	Mean Absolute Error	32.075	38.995	37.639	32.792
	Correlation Coefficient	0.638	0.404	0.590	0.662

Table 65. Statistical Measure Comparison between ANN and LM for Revised Models with two types of input variables

		Complete Input Set		Reduced Input Set	
		ANN	LM	ANN	LM
Station 612: Two-week Ahead Cyanobacteria Prediction	Mean Absolute Error	4.019	9.622	10.973	35.487
	Correlation Coefficient	0.987	0.932	0.983	0.863
Station 100*: One-week Ahead Chlorophytes Prediction	Mean Absolute Error	33.123	53.680	34.560	40.959
	Correlation Coefficient	0.839	0.596	0.805	0.702
Station 101: Two-week Ahead Chrysophytes Prediction	Mean Absolute Error	19.655	30.568	26.909	49.810
	Correlation Coefficient	0.824	0.491	0.865	0.361

* - excluded only four less frequently measured water quality variables for the reduced input set

Figures 97 and 98 compare the ANN and LM performance for predicting cyanophyta counts at station 612 two-week ahead and chlorophyta counts at Station 101 one-week ahead prediction periods, respectively. The figure show the original and revised modeling approach using the two type of data set (i.e. larger data set with lesser input variables and smaller data set with more input variables). Similar figures for the remaining prediction events (i.e. combinations of algae types, stations, and prediction periods) can be found in Appendix B-6.

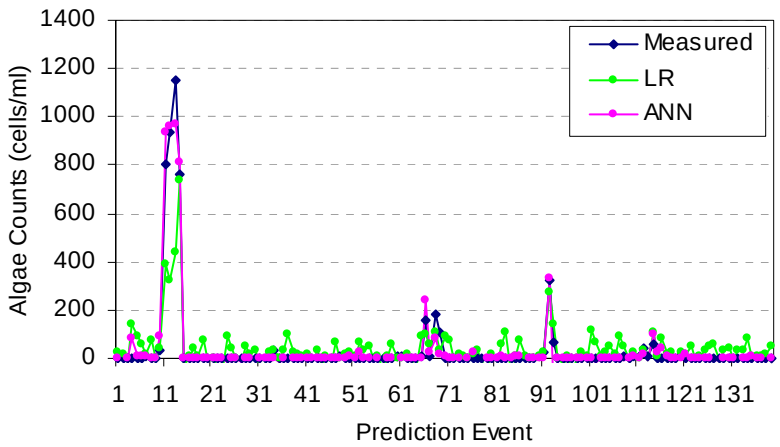


Figure 97. Comparison of Original ANN and LM performance for two week-ahead predictions of cyanobacteria at Station 612 without the five chemical variables

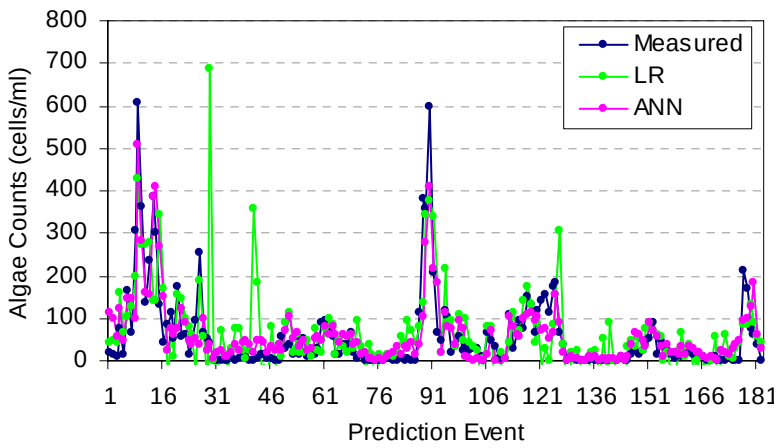


Figure 98. Comparison of Revised ANN and LM performance for One-week predictions of chlorophyta at Station 100 with complete input set

As shown by Figure 97, for the two-week ahead prediction of cyanobacteria counts at Station 612, the LM seriously under-predicted the three highest count events. The LM predicted just 388, 320 and 434 for algal blooms of 800, 932 and 1152 counts, respectively. By contrast, the ANN model accurately predicted six of the eight bloom events, and for the entire data record produced just two relatively minor false positives. Similarly for the other prediction cases using the same modeling approach, LMs have the tendency to under-predict most of the high count events. In particular, for one-week ahead prediction of chlorophyta counts at Station 101, the LM predicted just 80 and 253

for 304 and 608 count events, respectively. Similarly, in predicting two-week ahead chrysophyta counts at Station 101, LM again under-predicted the two particularly high count events. Figure 98 shows that for one-week ahead prediction of chlorophyta at Station 100, and as shown LM provided a total of 15 false positives, with three serious ones that predicted 688, 355 and 184 to a 44, zero and four count events, respectively. By contrast, the ANN accurately tracked down the high and low count events and provided just minor false positives. As the other figures in Appendix B-6 show, the LM in general was less reliable in avoiding false positives and negatives.

Overall then, the generally inferior LM performance supports the assumed non-linearity of this modeling problem. In addition, it also provides some degree of confidence that the ANN technology was, despite limited data, still able to learn to some degree seemingly subtle and complex relationships between the predictor variables and the algae count.

Tables for the sensitivity analysis for the LMs can be found in Appendix B-6. Because of the inferior performance of the LMs and the limited data sets, a formal evaluation of the sensitivity analysis results is not presented.

9. DISCUSSION AND CONCLUSIONS

This primary objective of this research project was to investigate the feasibility of using ANN technology for forecasting algal bloom events in surface water systems used for potable supply. ANN technology differs from traditional mechanistic modeling approaches that attempt to explicitly represent the governing laws with physical-based equations for forecasting system states of interest. Instead, ANNs represent a learning paradigm approach, where by processing representative historical events through their architecture, state-transition equations that predict system responses as a function of input predictor variables are obtained. Although previous work has been conducted in this area, every open water system presnts its own unique set of challenges and problems. In addition, unlike previous work in the literature, the number of available historical events was rather limited in this study, which likely will be the case for most facilities. Recognizing this, one of the objectives, then, was to attempt to identify important predictor variables for effective model performance so that sampling strategies could be improved. In addition, classification nets were also developed and tested as an alternative forecasting approach. Lastly, the feasibility and benefits of using ANN technology for modeling water treatment processes was also investigated.

Two water utilities served as test cases for forecasting algal population counts, New Jersey American Water, at its Swimming River facility, and PVWC, with the former utility also serving as the test case for the water treatment component. Each represents a unique system; Swimming River consists of a single reservoir within a watershed, while PVWC obtains its water supply from two different rivers that are part of two different watersheds with distinct characteristics. Hence, for Swimming River, water quality samples collected at three locations were treated as one location, while for PVWC, the best results were achieved when each of the three sampling stations were each modeled individually. While cyanobacteria, a recognized threat to human health and the environment, was the initial focus of this algae forecasting modeling effort, the study was expanded to include two other algae types measured at PVWC, chlorophyta and chrysophyta.

Several hundred ANN models of different types were developed and tested for the algal bloom forecasting problem, and their predictive performance was compared against measured values. In addition, linear models (LMs) were also developed with the same data sets as an additional benchmark for ANN performance. For Swimming River, a single one week-ahead prediction period was used, while for PVWC, one-week and two-week ahead prediction periods were primarily used. Input predictor variables included chemical, physical, hydrological, weather/meteorological, and water extraction data.

Unlike the PVWC facility, it was determined on the basis of the validation results that the ANN models were over-fitting the data for the Swimming River facility. Although the ANNs did significantly outperform LMs for the Swimming River data, the discrepancy between ANN training and validation results were relatively large. In addition, based upon sensitivity analyses, it was determined that water quality variables measured relatively infrequently by the utility are important predictors of cyanobacteria populations in the reservoir system. Consequently, the great majority of the ANN algae modeling effort were directed to the PVWC data.

For the PVWC system, two different input structures were initially used to assess possible time lags in algal system dynamics, and to address the feasibility of real-time implementation. The first or original input structure used input values measured primarily at the beginning of the prediction period, while the second or revised modeling structure used model input values measured primarily at the end of the prediction period, coinciding with the final or predicted algal count. Thus, unlike the original approach, where, under real-time forecasting conditions, the input values would be known a-priori, the revised modeling approach would have to forecast or assume input values corresponding to the future prediction day.

The number of historical training events available for each forecasting problem ranged between 19 and 136, and averaged 65, far below the minimum required number of 200, computed on the basis of the number of input and output variables. To address the data

quantity issue, both the original and revised modeling approaches were assessed with two distinct data sets. The first set consisted of the smaller number of historical events, which included a higher number of input variables, while the second set consisted of a larger number of historical events by excluding select water quality variables that were measured less frequently than other input variables. The five water quality variables included some of the so-called limiting nutrients, and are: Biological Oxygen Demand (BOD), Total Phosphorous/Orthophosphate, Nitrite/Nitrate, Sulfate, and Total Organic Carbon (TOC) (BOD was not excluded for Station 100).

In general, ANN models performed well during validation, and in many cases, accurately predicted large changes in algal populations. The level of accuracy was surprising, given the complexity and non-linear behavior of algal populations, the inherent data noise, and the relatively small number of historical events available for training. On the basis of validation correlation coefficients, the models (not classification) that used input values measured at the beginning of the prediction period slightly outperformed those that used input values measured at the conclusion of the prediction period, with average values of 0.72 and 0.69, respectively. A more subjective visual comparison of the time-series for the validation figures appears to confirm that the original models did achieve higher performance. The models that excluded the less frequently measured water quality variables with the benefit of more training events produced a higher average correlation coefficient of 0.77, to the 0.63 value for models that included these variables. However, there was at least one case where the models that included the select water quality variables achieved significantly higher validation performance.

The ANN models developed with inputs measured at the beginning of the one-week and two-week ahead prediction periods accurately predicted formation and dissipation of algal bloom events, as well as relative increase and decreases, indicating that there are natural time lags between system conditions and algal population responses. That is, algal populations may on average evolve predictably in response to system conditions, and the trajectory of algal counts over one and two-week forecast periods can be

accurately forecasted on the basis of real-time measurements. This may also reflect that open water conditions as influenced by external factors like weather do not typically change significantly in the short-term (e.g. weekly or even bi-weekly), and thus evolving algal populations are not prone to abrupt deviations from trajectory paths. The relatively small changes in conditions over prediction periods is supported by the statistical analyses of the data, and the fact that the revised models, which primarily used final measured input values, also performed relatively well.

There is also some physical foundation for this hypothesis. For example, because of the high specific capacity of water, significant water temperature changes will not typically occur over one and two-week prediction periods. Exceptions may occur with a particularly extreme weather event, which may also induce large water quality changes, but this will be atypical. Recognizing the complexity of these systems, additional research is necessary to test the validity of these claims for this system. Furthermore, because algal population dynamics vary from system to system, different time lag scales may be observed for different systems.

That the ANN models that excluded select water quality variables on average slightly outperformed models that included them (not classification) may signify less about the influence of these variables on algal population dynamics, and more about the inadequate number of training events. At the same time, it does indicate that during most time periods in the PVWC system, these variables may not be important predictors of algal populations, suggesting that they usually exist within a range of values that neither inhibit nor stimulate algal blooms. This is weakly supported by additional sensitivity analysis, as well as the Swimming River results, where significantly better results were achieved when water quality variables were included, even though this meant a five-fold reduction in the number of data events.

It should be recognized that for some time periods, inclusion of some or all of these variables may be important. There was at least one case where inclusion of these

variables significantly improved validation performance. A comparison of time-series between nitrite/nitrate concentrations and algal counts suggest at least a correlative if not causal relationship, where some large blooms occurred during periods of high concentrations. Thus, it may be that with an adequate number of data events for training, inclusion of the select water quality variables will improve overall performance, and may increase the likelihood of forecasting the formation and dissipation of bloom conditions during unusual conditions.

In comparison, the LMs did not perform as well, achieving significantly lower correlation coefficients and higher mean absolute errors, and in some cases, failed to predict very high count algal blooms while erroneously predicting other blooms during low count periods. It should be mentioned that the statistical distribution of the variables were not formally determined for this study, and consequently, data transformations were not performed (e.g. log normal). Had statistical transformations been made, the LMs would most likely have performed better. However, this also underscores one of the inherent advantages of ANNs; because of their universal non-linear modeling capability, they are not limited by the form of the data distribution(s).

The small number of historical data events limits the accuracy of the sensitivity analyses performed by measuring the relative increase in RMSE by excluding each input variable. However, some basic trends did emerge, with the most important possibly being the relative non-importance of the select water quality variables excluded from some models. In particular, the two "limiting nutrients", total phosphorous/orthophosphate and nitrite/nitrate, generally did not rank high as important predictor variables. This relative non-importance is weakly supported by the better performance of the models that excluded these variables. The time-series comparison of these parameters versus algal population also does not reveal an obvious relationship between concentrations and counts. Other variables like river and reservoir extractions ranked highly, and this is not surprising, given that water extraction volumes are often modified by PVWC in response to measured algal counts.

For example, a high extraction from Reservoir A, a backup source which normally is not used, occurs during periods of algal blooms on River A, where extraction from this river source is minimized. This potentially overly correlative relationship or model bias would be problematic for a forecasting method that is predicated on capturing the underlying mechanistic processes that govern algal population dynamics. When volumetric water extractions were excluded for four select test cases, forecasting performance remained high for models developed for Stations 101 and 612. In contrast, there was observable diminishment in performance for models developed for Station 100, which is a mixing point for various water sources, and thus extractions would be considered more causal in nature (i.e. hydraulic mixing of various source waters with differing levels of algal counts). The possibility for some causative relationship between water extractions and algal populations at river stations should not be dismissed. Variable extraction rates undoubtedly induce certain physical (e.g. different river stages) and water quality changes on the river that influences algal population dynamics.

As a final ANN modeling paradigm, RBF classification nets were developed with the single output variable representing the predicted "bin" or classification range of values for final measured algal counts, with four such possible bins; 0 to 10; 11 to 50; 51 to 200; and > 200. For the eight test cases, which used the original models with both the complete and reduced input sets, the ANN models classified the counts into the correct bins with very high accuracy, despite limited data. As with the previous models developed for predicting single count values, the highest performing classification nets excluded the select water quality variables. Even the poorest performing RBF net correctly classified 83 percent of the events, with all incorrect classifications falling within an adjacent bin (e.g. measured count of 8, predicted bin of 11 to 50).

There are a number of possible ways in which the ANN algal population forecasting models can be improved with additional work, and include:

1. The systematic elimination of input variables to further distinguish between critical and non-critical ANN inputs. This would help offset the relatively small number of historical events by reducing the dimensionality problem of the error space.
2. Increased monitoring of certain "limiting" nutrients, such as nitrite/nitrate and total phosphorous/ortho-phosphate, which would further define their importance on algal population dynamics.
3. Inclusion of other potentially important causal variables as model inputs, such as biological organisms that graze on algae.
4. Use of time lags for select predictor variables, such as streamflows and algal counts, which have been shown in a previous study (Maier, 1998) to significantly increase model performance.
5. A possible hybrid of the two modeling approaches, where some combination of existing/historical and future conditions is used as inputs. The obvious example of future conditions would include weather, where weather forecasts could be used as inputs to account for possible significant short-term effects on algal populations.
6. Collection of additional data to generate a larger number of events for model development and testing.
7. Following development of robust models, a perturbation sensitivity analyses that quantifies how different changes in input values affect algal population changes.

To increase data set sizes used in future modeling efforts, it is also possible to exploit the recently automatic data collection system recently implemented at the facility. Specifically, water quality conditions at Station 100, the intake point for the water treatment plant, is essentially the product of the relative contribution of the different water sources, which for most time periods is the rivers. At the very least, real-time water quality data measured at Station 100 could be used to estimate real-time water quality conditions at the water sources, and vice versa. This type of spatial-relational modeling capability could in the long-run be used by the utility to make more informed management decisions while offsetting sampling costs. This type of analysis also has a source water protection component to it, in that water quality conditions can be

continuously assessed in real-time. In terms of existing sampling methodology, it is recommended that the five water quality variables be sampled at a higher frequency.

The modeling results taken in their totality strongly indicate that the ANN models developed for the PVWC system learned some underlying relationship between select hydrologic, weather/meteorological, water quality, and extraction inputs and counts for the three algal classes. This is supported by a number of study outcomes, including; 1) relatively high model accuracy and overall consistency between training and validation results; 2) consistency in performance for different types of models, including original, revised, and classification models; 3) consistency between modeling results and physical intuition/system understanding; and 4) relatively poor performance of LMs.

Future research should focus on evaluating the use of ANN as a forecasting tool to predict single algal species. For example, odor problems are often produced by a single algae specie. However, it is not cost effective for most utilities to monitor populations at the species-specific level. Currently, taste and odor events attributed to algal productivity are best predicted by direct measurement of the odorants, with budgets for analytical services to measure odorant concentrations sometimes running into the thousands of dollars per year. ANN forecasting of specific odorant producing algal species could prove to be a more cost effect approach for predicting algal related taste and odor events. Research should be conducted to evaluate the cost savings that could be realized by replacing a 'traditional' grab and online monitoring program with an ANN generated forecast. Utilities would benefit from being able to provide the same level of monitoring while minimizing the costs of consumables and staff hours needed to maintain a monitoring program. Related to this, guidance is needed for utilities to develop sampling matrices that will generate sufficient data to adequately train and validate the ANN and reduce sampling costs. Identification of important predictor variables for effective model performance is also needed to improve sampling strategies and minimize analytical costs. Thus, in final summary for the algal bloom modeling:

- Despite a very limited number of available data sets, the ANN models performed well in most cases during validation, accurately predicting large changes in algal cell populations. The degree of accuracy was surprising, given the complexity and non-linear behavior of algal populations, inherent data "noise", and the relatively small number of historical events available for model training.

- The ANN models that forecasted algal count values (instead of classification ranges) achieved the highest performance when the less-frequently measured water quality variables (phosphate, nitrate, sulfate, TOC and BOD) were excluded as input variables. This may be due to a data quantity issue rather than inherent importance of these parameters to algal cell growth, but it could also be that, at the concentrations at this WTP, these parameters were not "limiting" algal growth.

- Like the cell count models, the Radial Basis Function classification net models classified the counts into the correct concentration ranges with very high accuracy, averaging 94 percent.

- Linear models did not perform as well as the ANN models, however the LM models were not optimized.

- While not definitive, the results strongly indicate that the ANN models learned some underlying relationship between select water quality and meteorological parameters, and algal cell concentrations at this WTP. This is supported by: 1) relatively high model accuracy and overall consistency between training and validation results; 2) consistency in performance for different types of models (single value outputs and classification) and input structures (original and revised); 3) consistency between modeling results and physical intuition/system understanding; and 4) comparatively poor performance of linear models.

For the water treatment study component, the ANN technology accurately learned to predict finished water quality conditions, namely average daily turbidity, highest daily

turbidity, and number of turbidity counts exceeding 0.1 NTU, based upon raw water conditions and treatment processes. The ANN models verified a seasonal component to treatment conditions and outcomes, and also confirmed a non-intuitive negative correlation between raw water temperature and raw water turbidity. It is believed that future consultation with water treatment experts could improve model performance by identifying the most important predictor variables based in accordance with professional experience and knowledge. As with the algae forecasting models, another possible way for improving model performance may be with inclusion of time lags for certain input variables.

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APPENDIX A-1

SWIMMING RIVER
Cyanobacteria Modeling

CYANOBACTERIA MODELING – SWIMMING RIVER RESERVOIR

The original data set consisting of 48 chemical events was used for developing and testing additional ANN models. Again, the chemical events include all of the physical variables used during the physical modeling, such as precipitation, air temperature, water temperature, etc., plus the four chemical variables that are intermittently measured; nitrite/nitrates, total phosphorous, ammonia, and turbidity. One issue of concern for this particular modeling problem is the relatively small number of events for the chemical data set relative to the number of nodes in the network models. As the size of the ANN increases, with more input, output, and hidden nodes, the dimension of the error space increases, and hence, larger data sets are required for the ANN to search along the error space and effectively learn. This concern is supported by the testing error relative to the training error achieved with the ANNs. As discussed in the ANN background section, the training data, consisting of half of the available data, in this case, 24 events, is used by the ANN during learning to identify the optimal weight connections. A separate validation or testing data set is used to determine how effectively the ANN has learned to generalize system behavior.

Table 1 (modified Table 5 in interim report) compares the statistical performance of the different ANN models. For the first ANN model, all four chemical variables were used as inputs (i.e. "All"). For the four next models, only the chemical variable corresponding to the heading in Table 1 was used as a chemical variable input (e.g. ammonia) for the ANN model. The last model, designated "None", used no chemical input variables. The table has been expanded to include the number of false positives and false negatives predicted by each model in terms of algal bloom events. In this case, algal bloom events are defined as measurement episodes with a cyanobacteria count of at least 100. There were five such algal bloom events in the period of record.

It should be noted that the ANN models sometimes predict a negative algae count, which is physically infeasible, and accordingly has been "corrected" to 0 for Swimming River. These tables presented in the report, however, depict statistical results that include

negative values; thus, the overall ANN performance in terms of MAE and correlation coefficient after correction will be even higher. The uncorrected measures presented in the tables still provide a relative comparison of model performance. In Table 3 presented later in this section, corrected MAEs are provided for comparison against uncorrected MAE's. As shown, the corrected MAE's decrease, but more importantly, the relative performance of the different models remains the same, which was consistent throughout.

One last important note; data file input errors were identified for the phosphorous variable following submission of the preliminary report. Accordingly, the complete and reduced phosphorous ANN models were redeveloped and evaluated with the corrected input values. Thus, Table 2 below includes these redeveloped models.

Table 1. Statistical Comparison of ANN performance with all chemical inputs Versus reduced ANN models – Iteration 1

Statistical Measure	All	Ammonia	Turbidity	Nitrite/ Nitrate	Phospho-rus	None
Data Mean	47.39	47.39	47.39	47.39	47.39	47.39
Data Standard Deviation	95.30	95.30	95.30	95.30	95.30	95.30
Error Mean	8.97	6.88	2.86	2.18	-3.87	20.42
Error Standard Deviation	46.95	49.56	48.56	54.06	57.27	86.00
Mean Absolute Error	31.52	39.15	30.10	29.99	36.54	37.06
Standard Deviation Ratio	0.49	0.52	0.51	0.56	0.60	0.90
Correlation	0.87	0.86	0.86	0.83	0.80	0.71
No. of False Positives	0	3	0	2	1	1
No. of False Negatives	1	0	2	3	1	2

Source: Preliminary Report submitted to NJDEP, August 4, 2004. Complete and Phosphorous ANN models were retrained with corrected phosphorous data.

Overall statistical performance of the five models that used at least one chemical input is strikingly similar. What is obvious in this case is the degree to which the complete ANN model minimized total number of false positives and negatives relative to the other models. While failing to predict one of the five algal blooms, it did not falsely predict any blooms, or events with cyanbacteria counts above 100. In contrast, the other models provided some combination of at least two false positives and/or negatives. The ANN

model that did not use any chemical inputs may have performed the worst overall when considering both predictive accuracy and the ability to avoid false positives and negatives. It is also interesting to note that a low MAE does not necessarily result in fewer incidences of false positives and negatives, as demonstrated by the nitrite/nitrate model, which while having the lowest MAE, produced the highest number of false positive and false negative events (5).

New ANN models using the same sets of input predictor variables were developed and tested. That is, using the same set of data, new ANN models were trained to determine how repeatable the modeling results are with the relatively small data set. A lack of repeatability or consistency indicates that the data set is not sufficient to permit robust ANN learning. Table 3 below presents the results of the second set of model runs using the same set of input variables displayed in Table 1 above. In addition, the corrected MAE values, where computed negative counts are corrected to 0, are provided for comparison with the uncorrected MAE values.

Table 2. Statistical Comparison of ANN performance with all chemical inputs Versus reduced ANN models – Iteration 2

Statistical Measure	All	Ammonia	Turbidity	Nitrite/ Nitrate	Phospho-rus	None
Data Mean	47.40	47.40	47.40	47.40	47.40	47.40
Data Standard Deviation	95.31	95.31	95.31	95.31	95.31	95.31
Error Mean	9.57	-1.94	1.50	6.09	-8.15	-4.52
Error Standard Deviation	49.56	43.84	48.90	48.69	41.78	42.92
Actual Mean Absolute Error	33.35	33.44	33.04	29.27	40.22	23.53
Recalculated Mean Absolute Error	29.71	26.31	32.64	24.23	27.24	22.75
Standard Deviation Ratio	0.59	0.46	0.51	0.51	0.44	0.45
Correlation	0.86	0.89	0.86	0.88	0.90	0.89
No. of False Positives	3	2	0	1	0	0
No. of False Negatives	0	0	2	0	0	1

As shown, there is some discrepancy between the first and second iteration results in terms of relative performance of the individual models. Statistically, there is little discrepancy between the original models (Table 1) and the second set of models for the turbidity, ammonia, and nitrate/nitrite models**.** However, the ANN model that used no chemical inputs (i.e.) performed much better in the second iteration, even outperforming the other models in terms of a lower MAE.

There are also differences between the two model sets in terms of avoiding false positives and false negatives. The model that did not use any chemical inputs failed to predict only one algal bloom, and did not produce any false positives. In contrast, while the model that used all four chemical inputs predicted all five blooms, it also predicted three false positives. The ANN model with only phosphorous as an input performed the best, predicting all five blooms without any false positives. The ANN model with ammonia also predicted all five blooms, but provided two false positives. The ANN model with nitrate predicted four of the five blooms, with two false positives. Lastly, the ANN model with turbidity predicted three out of the five blooms with no false positives. Measured versus ANN predicted values for the second set of models are shown below in Figures 1 through 6.

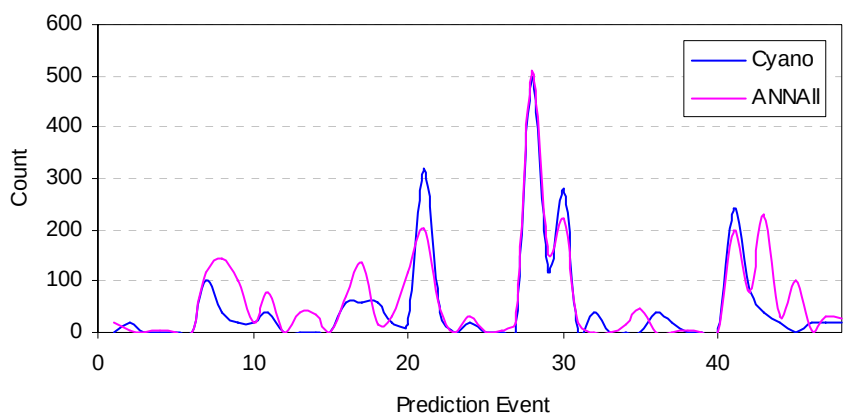

Figure 1. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with all chemical inputs (second model set).

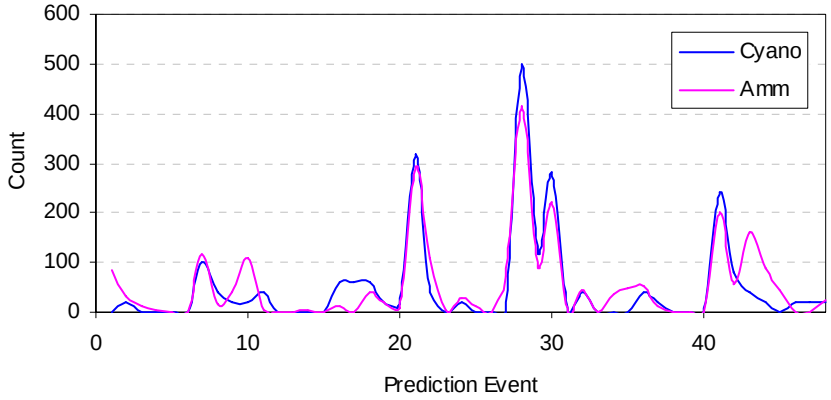

Figure 2. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with ammonia as the sole chemical input (second model set).

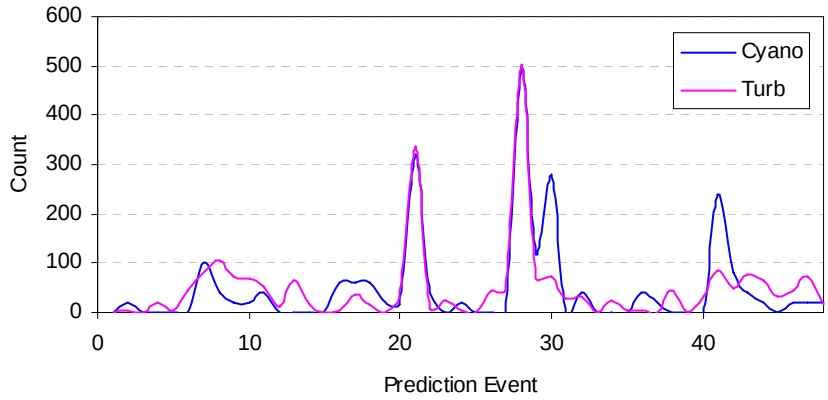

Figure 3. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with turbidity as the sole chemical input (second model set).

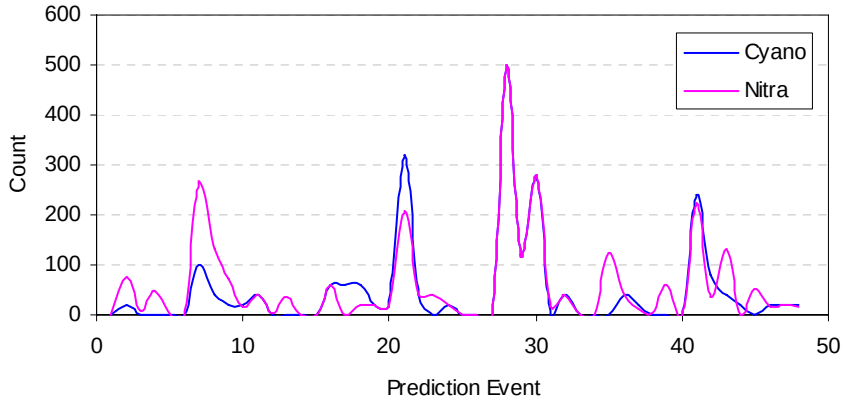

Figure 4. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with nitrite/nitrate as the sole chemical input (second model set).

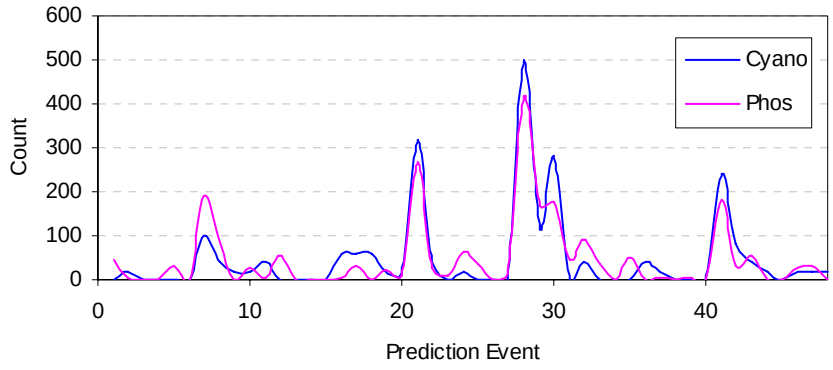

Figure 5. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with phosphorous as the sole chemical input (second model set).

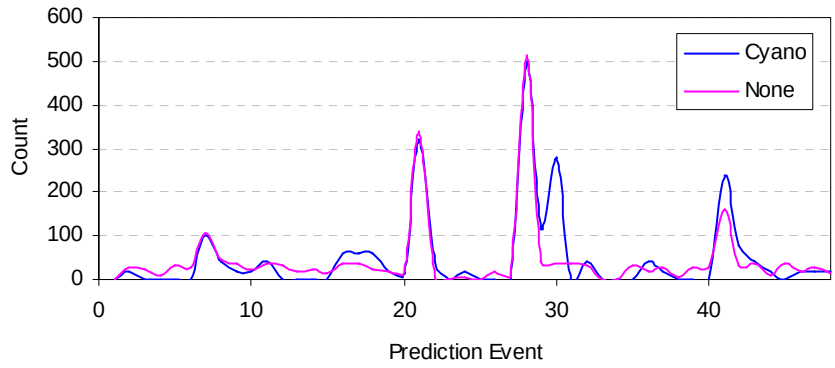

Figure 6. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with no chemical inputs (second model set).

For both model sets, the algal bloom that occurred during event 30 was the one that was most consistently missed by the models. A review of the input data for event 30 does not reveal any obvious anomalous condition that could be a source of difficulty for the ANN models.

Because of the very limited data set, particularly relative to the number of ANN input variables, it is difficult to draw firm conclusions. It may be weakly inferred that inclusion of chemical inputs in this data set increases model sensitivity for algal blooms. Undoubtedly chemical variables as part of the dynamics responsible for producing algal bloom events are important, and inclusion of them increases the likelihood of the ANN model for accurately forecasting such an event. However, in this case, because of the

limited number of data events, the ability of the ANNs to generalize system behavior is reduced.

Further supporting the relatively non-robust data set is the fact that the validation or testing error was generally higher than the training error. Table 3 presents a statistical comparison of the different models overall performance, as well as training and validation, for the second model set with chemical inputs.

Table 3. Performance Statistics of Second Iteration, for Overall Data, Training Data, and Validation Data for Chemical ANN Models

Parameter	Overall		Training		Test	
	MAE	Corr	MAE	Corr	MAE	Corr
All	29.71	0.86	15.70	0.98	59.96	0.59
Ammonia	33.44	0.89	26.42	0.90	29.67	0.46
Nitrate	29.27	0.88	1.92	1.00	71.41	0.63
Turbidity	33.04	0.86	31.15	0.88	43.56	0.45
Phosphorous	40.22	0.87	33.32	0.95	52.19	0.14

The ANN model with all the chemical inputs has a relatively low mean absolute error. What is most important, however, is that often, though not always, there is a large difference between training and validation performance. For example, the mean absolute training error for the model with nitrate as the sole chemical input was just 1.92; during validation, it increased to 71.4. This is the most extreme case, but in general, ANN training performance consistently exceeded model validation performance. This discrepancy indicates that additional data events are necessary to further improve ANN learning for generalization of system behavior, and that the ANNs may be overfitting the training data. However, the consistently relatively low training errors and overall performance does suggest that the ANNs are learning some general behavior, the possibility for achieving robust algae forecasting models for Swimming River with as additional data records are collected over time. This is further supported by the clearly superior performance of ANN relative to linear regression models obtained during the preliminary study.

As a further assessment of ANN capability, different combinations of the four chemical input variables were used to develop and assess ANN forecasting capability. Table 4 summarizes the statistical results, with figures 7 through 9 presenting measured versus predicted values for these models. Note that the abbreviated headings Ni, Pho, Tub, and Am designate nitrite/nitrates, total total phosphorous, turbidity, and ammonia. Thus, the heading Ni/Pho signifies the ANN model that used both nitrite/nitrate and total phosphate as the ANN input variables.

Table 4. Statistical Comparison of ANN performance with all chemical inputs Versus ANNs with different combinations of the four chemical inputs – Iteration 3

Statistical Measure	All	Ni/Am	Tur/Ni	Am/Pho
Data Mean	47.40	47.40	47.40	47.40
Data Standard Deviation	95.31	95.31	95.31	95.31
Error Mean	9.57	-7.58	0.87	0.97
Error Standard Deviation	49.56	49.33	58.25	43.99
Mean Absolute Error	29.71	23.16	33.16	26.99
Standard Deviation Ratio	0.52	0.52	0.61	0.46
Correlation	0.86	0.86	0.79	0.89
No. of False Positives	3	1	1	1
No. of False Negatives	0	2	1	1

Using two chemical inputs versus only one does not seem to improve performance; in fact, based upon the statistical results and the algal bloom prediction criterion, these models had lower performance. The Am/Pho model and the Tur/Ni models both predicted four out of the five algal blooms, while producing one false positive. The Ni/Am model performed the worst, predicting just three of the five blooms with one false positive.

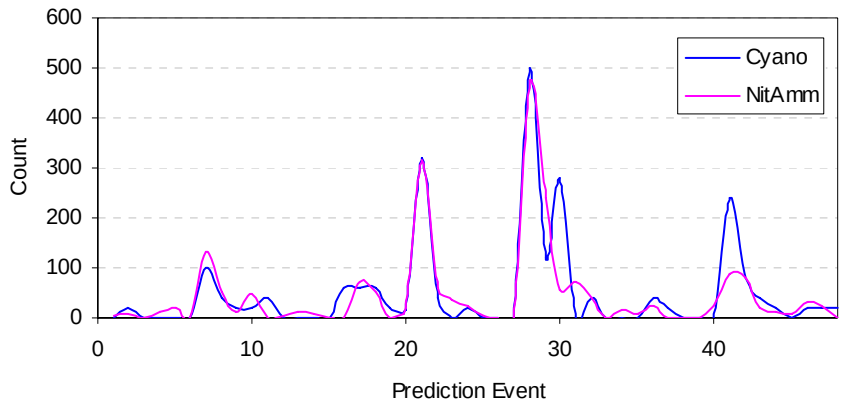

Figure 7. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with nitrite/nitrate and ammonia chemical inputs

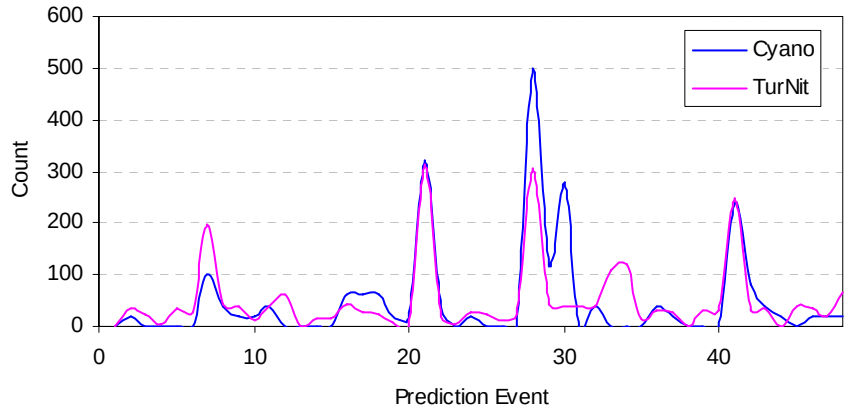

Figure 8. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with turbidity and nitrite/nitrate chemical inputs

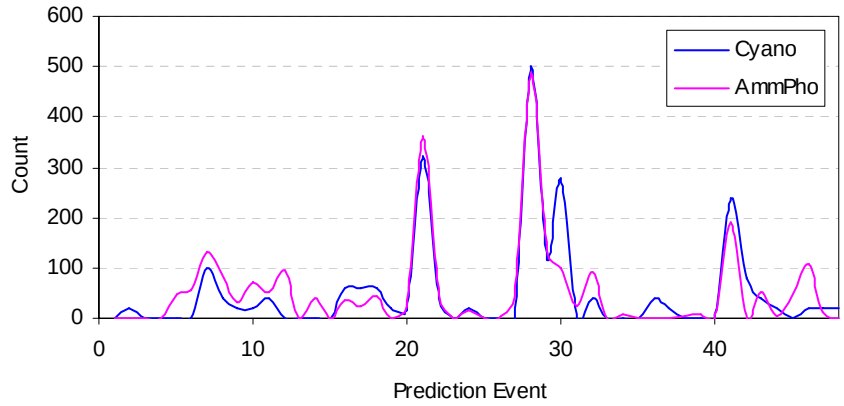

Figure 9. Measured versus predicted ANN model predicted cyanophyta counts for Swimming River Reservoir with ammonia and phosphorous chemical inputs

The sensitivity analysis results further demonstrate the apparent non-robustness of the data sets. The ratio for a given input predictor variable is the factor by which the RMSE increases by eliminating the variable as an input from the ANN model.

Formally, the ratio for a given ANN predictor variable is:

$$\text{Ratio Value} = \frac{\text{RMSE without ANN predictor variable}}{\text{RMSE with ANN predictor variable}} \qquad \textbf{(4)}$$

Therefore, a ratio value > 1.0 signifies that inclusion of the predictor variable improves ANN accuracy, a ratio value < 1.0 signifies that elimination of the input variable actually increases ANN predictive accuracy, and a ratio value = 1.0 signifies neutrality, where the variable neither increases or decreases ANN predictive accuracy. The rank is a numerical ranking of the variables from most (rank 1) to least (rank 18) important for accurately predicting final cyanobacteria counts on the basis of the computed ratio values.

Tables 5 and 6 below summarize the sensitivity analysis results, with the corresponding ratios and ranks provided for each of the predictor variables, where ratio values < 1.0 have been highlighted.

Inspection of the ratio table does not reveal an obvious pattern. Only five variables had a ratio value < 1.0 for at least one model, with this outcome occurring twice for two variables, turbidity and average dissolved oxygen (over depth). To facilitate analysis, the average ratio ranking of each variable for all the models in which it was used for the second phase of modeling were computed, and are presented in Table 6 below, with the variables listed in order of importance.

In terms of the order of the most important variables, there is some consistency, albeit weak. Wind direction (4.7) is generally high, which agrees with the preliminary modeling findings. The next three highest ranking variables, wind speed, secchi depth, and nitrate are clustered near each other, and have average rankings between 5.2 and 5.8.

Of the four lowest ranking variables, three are chemical input variables, ammonia, total phosphorous, and turbidity.

Table 5. Ratio Values of the Variables for the different ANN Cyanobacteria Prediction Models for Swimming River Resevoir

	All	Nit/ Amm	Tur/ Nit	Am/ Pho	Amm	Nit	Tur	Phos	None
Ammonia	1.051	1.153		0.979	1.245				
Nitrate	1.452	1.218	2.152	1.045		1.168			
Turbidity	0.988		0.912	1.083			1.010		
Phosphorus	1.069			1.352				1.086	
Temperature at Shallow depth	1.593	1.274	1.178	1.340	1.407	1.445	1.081	1.077	1.085
Average Temperature	1.245	1.092	1.102	0.972	1.856	1.121	1.264	1.487	1.129
Temperature at Deep depth	1.487	1.217	1.284	1.008	1.926	1.161	1.021	1.240	1.013
Precipitation for Previous week	1.025	1.009	1.037	1.706	1.157	1.237	1.013	1.090	1.037
Precipitation for current week	1.043	1.028	1.040	1.442	1.216	1.174	1.309	1.103	1.150
Wind Speed	1.132	1.365	1.337	1.239	1.037	1.741	2.226	1.108	1.840
Wind Direction	1.070	1.413	1.614	1.297	1.265	1.270	1.502	1.271	1.745
Solar	1.148	1.145	1.454	1.610	1.346	1.622	1.174	1.118	1.020
Secchi	1.133	1.077	1.432	1.187	1.697	1.949	1.204	1.275	1.398
Dissolved Oxygen at shallow depth	1.001	1.121	1.300	1.112	1.290	1.170	1.052	1.117	1.054
Dissolved Oxygen Average	1.096	1.060	1.210	1.118	0.963	1.252	1.220	0.971	1.054
Dissolved Oxygen deep depth	1.424	1.338	1.279	1.283	1.277	1.712	1.056	1.120	1.385
pH	1.603	1.091	1.033	0.979	1.185	1.682	1.057	1.159	1.378
Initial Cyano level	1.148	1.032	1.369	1.045	1.223	1.549	1.183	1.577	1.370

Table 6. Rankings of the Variables for the different ANN Cyanobacteria Prediction Models for Swimming River Resevoir

	All	Nit/ Amm	Tur/Nit	Am /Pho	Amm	Nit	Tur	Phos	None	Avg
Wind Direction	12	1	2	3	8	8	2	4	2	4.7
Wind Speed	10	2	6	1	14	2	1	10	1	5.2
Secchi	9	12	4	6	3	1	6	3	3	5.2
Nitrite/Nitrate	4	5	1			13				5.8
Dissolved Oxygen at deep depth	5	3	9	11	7	3	11	7	4	6.7
Average Temperature	6	10	12	4	2	15	4	2	8	7.0
Initial Cyano counts	7	14	5	7	10	6	7	1	6	7.0
Solar	8	8	3	8	5	5	8	8	13	7.3
Temperature at Deep depth	3	6	8	5	1	14	13	5	14	7.7
Temperature at Shallow depth	2	4	11	12	4	7	9	14	9	8.0
pH	1	11	15	10	12	4	10	6	5	8.2
Dissolved Oxygen at shallow depth	17	9	7	2	6	12	12	9	10	9.3
Average DO	11	13	10	9	15	9	5	15	11	10.9
Current week Precipitation	15	15	13	14	11	11	3	11	7	11.1
Ammonia	14	7		15	9					11.3
Phosphorus	13			13				13		13.0
Previous week Precipitation	16	16	14	16	13	10	14	12	12	13.7
Turbidity	18		16				15			16.3

Lastly, Table 7 compares the sensitivity analysis results obtained with the complete chemical input variable set during the first and second iterations. Variables predictor types have been shaded with similar colors to help distinguish some patterns (i.e. chemical, weather, physical, and cyanobacteria).

Table 7. Sensitivity analysis results for ANN Cyanobacteria Prediction Models for Swimming River Resevoir that used all four chemical inputs.

Iteration 1	ANN Ratio	ANN Rank	Iteration 2	ANN Ratio	ANN Rank
Wind Speed	1.624441	1	pH	1.603	1
Nitrite/nitrate	1.529473	2	Shallower Temp	1.593	2
Wind Direction	1.370768	3	Deep Temperature	1.487	3
Shallower D.O.	1.313101	4	Nitrite/nitrate	1.452	4
Deeper D.O.	1.310284	5	Deeper D.O.	1.424	5
Secchi Depth	1.209016	6	Average Temperature	1.245	6
Total Phosphorus	1.162749	7	Initial Cyano	1.148	7
pH	1.153351	8	Solar Radiation	1.148	8
Previous Week Precipitation	1.049101	9	Secchi Depth	1.133	9
Initial Cyano	1.040749	10	Wind Speed	1.132	10
Shallower Temp	1.035106	11	Average. D.O.	1.096	11
Average. D.O.	1.030823	12	Wind Direction	1.070	12
Current Week Precipitation	1.019911	13	Total Phosphorus	1.069	13
Ammonia	1.016448	14	Ammonia	1.051	14
Solar Radiation	1.011603	15	Current Week Precipitation	1.043	15
Turbidity	1.001922	16	Previous Week Precipitation	1.025	16
Average Temperature	0.995978	17	Shallower D.O.	1.001	17
Deep Temperature	0.995449	18	Turbidity	0.988	18

There is some consistency in the results. The two models have similar extreme ratio values, and both have relatively few variables with a ratio value < 1.0. For both models, ammonia and turbidity rank near the bottom. Wind speed and wind direction both rank

very high for the first model, which is consistent with the overall sensitivity analyses results presented in Table 7 above, which excluded this model in its tabulation. Nitrite/nitrate is the top ranking chemical variable for both models, and ranks within the top four for both models. Deeper depth dissolved oxygen ranks fifth for both models. There are, however, significant inconsistencies. For example, average temperature not only had the second to last lowest ranking in the first model iteration, but its ratio value was < 1.0. In contrast, for the second model iteration, average temperature ranked as the sixth most important variable, with a relatively large ratio value of approximately 1.25.

The inconsistency of the sensitivity analyses results in combination with the relatively large discrepancy between training and validation only serves to support the following preliminary finding stated in the interim report (page 25, paragraph 1):

The sensitivity analysis results achieved with different ANNs are not always consistent. That is, while one particular predictor variable may be relatively important for one ANN for predicting algae levels, it may be relatively non-important for another ANN. This inconsistency is probably due primarily to the relatively small data set as well as inherent noise associated with many of the measured variables, including algae levels… Additional data should be collected for additional ANN development and assessment before conclusions regarding the relative importance of different variables for accurately predicting algae levels can be drawn with confidence.

While chemical data would undoubtedly improve model performance, it has not been clearly demonstrated in this modeling work. The ANN model that did not use the chemical inputs for the chemical data set performed relatively well in the second iteration, and in fact had the lowest mean absolute error. However, it also failed to predict all five algal blooms, unlike four of the five ANN models that used one chemical input. Collectively, the modeling results, both in terms of predictive accuracy and overall sensitivity analyses results, demonstrate the *potential* for using ANN technology as a method for forecasting algae levels at this site. This is supported by the relatively accurate overall performance of the models and their superiority over the linear models as demonstrated in the preliminary analysis.

INCREMENTAL SENSITIVITY ANALYSIS FOR SWIMMING RIVER

As a final modeling exercise, an incremental sensitivity analysis was performed. The objective is to assess how algae counts change with respect to changes in input values for select variables. For example, a utility may want to assess how algae counts computed by the ANN model change in response to a range of different values for temperature. This type of analysis can help determine in what manner the ANN model correlates algae counts with select variables (i.e. negative, positive, inverse, etc.). In an ideal situation, where the ANN has truly learned the underlying system behavior, the results of this analysis could be extended to the physical system being modeled by the ANN. It should be emphasized, however, that in non-linear systems**,** such relationships may not be straightforward. Rather, the corresponding change of the system with respect to a given variable is undoubtedly related to the other states (i.e. variables) of the system. For example, similar increases in temperature for two events may product two different outcomes, depending upon other system states (i.e. inputs), such as dissolved oxygen. The relative lack of data for developing the ANN models limits the degree of confidence in the results. However, at the same time, some consistent patterns may emerge that help to foster system understanding.

In this exercise, four historical algae events were selected for which the values of individual input variables were changed to their minimum, average, and maximum observed values over the complete data record, while holding all values for all other input variables constant, from which the corresponding algae levels were computed. As part of this analysis, the relative effect of the different input variables on the computed outputs was also computed. That is, because different input variables exhibit significantly different range of values, a direct comparison of the range of computed outputs for minimum and maximum input values has limited value. Consequently, the relative effect of each input variable on the corresponding algae level was computed using a normalized sensitivity ratio. Mathematically, the normalized sensitivity ratio was computed as:

Sensitivity Ratio = (ANN Output (Maximum Input Value) –ANN Output (Minimum Input Value)/(Maximum Input Value – Minimum Input Value) **(5)**

In this analysis, six input variables were systematically changed, and they are: ammonia, nitrite/nitrate, turbidity, phosphorous, deep temperature, and deep dissolved oxygen. The computed results for one representative event is depicted by Figure 10, a bar graph, where the algae count for the actual input value is compared against the corresponding minimum, mean, and maximum values for each input variable.

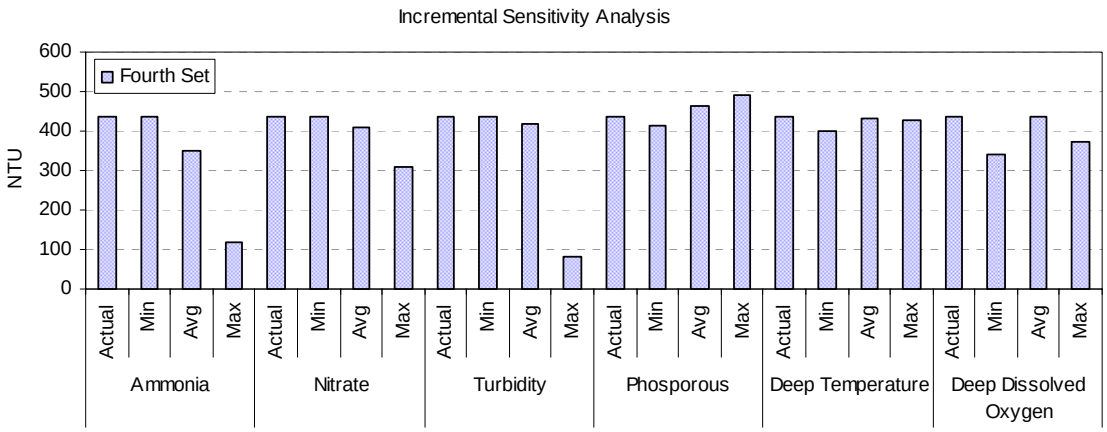

Figure 1. Bar graph depicting algae counts for actual input value compared to algae counts for minimum, average, and maximum values for six selected input variables for a representative event for Swimming River.

In this case, ammonia, nitrate, and turbidity are negatively correlated with algae count. That is, as concentrations of these chemicals increase, computed algae counts decrease. Contrary, increases in phosphorous and deep temperature increase algae counts. Deep dissolved oxygen displays a changing relationship with algae counts, with an increase in algae counts occurring as oxygen increases from its minimum to average value, but then a decrease in algae counts as oxygen increases from its average to the maximum value.

There was not complete consistency with respect to negative and positive correlations for some variables for different events. That is, for some events, a given variable may be positively correlated with algae counts, while in another case, negatively correlated.

Table 8 below is a computed average range change and sensitivity ratio values for all four events. Negative values reflect a negative correlation, and in this case, increases in deep temperature, nitrate, and turbidity actually produced a decrease in algae counts. For this model, and for the four events, increases in deep dissolved oxygen, phosphorous, and ammonia led l to increases in algae counts, on average.

Inconsistency with respect to positive and negative correlations for certain variables, however, highlights the seemingly contradictory behavior that can result with a non-linear and complex system. The state of the other variables in this open system would likely have some effect on the corresponding changes induced by certain variables. From an intuitive perspective, this type of behavior makes sense. Depending upon the other conditions of the system, increases in a certain variable could promote or suppress algae levels. For example, while an increase in turbidity during a low precipitation period could be indicative of higher algae counts, among other things, during a high precipitation period, it could be indicative of higher sediment loading, which could in fact suppress algae formation by inhibiting sunlight penetration.

Table 8. Comparison of RMSE Ratios, Range Change and Sensitivity Ratios for Cyanobacteria Modeling with all four chemical inputs for Swimming River

Variable Name	RMSE Ratio Ranking	Range Change	Range Ranking	Sensitivity Ratio	Sensitivity Ranking
Deeper Temperature	2	-308.759	1	-14.564	1
Deeper DO	1	39.243	6	4.0878	2
Phosphorous	10	208.165	2	2.657	3
Nitrate	9	-198.451	3	-0.437	4
Turbidity	15	-82.852	4	-0.279	5
Ammonia	18	39.379	5	0.0424	6

Another issue to consider is the possibility for violation of certain physical laws or conditions with this simplified modeling analysis. For example, increases in turbidity levels likely reduce the secchi depth, which in turn reduces sunlight penetration,

inhibiting cyanobacteria growth. However, in this analysis, it is assumed that all other variables remain constant; thus, a corresponding increase in turbidity would not be accompanied by a decrease in secchi depth. Future work should attempt to correlate these changes during the sensitivity analysis. And then lastly, the most serious concern in this analysis is the relative lack of data which constrains efforts to develop robust models. All of these issues, then, reduce confidence in any inferences that drawn from this analysis at this time. It is believed, however, that more robust data sets coupled with a more systematic and directed incremental sensitivity analysis would likely produce important insights into system behavior.

APPENDIX A-2

SWIMMING RIVER

Water Treatment Modeling

Seasonal ANN Models

Water quality conditions of the reservoir, and hence the raw water, are to some extent influenced by seasonal conditions. Figure 1 is a time series comparing raw water temperature against raw water turbidity and exhibits a distinct seasonal pattern. In general, these two variables for the period of record are unexpectedly inversely correlated, with higher raw water temperatures corresponding with lower raw water turbidity, and lower temperatures corresponding with higher raw water turbidity.

Figures 2 and 3 below are time series depicting, by season, average turbidity readings and daily readings, respectively, for finished (i.e. effluent) water. Similarly, Table 1 summarizes statistical measures for average turbidity and number of turbidity readings > 0.1 NTU of finished water for each of the four seasons.

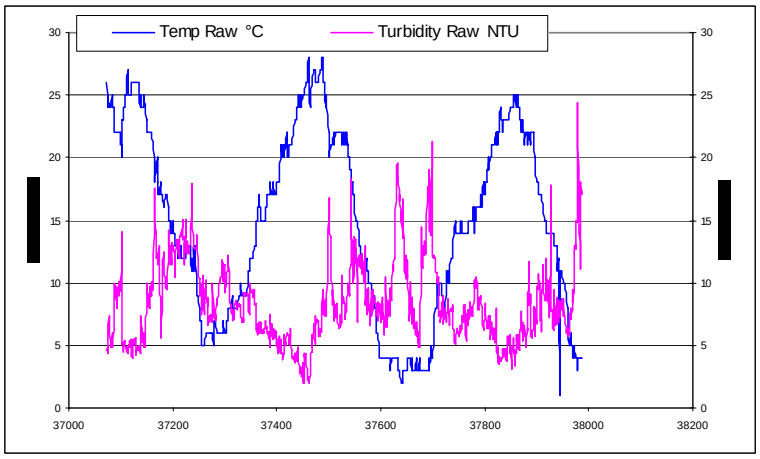

Figure 1. Raw water temperature versus raw water turbidity over time for Swimming River.

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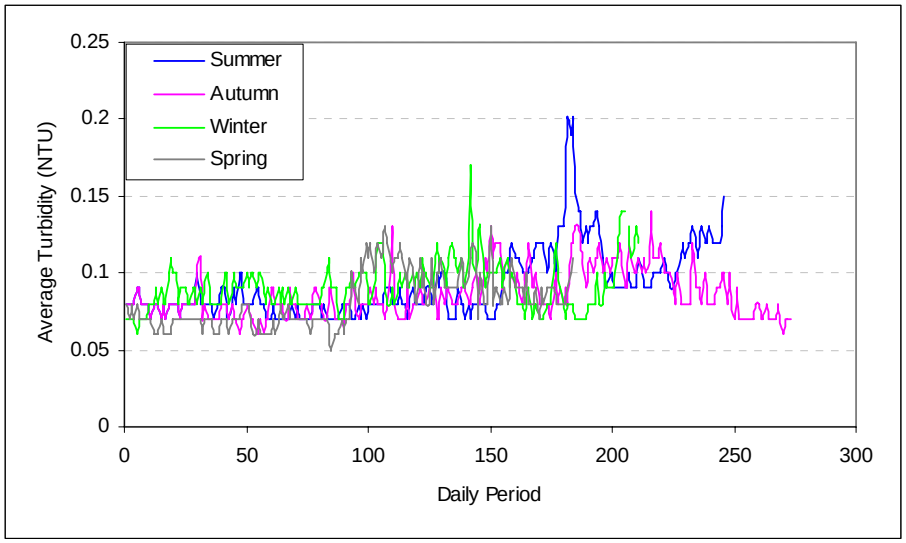

Figure 2. Seasonal comparison of average daily turbidity for Swimming River.

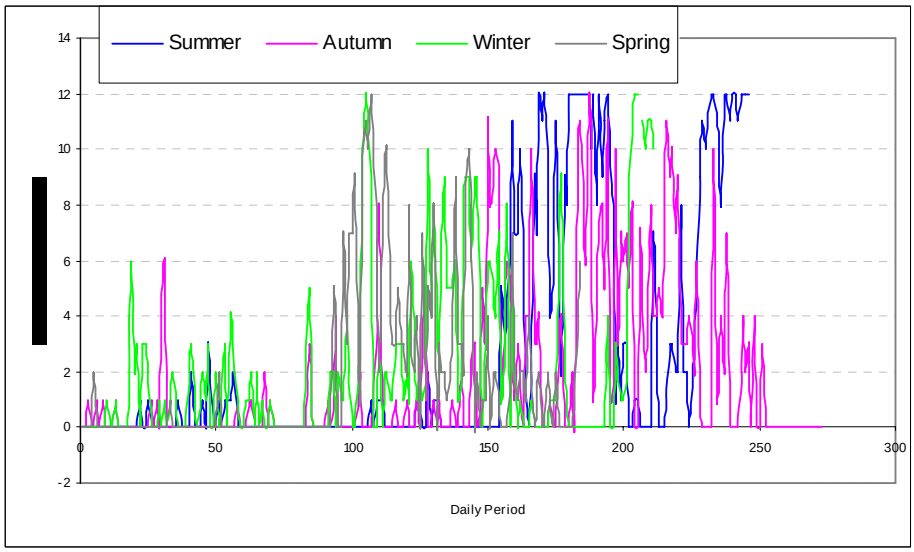

Figure 2. Seasonal comparison of highest daily turbidity for Swimming River.

Table 1. Seasonal Statistical Measures of Daily Average Turbidity and Number of Readings > 0.1 NTU for Swimming River

		Average Turbidity	No. of Readings
Spring	Minimum	0.05	0
	Average	0.08	1.71
	Maximum	0.13	12
Summer	Minimum	0.07	0
	Average	0.09	2.66
	Maximum	0.2	12
Autumn	Minimum	0.06	0
	Average	0.09	1.82
	Maximum	0.14	12
Winter	Minimum	0.06	0
	Average	0.09	2.26
	Maximum	0.17	12

In general, there does not appear to be significant variations in finished water quality between seasons, except perhaps for some rare anomalously high average turbidity events during warmer seasons (i.e. spring and summer).

Because distinct raw water quality conditions are expected for different seasons of the year, separate ANN models were develop and tested for each season. For the 2.5 years of available records, data was separated by season into Spring (March, April, May), Summer (June, July, August), Fall (September, October, November), and Winter (December, January, February). Due to the lower model predictive capability achieved for highest turbidity, ANN model development and testing was conducted for average turbidity and daily readings, only.

Table 2 compares the seasonal ANN models against the best ANN models developed for the entire data set (annual) for the average turbidity and daily reading prediction variables. For both cases, the seasonal models always outperformed the annual model in terms of mean absolute errors. It is interesting and perhaps important to note that the two summer ANN models significantly outperformed their corresponding annual models. This suggests that the summer season has some unique conditions and/or behavior that are distinctly different from the other times of the year. It is possible, then, that when this

season is individually modeled, the ANN models are more able to capture this distinct behavior. In contrast, autumn and winter do not appear to have as distinct behavior, particularly with regarding to daily readings**.**

Table 2. Statistical Performance Comparison of Annual versus Seasonal ANN Models for Swimming River

	Average Turbidity				
	Spring	Summer	Autumn	Winter	Annual
MAE	0.00683	0.00890	0.00827	0.00758	0.00948
Corr	0.856	0.824	0.728	0.720	0.720
	Daily Readings				
	Spring	Summer	Autumn	Winter	Annual
MAE	1.12	1.22	1.35	1.45	1.48
Corr	0.738	0.888	0.554	0.615	0.721

Figures 4 though 7 are time series for the four seasons, comparing measured predictions made by the seasonal ANN models against the corresponding against the models against the annual models for average turbidity. Similar figures for readings can be seen The annual models have a tendency to smooth out the predictions, whereas the seasonal models do a more effective job, in general, of capturing higher and lower values. The corresponding figures for daily readings can be found in Appendix B-1.

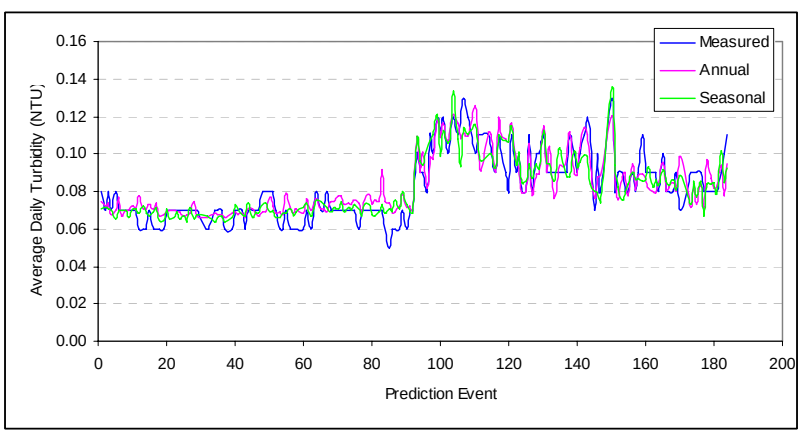

Figure 4. Spring ANN vs Annual ANN for Average Daily Turbidity for Swimming River

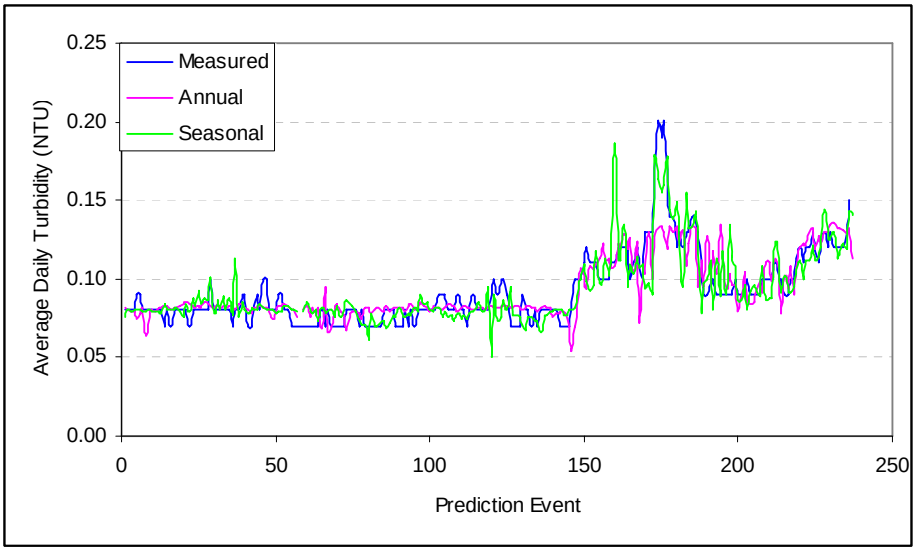

Figure 5. Summer ANN vs Annual ANN for Average Daily Turbidity for Swimming River.

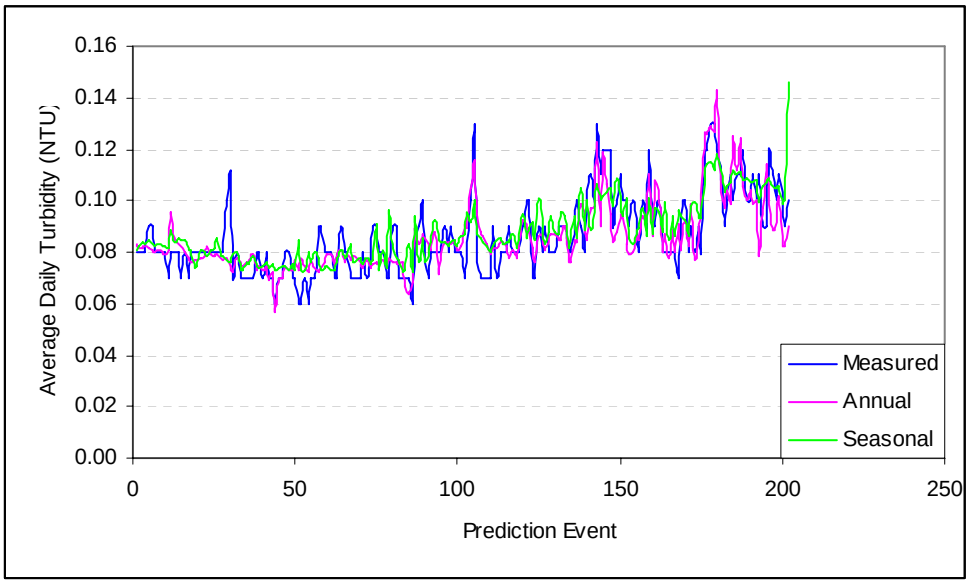

Figure 6. Autumn ANN versus Annual ANN for Average Daily Turbidity for Swimming River.

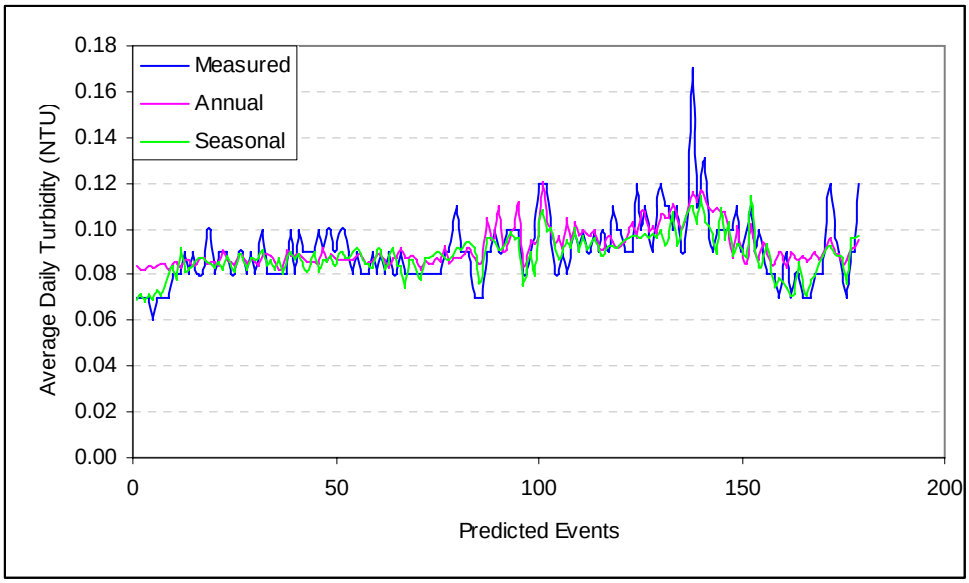

Figure 7. Winter ANN vs Annual ANN for Average Daily Turbidity for Swimming River.

Train One Season Test Another

To further confirm seasonal differences in system conditions and behavior, ANN models that were trained with data for a particular season were then validated with data for another season. For example, an ANN model trained with summer data was then validated or tested with data for spring. If there is little or no seasonal variability in system conditions, then ANN models trained with one season of data should perform well when presented with a data set for another season. Conversely, for a system that is characterized by seasonal differences, poor ANN model performance for the different validation season would be expected.

Initially, the ANN models developed with the summer data were validated with the winter data, and vice versa, for both average turbidity and average readings. Table 3 presents the results of this analysis, and compares ANN model performance against the ANN models that were trained and validated with a single season of data**.**

Table 1. Statistical Performance of ANN Models Trained with Summer and Tested with Winter Data, and Trained with Winter and Tested with Summer Data

	Trained Summer Tested Winter		Trained Winter Tested Summer	
	Turbidity	Readings	Turbidity	Readings
Mean Absolute Error	0.055	6.28	0.063	3.62
Correlation Coefficient	0.37	0.32	-0.44	0.098

As reflected by the low correlations, the models did not perform very well. In general, the ANN models developed with the summer data and tested with the winter data did significantly better than those developed with the winter data and tested with the summer data.

Figures 8 through 11 below present measures versus predicted values for these models. As shown by Figure 8, the ANN model trained with winter data has a tendency to seriously overestimate average turbidity levels for the summer season. The ANN model developed with the summer data and tested with the winter data also had a general tendency to overestimate average turbidity levels, with some notable exceptions where several negative values were predicted. The same tendencies occurred with the models developed and tested for the average readings data.

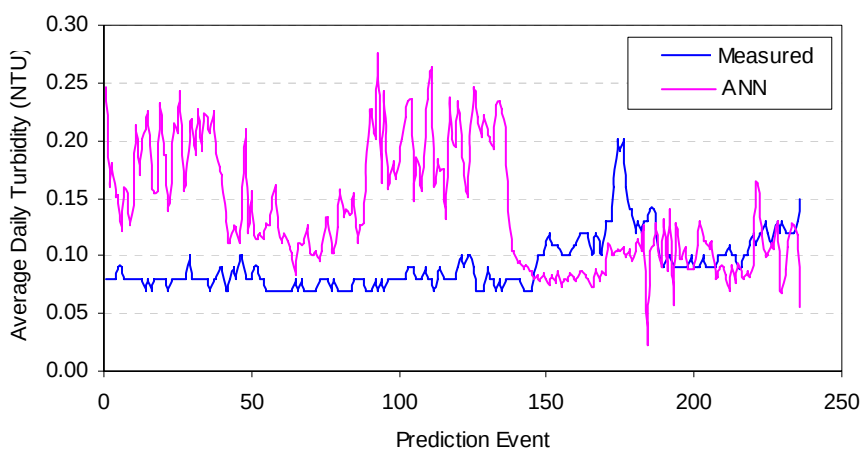

Figure 8. Average turbidity predictions for summer season with ANN model trained with winter data for Swimming River.

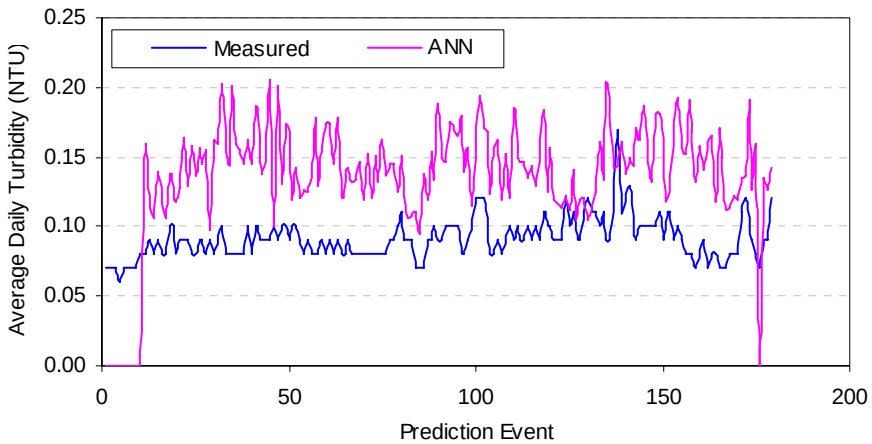

Figure 9. Average turbidity predictions for winter season with ANN model trained with summer data for Swimming River.

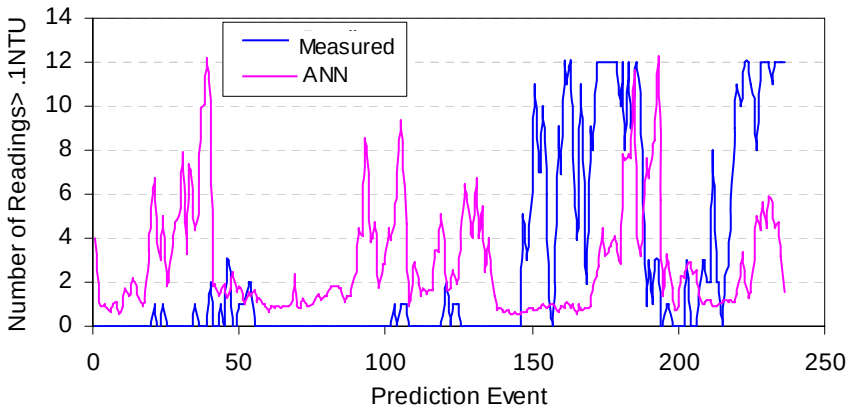

Figure 10. Number of daily readings predictions for summer season with ANN model trained with winter data for Swimming River.

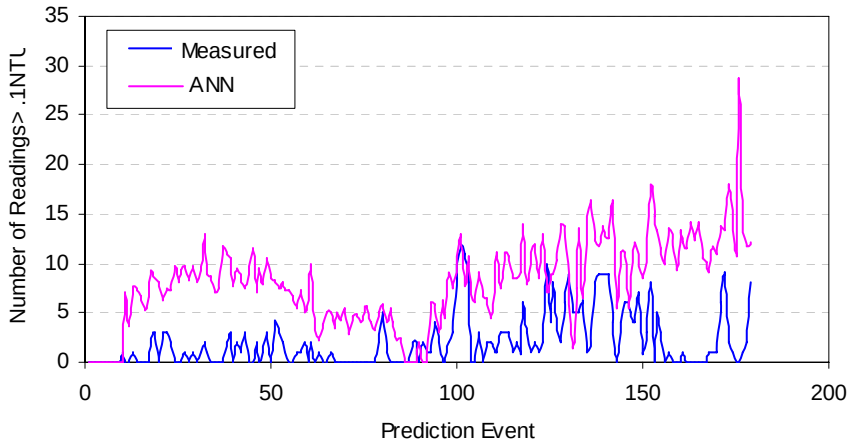

Figure 11. Number of daily reading predictions for winter season with ANN model trained with summer data for Swimming River.

As a final analysis, seasons that may exhibit more similar behavior, namely summer and spring, were selected for the same test. Thus, ANN models were developed with summer data for average turbidity and average readings, and then tested with spring data. Similarly, ANN models were developed with spring data and tested with summer data. Table 4 below summarizes statistical measures for model performance, with Figures 12 through 15.

Table 2. Statistical Performance of ANN Models Trained with Spring and Tested with Summer Data, and Trained with Summer and Tested with Spring Data for Swimming River.

	Trained Spring Tested Summer		**Trained Summer Tested Spring**	
	Turbidity	Readings	Turbidity	Readings
Mean Absolute Error	0.022	3.037	0.025	2.63
Correlation Coefficient	-0.003	-0.029	0.561	0.508

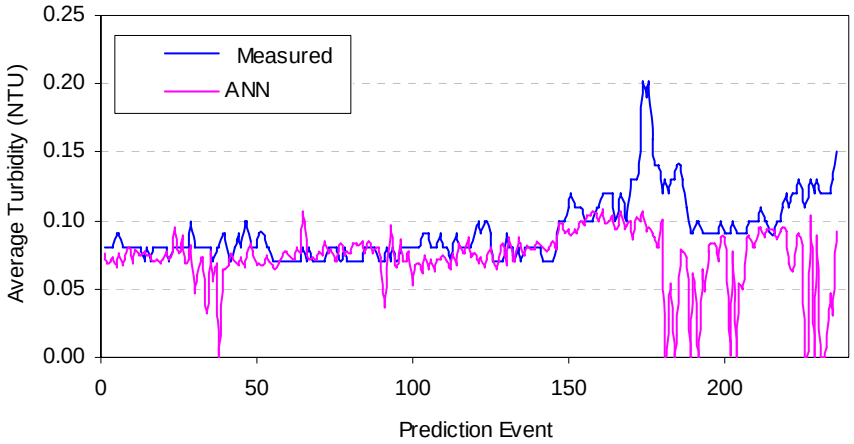

Figure 12. Average turbidity predictions for summer season with ANN model trained with spring data for Swimming River.

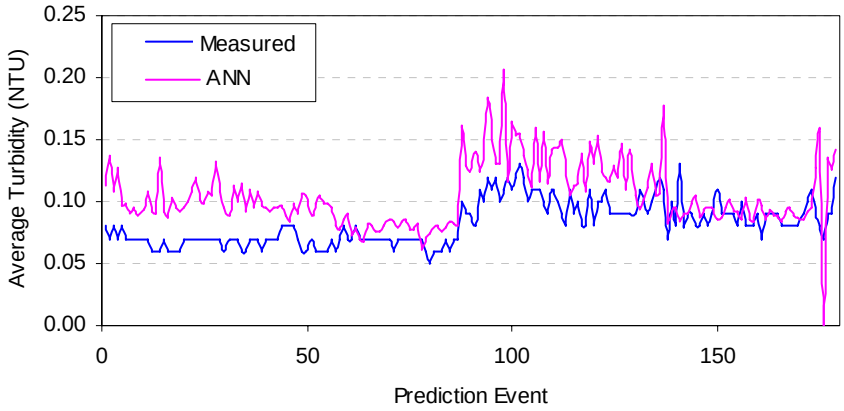

Figure13. Average turbidity predictions for spring season with ANN model trained with summer data for Swimming River.

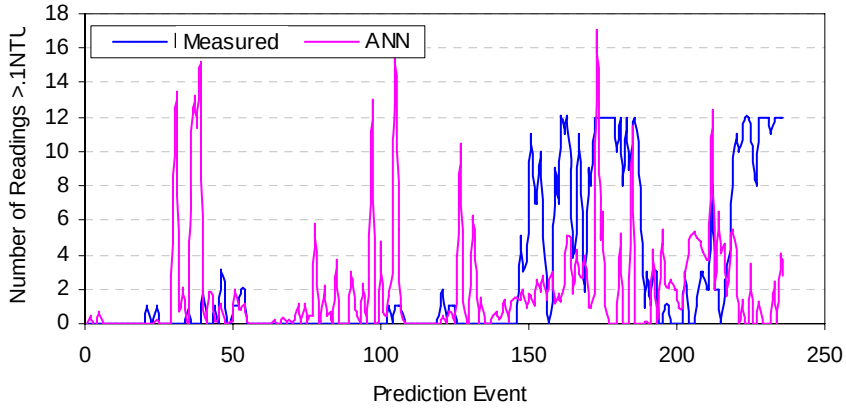

Figure 14. Number of reading predictions for summer season with ANN model trained with spring data for Swimming River.

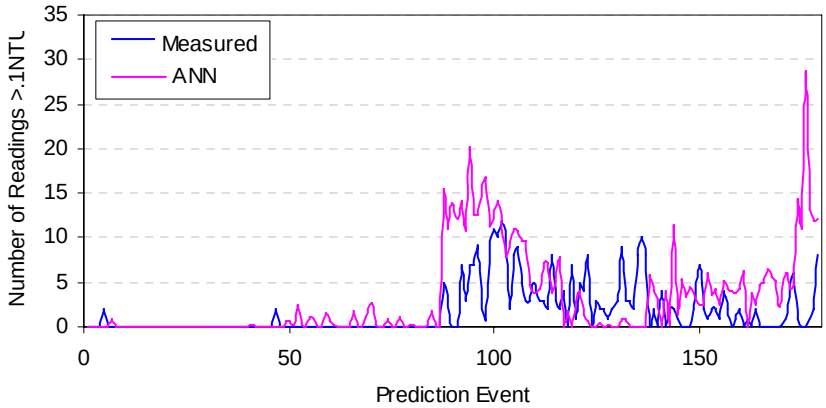

Figure 15. Number of reading predictions for spring season with ANN model trained with summer data for Swimming River.

As with the winter-summer exercise, the ANN models developed with the summer data performed the best during validation. This is likely due to the fact that the summer season exhibits the greatest variability in terms of conditions, and thus models trained with this data are the most robust. Conversely, a model validated or tested with the summer data is presented with a more difficult season to predict.

The seasonal modeling results strongly suggest that for certain seasons, namely summer and spring, which may have rather distinct characteristics, it might be best develop individual seasonal ANNs. For the winter and fall, it may be better to train them with all available data. This finding also demonstrates that the ANNs are able to learn relationships between the predictor or input variables and the prediction or output variables.

Dual Output Networks

ANN models are not restricted to predicting one output variable only; they can be used to predict any number of output variables simultaneously as dictated by the problem. In fact, one of the inherent strengths of ANN technology is that, unlike regression, which treats each output variable independent of the others, ANNs through interconnection via common arcs can account for inter-relationships between output variables. In cases where significant correlation exists between output variables, this capability can improve prediction performance.

In this modeling exercise, seasonal and annual ANN models were developed for simultaneously predicting two output variables; average turbidity and daily readings. Table 5 compares model performance of the previously developed ANN models that had only one output variable against the ANN models (dual) that simultaneously predicted two output variables, average turbidity, and daily number of readings (> 0.1 NTU).

The dual ANN models consistently outperformed their corresponding single ANN models when predicting daily readings, as reflected by the slightly lower mean absolute

errors (MAE). For predicting average turbidity, the dual ANN models outperformed the single ANN output models for just two of the five cases, though overall, there were relatively small differences between the two model types. Thus, the dual ANN models provided increased accuracy, though minor, for seven of the 10 cases, with consistent improvement for average readings. This indicates that the ANNs are able to infer some weak correlation between daily readings and average turbidity within the context of the inputs, which in particular enhanced predictive capability for the former output variable

Table 5. Statistical Performance Comparison of Single versus Dual Prediction ANN Models

Model		**Daily Average Turbidity**				
		Spring	Summer	Autumn	Winter	Annual
Single	Mean Absolute Error	0.00683	0.00890	0.00828	0.00758	0.00948
Dual	Mean Absolute Error	0.00693	0.00871	0.00764	0.00853	0.00984
Single	Correlation Coefficient	0.856	0.824	0.728	0.720	0.720
Dual	CorrelationCoefficient	0.859	0.805	0.767	0.664	0.702
Model		**Number of Daily Readings**				
		Spring	Summer	Autumn	Winter	Annual
Single	Mean Absolute Error	1.12	1.22	1.35	1.45	1.49
Dual	Mean Absolute Error	1.08	1.29	1.04	1.38	1.46
Single	Correlation Coefficient	0.738	0.888	0.555	0.615	0.721
Dual	CorrelationCoefficient	0.790	0.867	0.801	0.686	0.732

Figures 16 through 23 compare the single versus the dual ANN models for the different output variables by season. In general, there is discrepancy between the dual and single ANN models. In some cases, the single model appears to do better. However, on average, the dual model appears to reduce erroneous high and low values, perhaps providing some increased stability. For the summer turbidity, however, the single ANN model, while incorrectly predicting one peak, did correctly predict a later peak, unlike the dual ANN model.

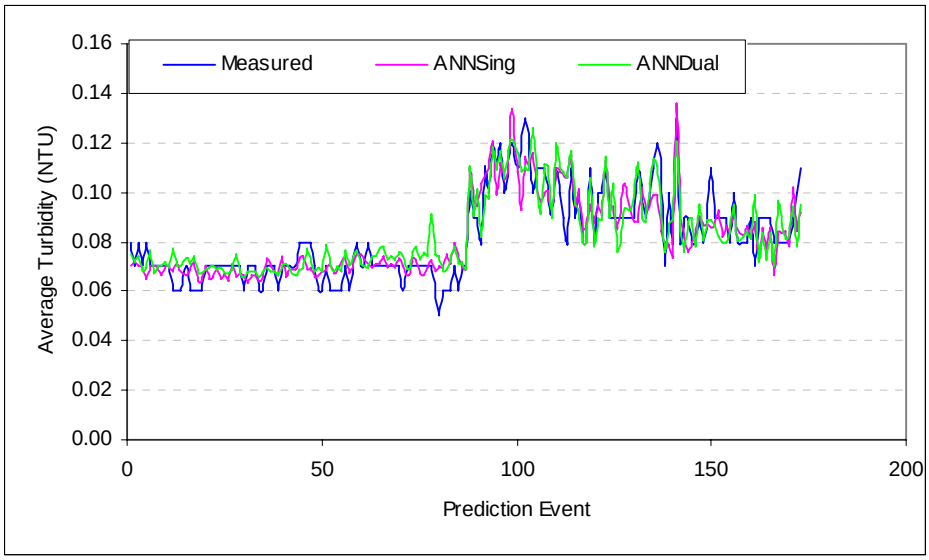

Figure 16. Comparison of average daily turbidity predictions by single and dual ANN output models for spring season for Swimming River.

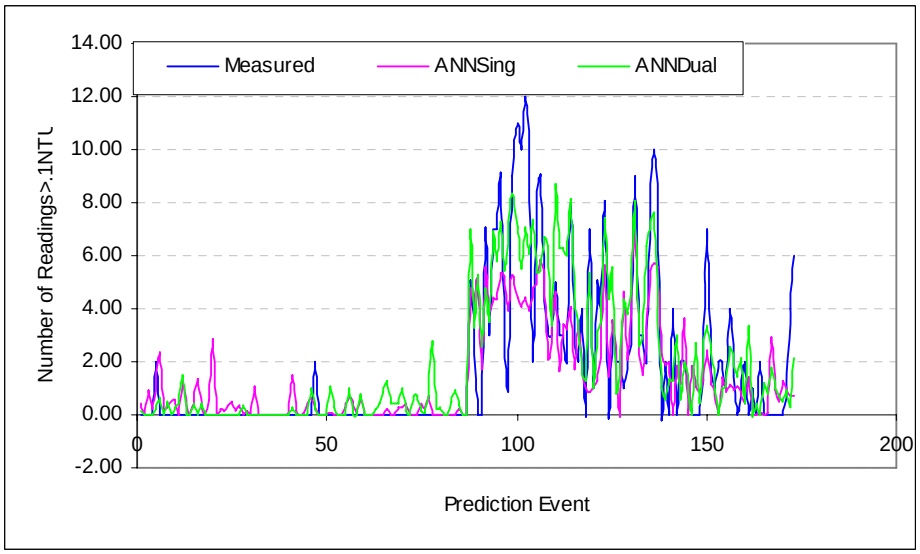

Figure 17. Comparison of number of reading predictions by single and dual ANN output models for spring season for Swimming River.

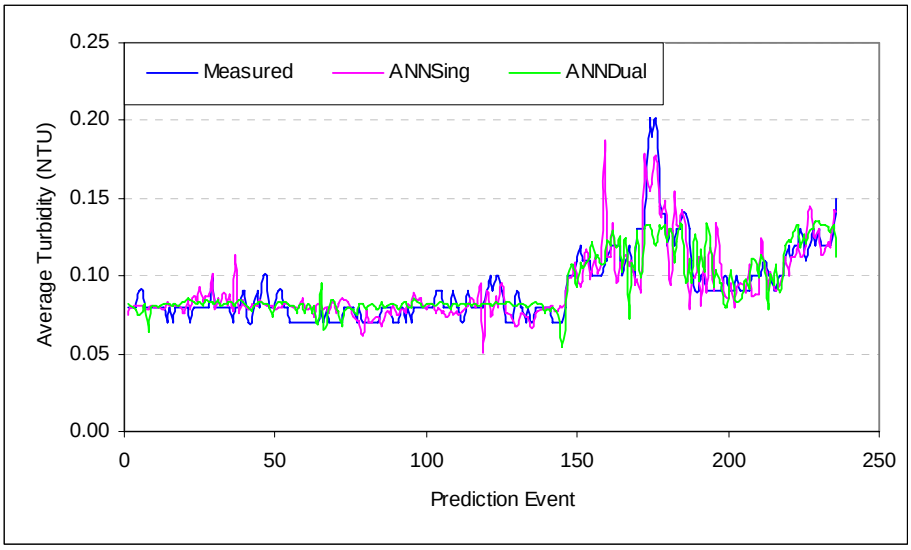

Figure 18. Comparison of average daily turbidity predictions by single and dual ANN output models for summer season for Swimming River.

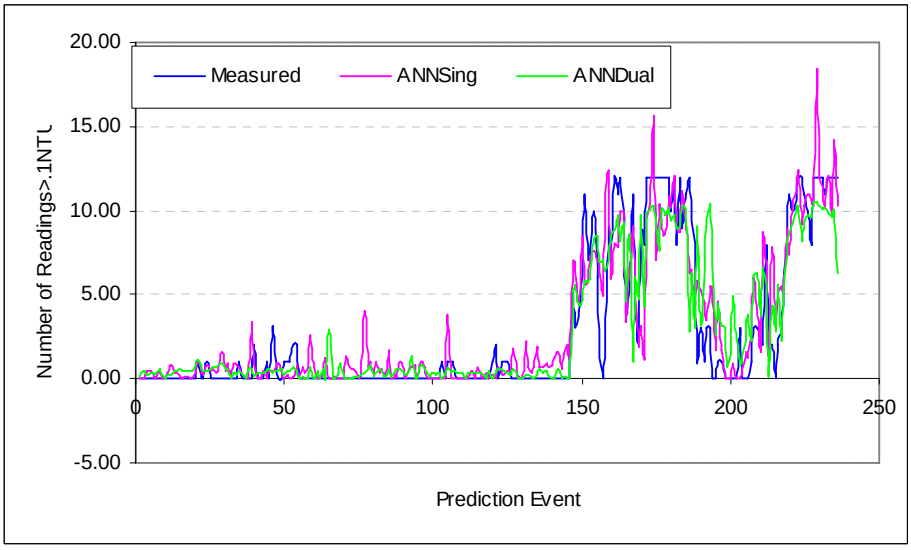

Figure 19. Comparison of number of daily predictions by single and dual ANN output models for summer season for Swimming River.

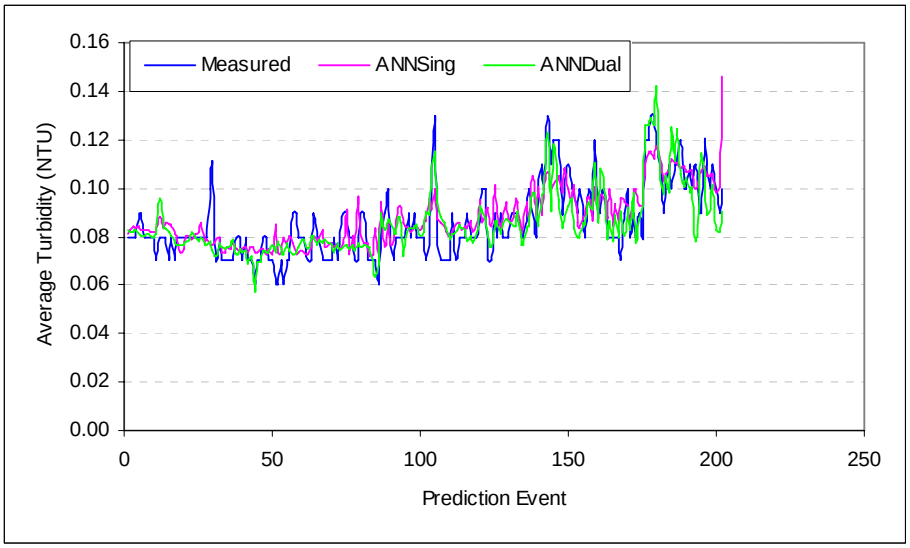

Figure 20. Comparison of average daily turbidity predictions by single and dual ANN output models for fall season for Swimming River.

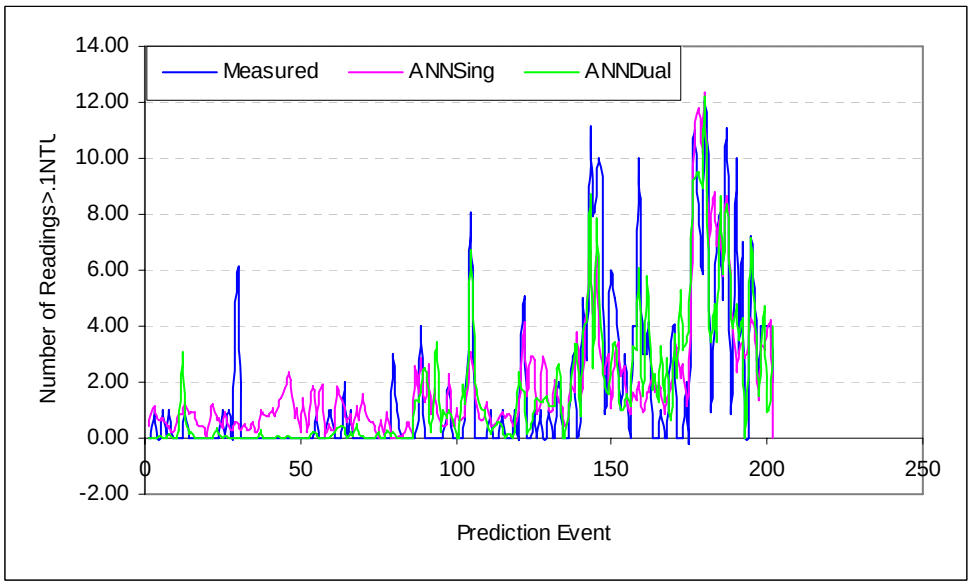

Figure 21. Comparison of number of reading predictions by single and dual ANN output models for fall season for Swimming River.

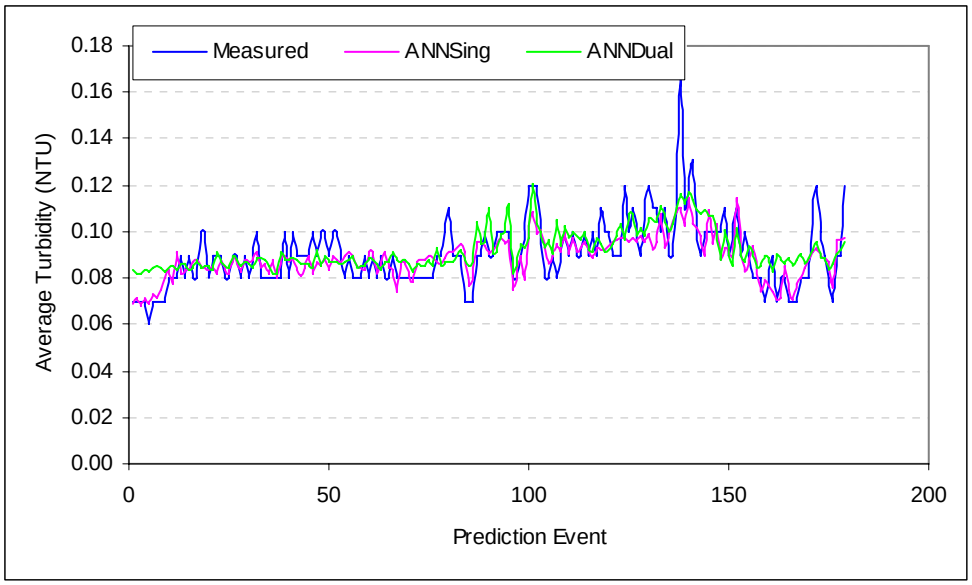

Figure 22. Comparison of average daily turbidity predictions by single and dual ANN output models for winter season for Swimming River.

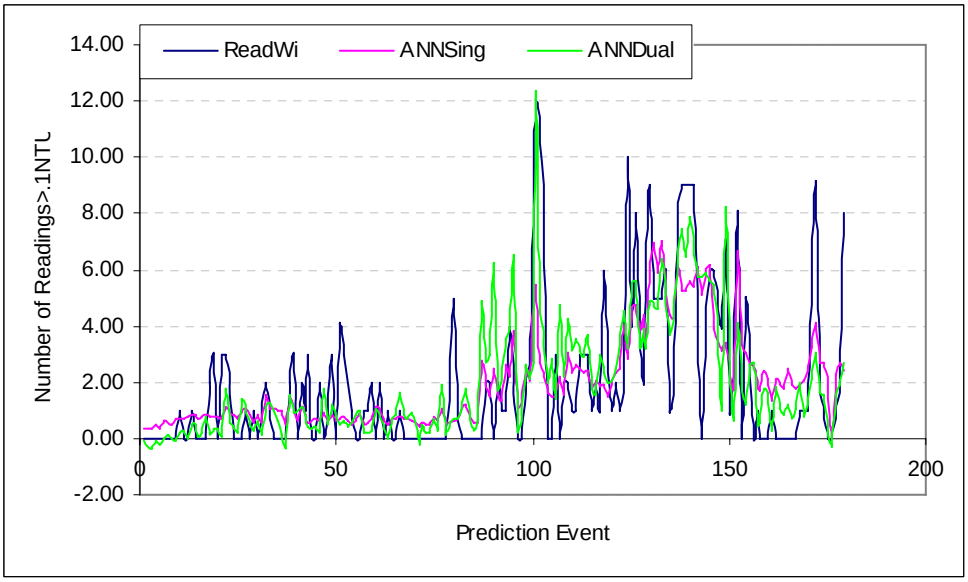

Figure 23. Comparison of number of reading predictions by single and dual ANN output models for winter season for Swimming River.

Lastly, figures 24 and 25 compare the modeling results obtained for the different models over the complete 2.5 year record of data for average turbidity and daily readings, respectively. Depicted by the figures for each of the two outputs are the predictions made

by the annual single output model, the predictions made by the seasonal single output model, and the predictions made by the seasonal dual output models. Again, the most striking difference is the dual seasonal models appear less likely to produce erroneously high or low output values. Thus, perhaps the dual output models provide some increased stability, in addition to some marginal improvement in overall predictive capability

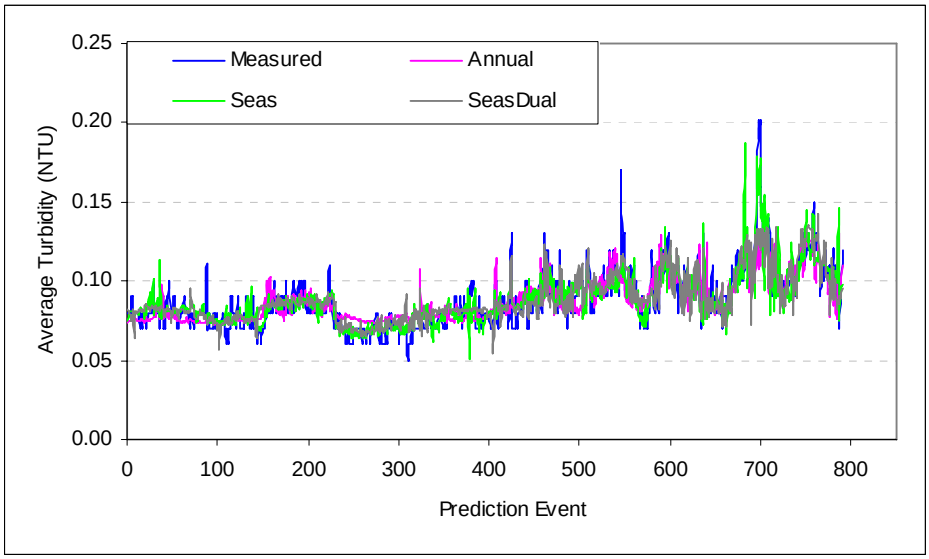

Figure 24. Comparison of annual dual ANN model against seasonal singular and seasonal dual ANN models for daily average turbidity for Swimming River.

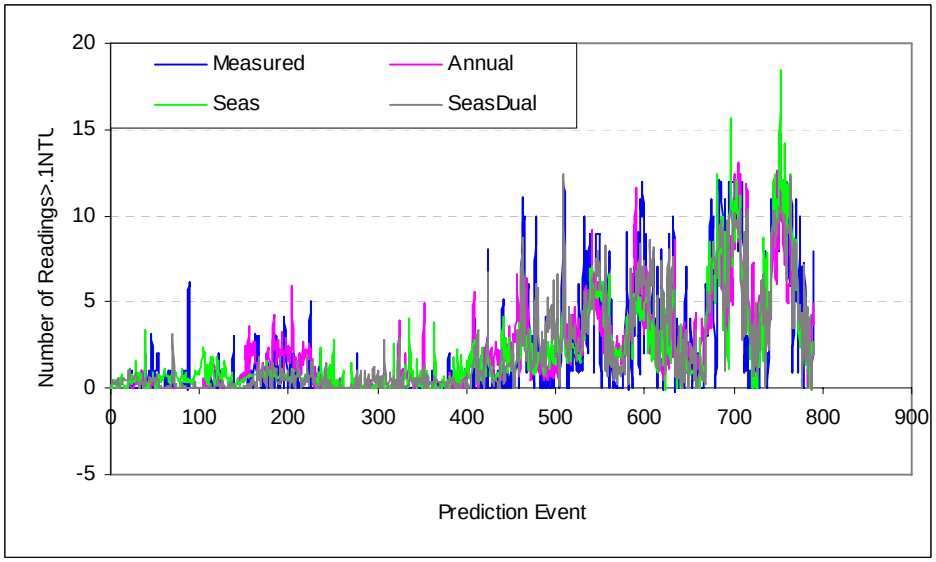

Figure 25. Comparison of annual dual ANN model against seasonal singular and seasonal dual ANN models for number of readings for Swimming River.

APPENDIX A-3a

PVWC (INITIAL) ORIGINAL MODELING
Figures

1. CYANOBACTERIA

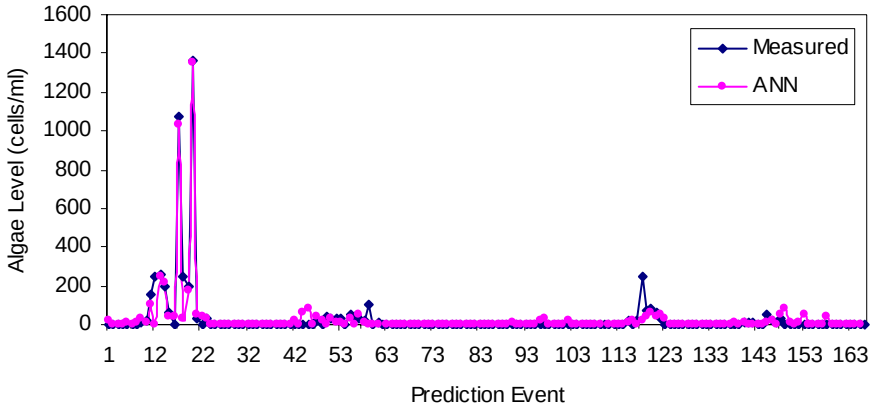

Figure 1.1. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs

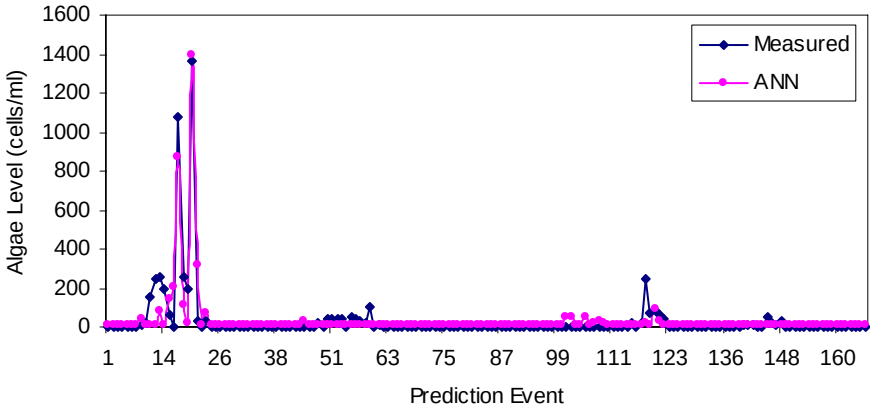

Figure 1.2. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding dissolved oxygen (DO)

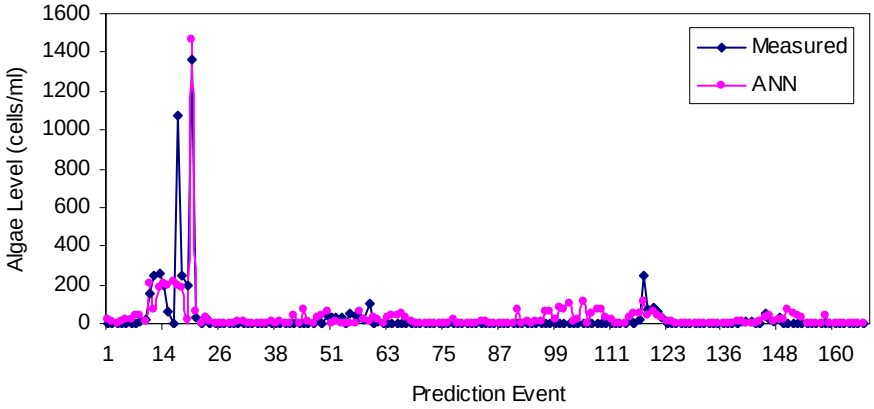

Figure 1.3. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding total suspended solids (TSS)

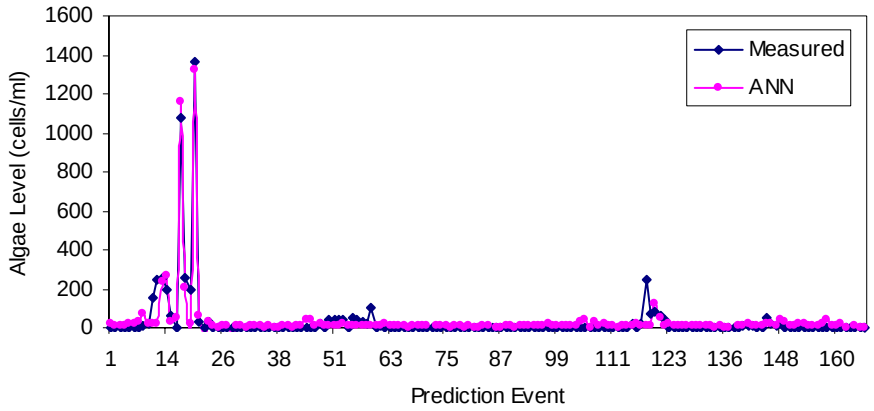

Figure 1.4. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding Pompton river extraction

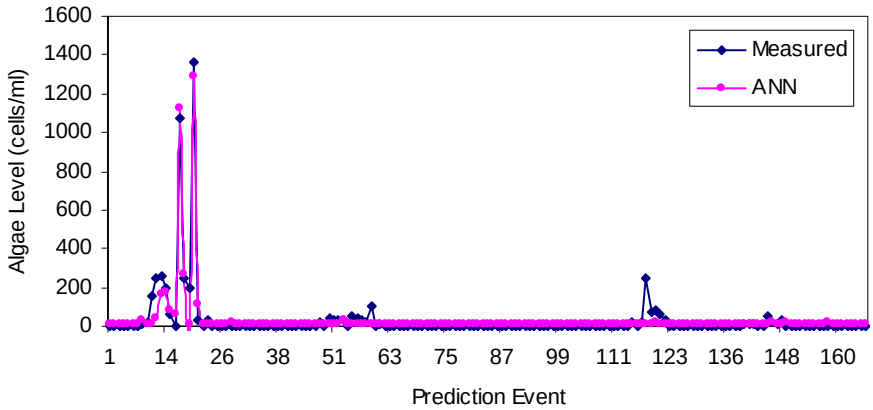

Figure 1.5. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding conductivity

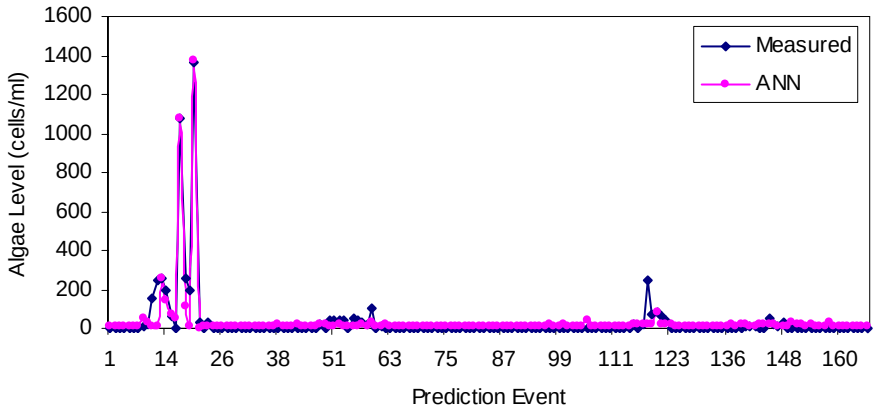

Figure 1.6. Station 100 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding pH

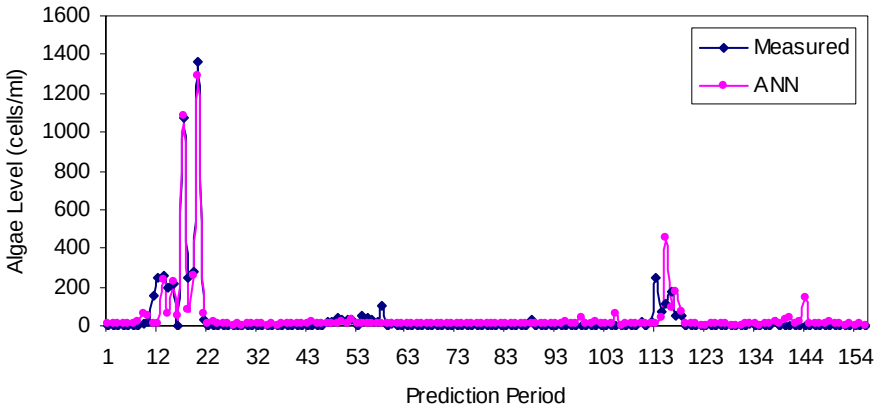

Figure 1.7. Station 100 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs

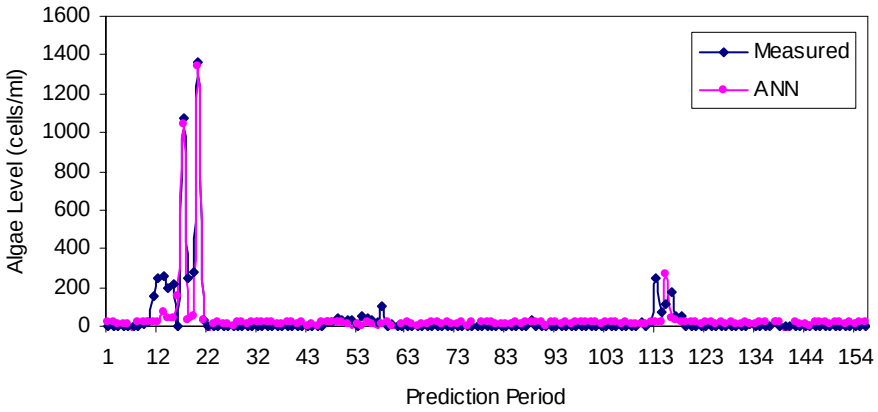

Figure 1.8. Station 100 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding total suspended solids

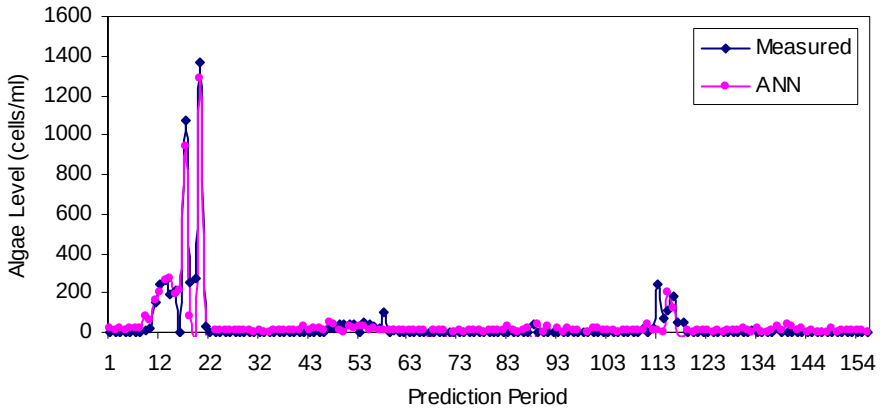

Figure 1.9. Station 100 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding Pompton river extractions

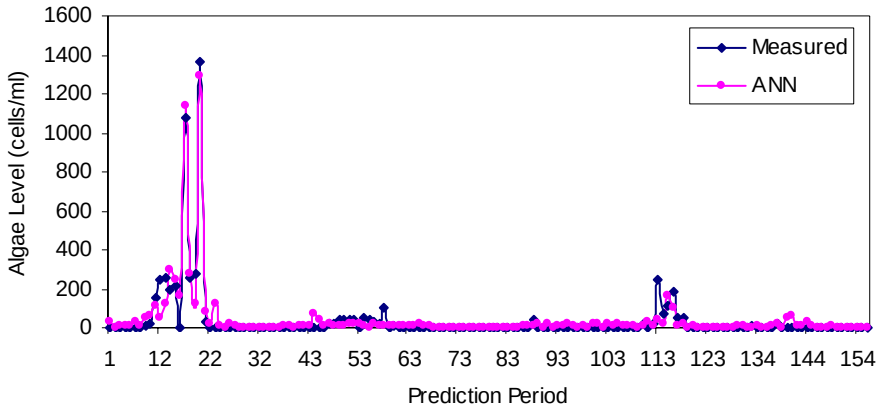

Figure 1.10. Station 100 time-series plots of mea sured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding wind directions

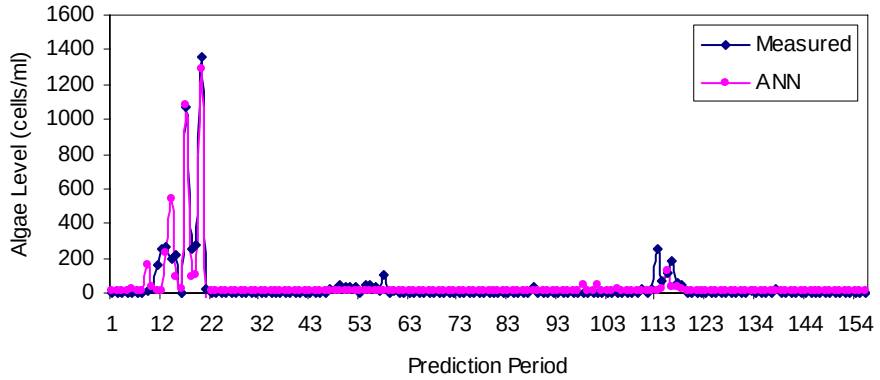

Figure 1.11. Station 100 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding extractions from Point View Reservoir

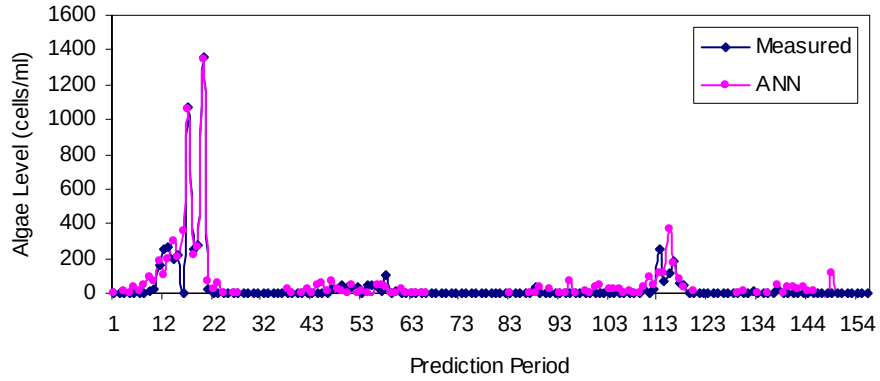

Figure 1.12. Station 100 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding conductivity

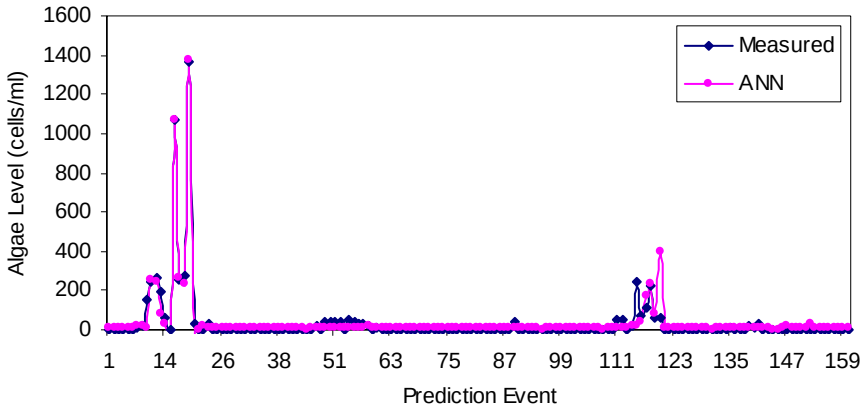

Figure 1.13. Station 100 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs

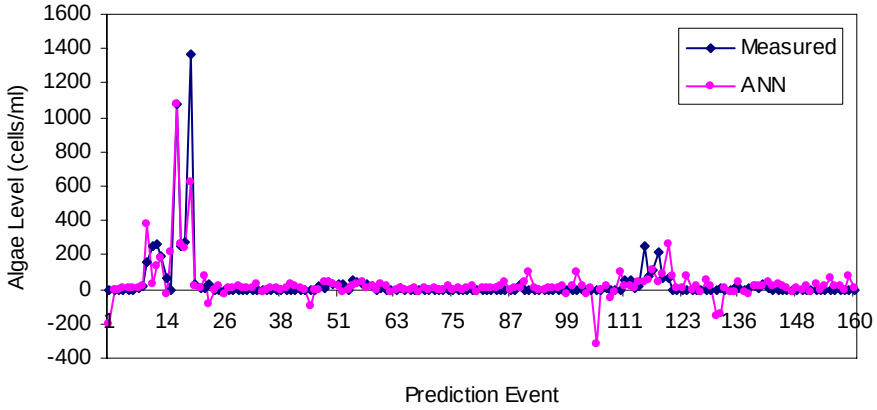

Figure 1.14. Station 100 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding sulfate

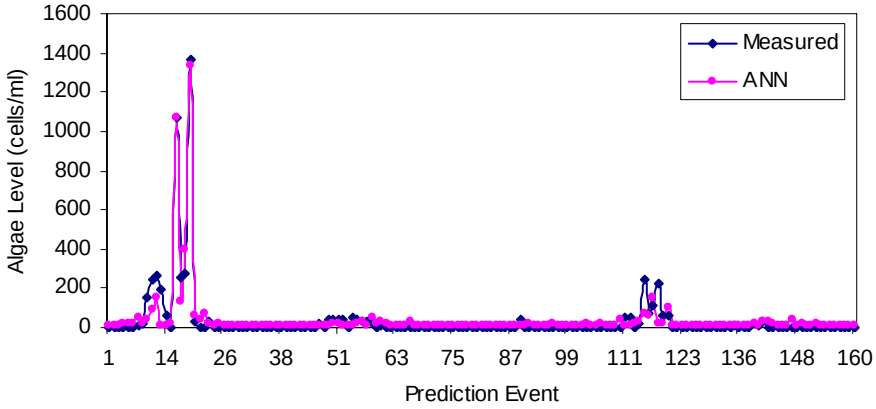

Figure 1.15. Station 100 time-series plots of measured cyanobacteria counts against ANN two -week ahead predicted values using all variable inputs excluding total hardness

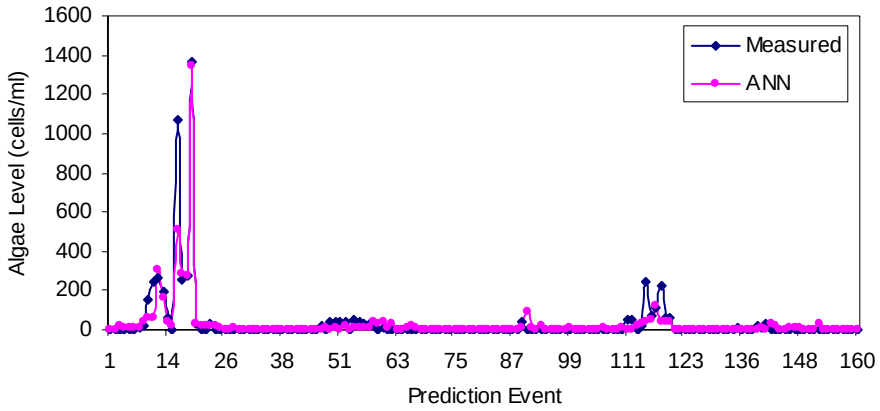

Figure 1.16. Station 100 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding nitrite/nitrate

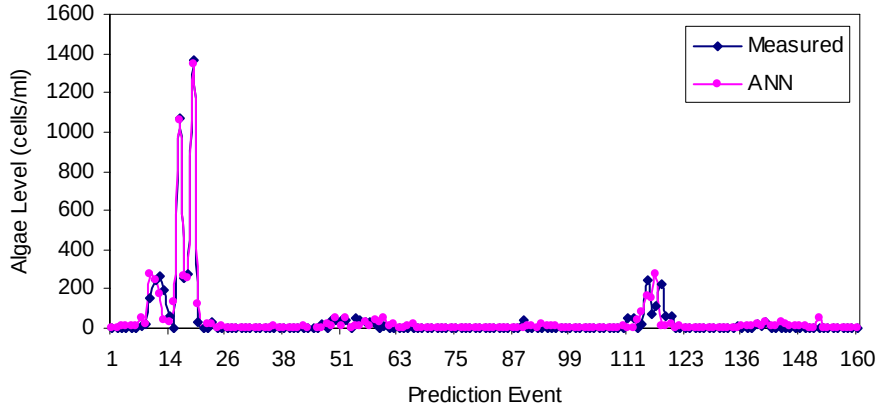

Figure 1.17. Station 100 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding UV_{254}

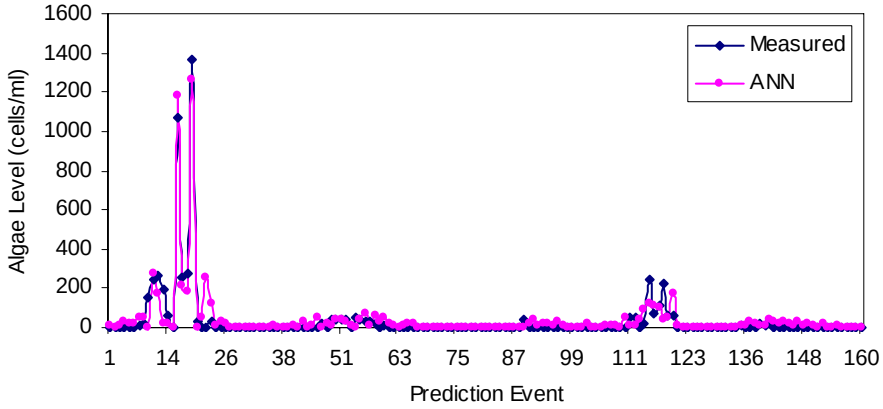

Figure 1.18. Station 100 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding Pompton streamflow (collected by USGS)

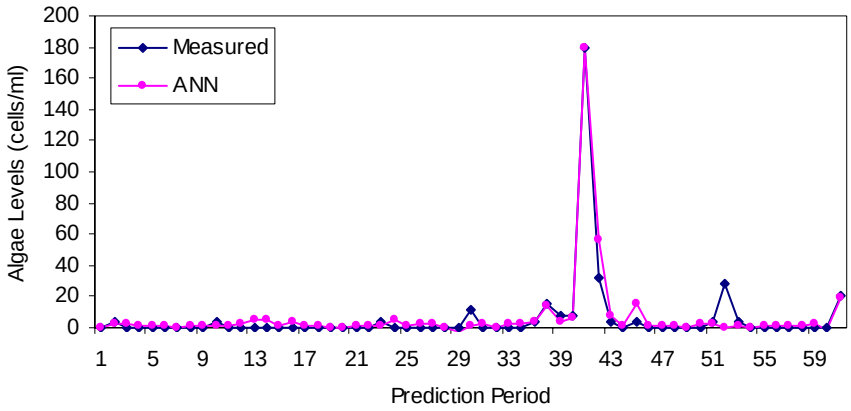

Figure 1.19. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs

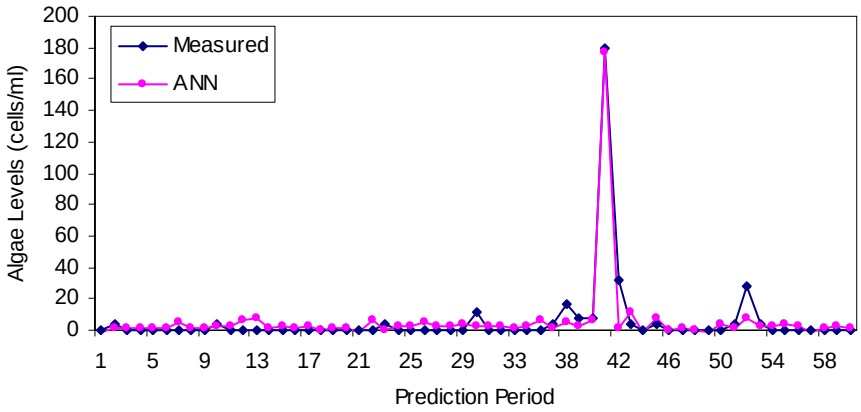

Figure 1.20. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding odor

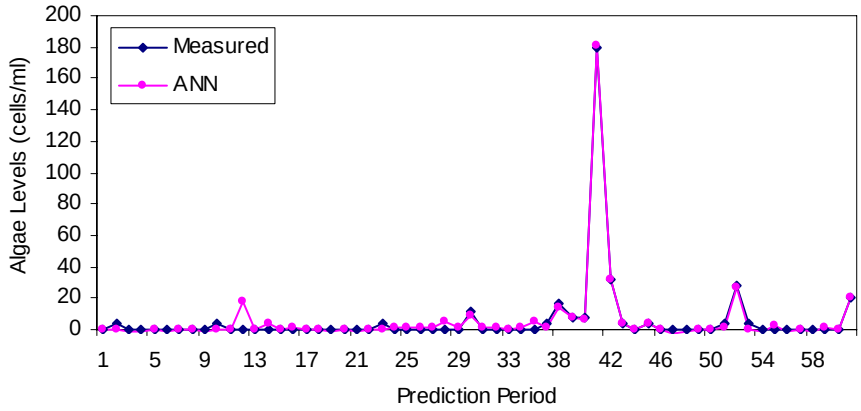

Figure 1.21. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding total amorphous materials

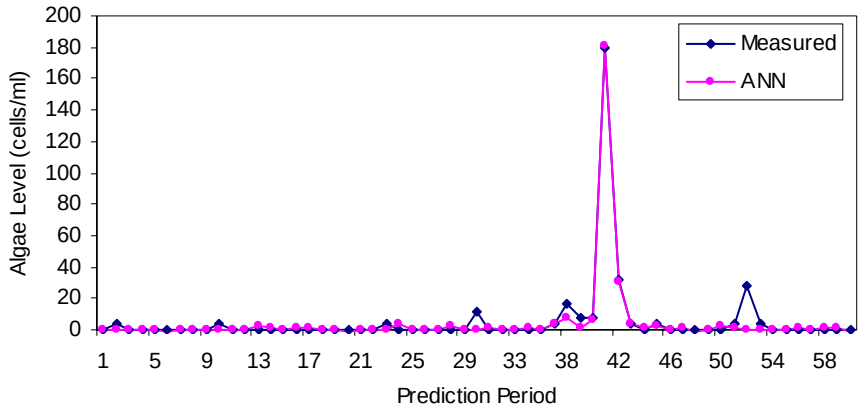

Figure 1.22. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding color

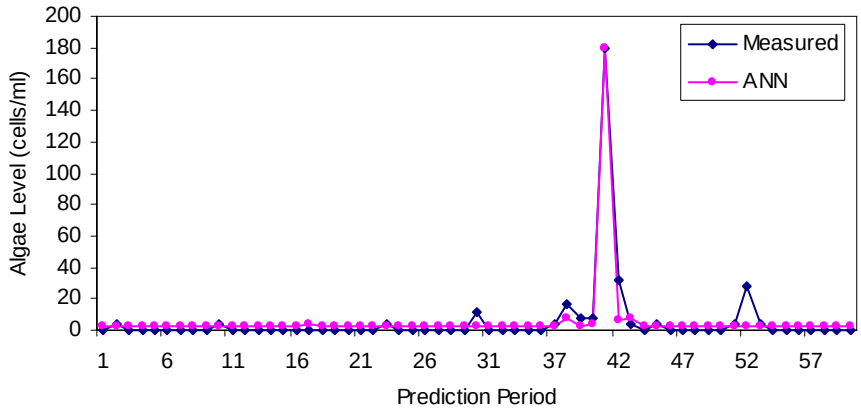

Figure 1.23. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding heating degree days

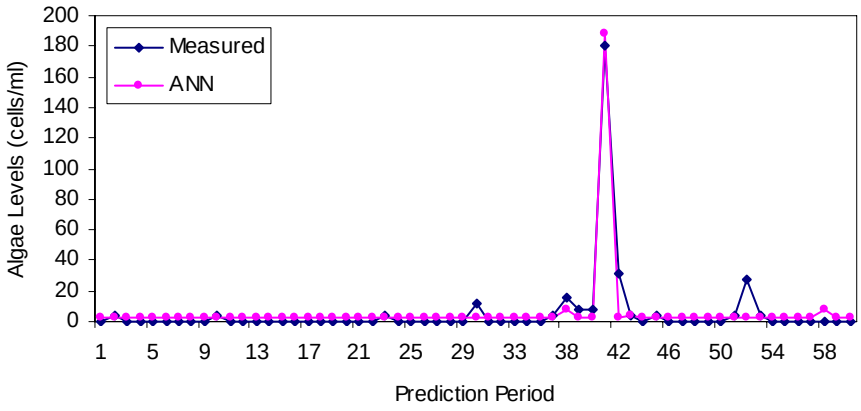

Figure 1.24. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding U V_{254}

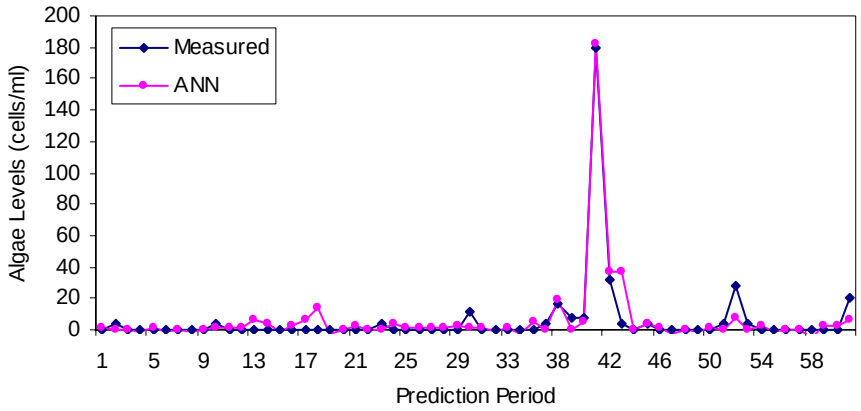

Figure 1.25. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding ammonia

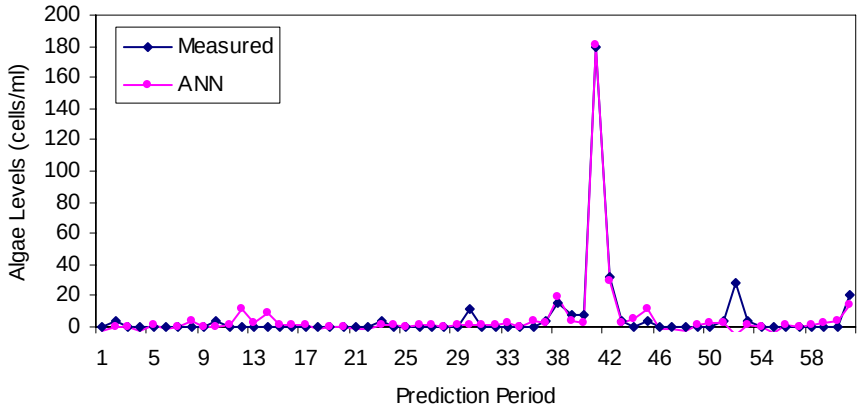

Figure 1.26. Station 101 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding initial cyanobacteria counts

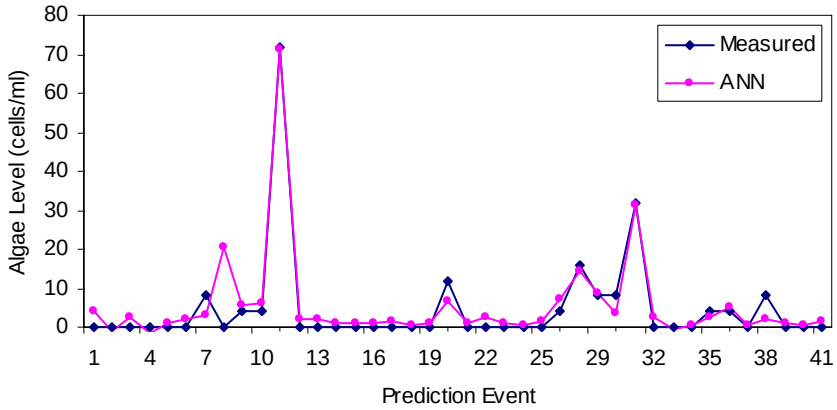

Figure 1.27. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs

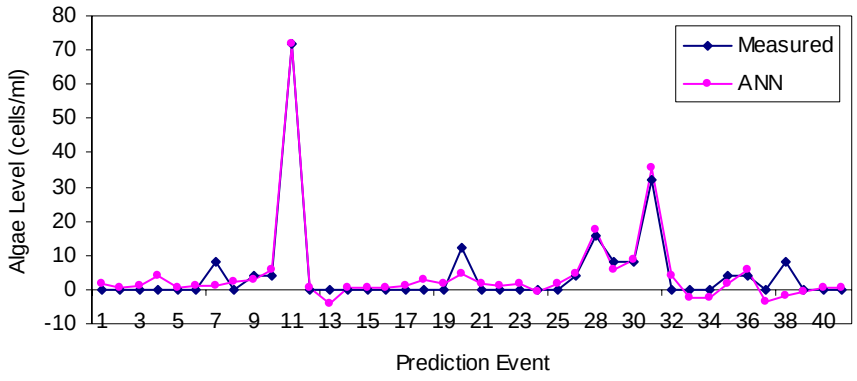

Figure 1.28. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding odor

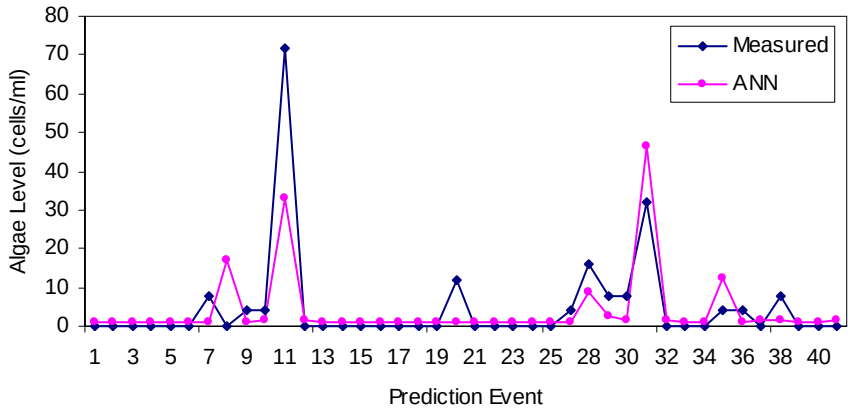

Figure 1.29. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding current week's precipitation

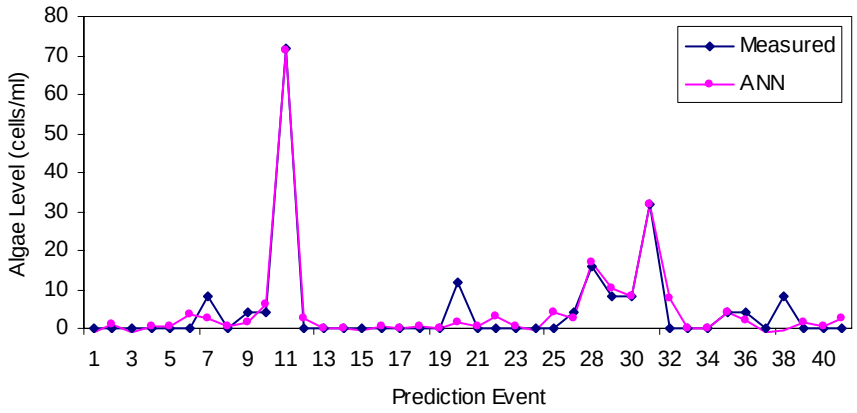

Figure 1.30. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding wind speed

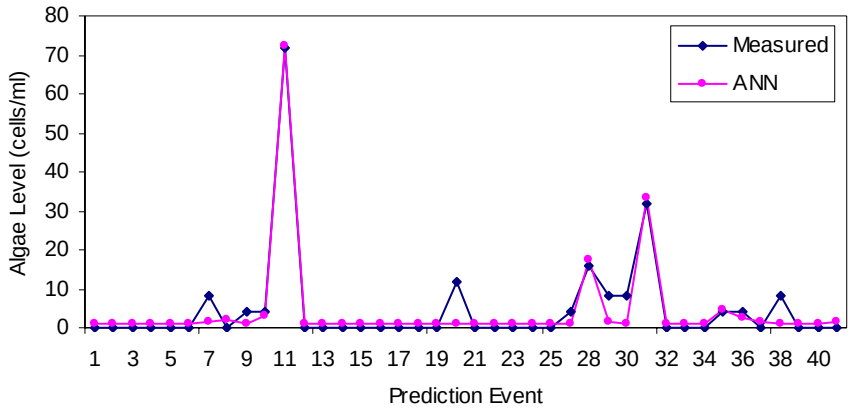

Figure 1.31. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding wind direction

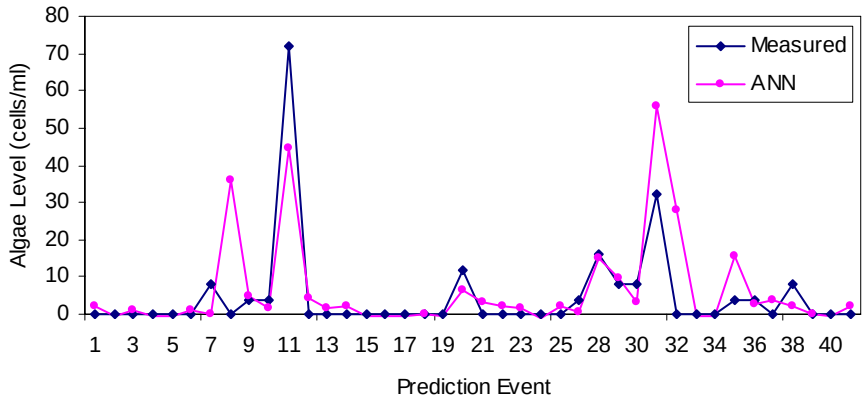

Figure 1.32. Station 101 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding Pompton river extractions

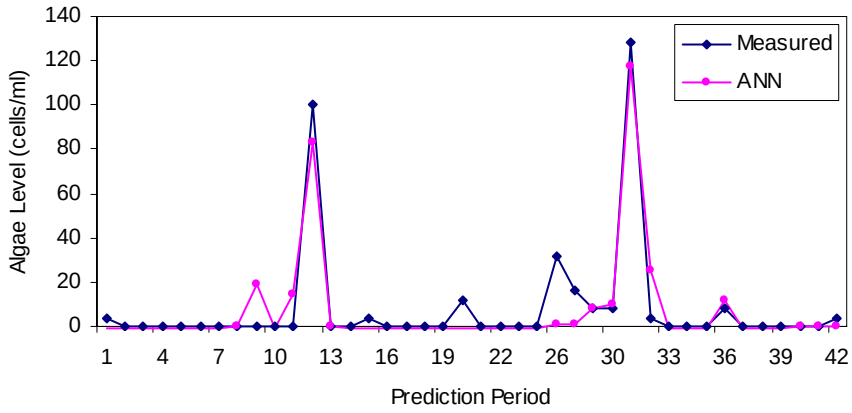

Figure 1.33. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs

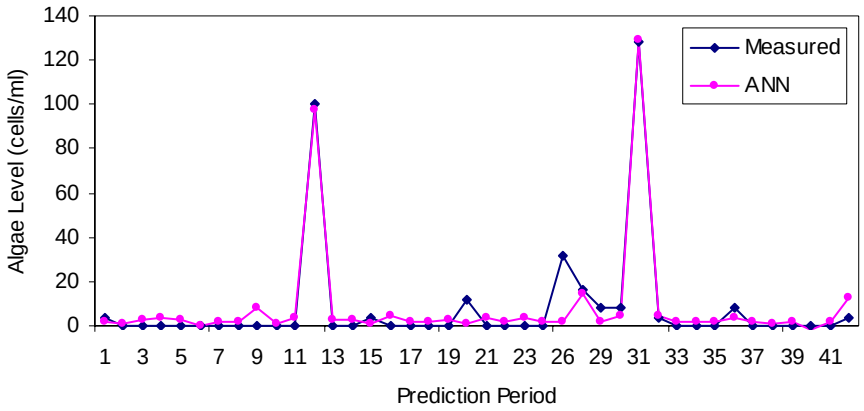

Figure 1.34. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding extractions from Point View Reservoir

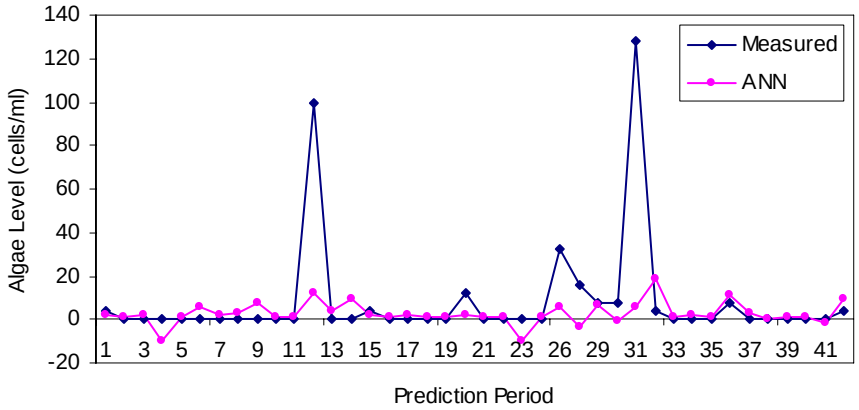

Figure 1.35. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding sulfate

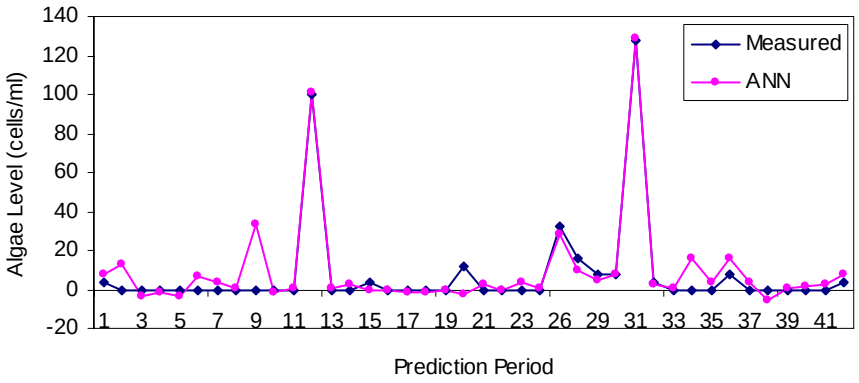

Figure 1.36. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding total phosphorus/orthophosphate

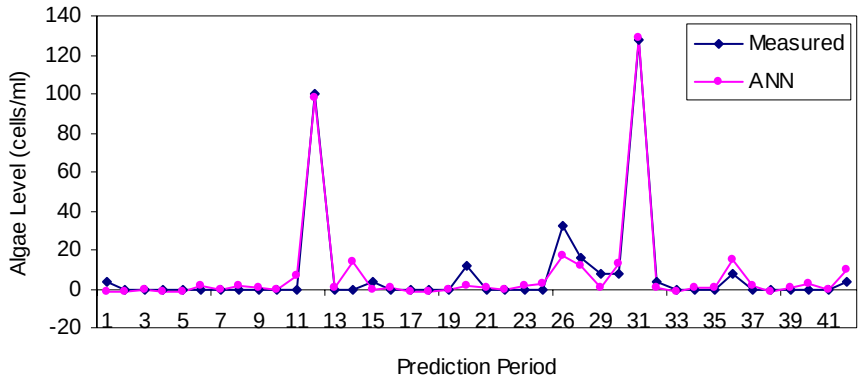

Figure 1.37. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding turbidity

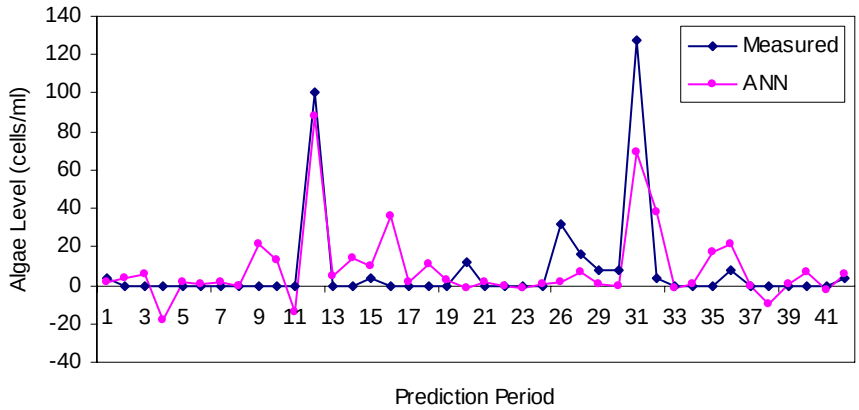

Figure 1.38. Station 101 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding total algal counts

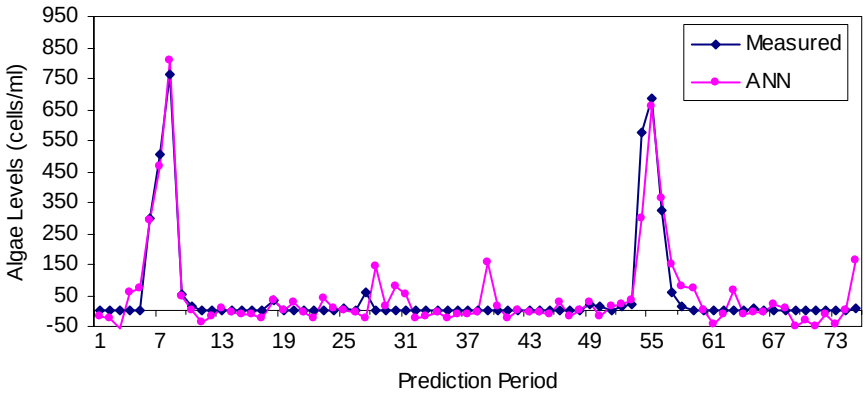

Figure 1.39. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs

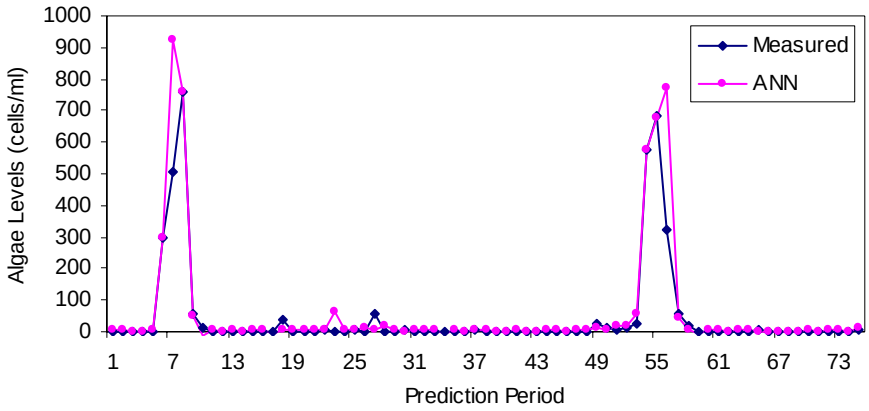

Figure 1.40. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding temperature

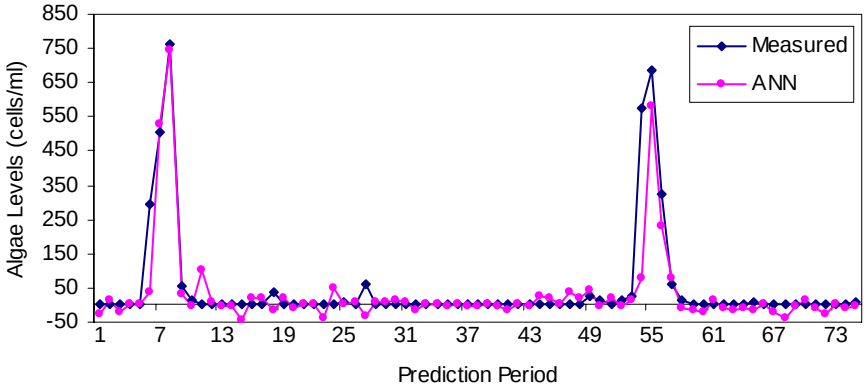

Figure 1.41. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding ammonia

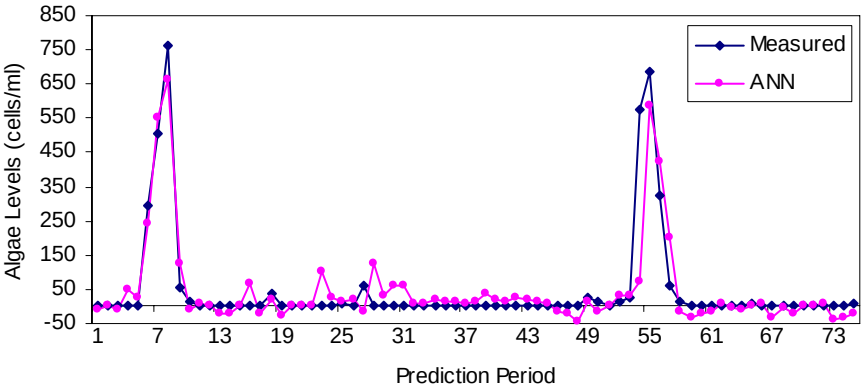

Figure 1.42. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding color

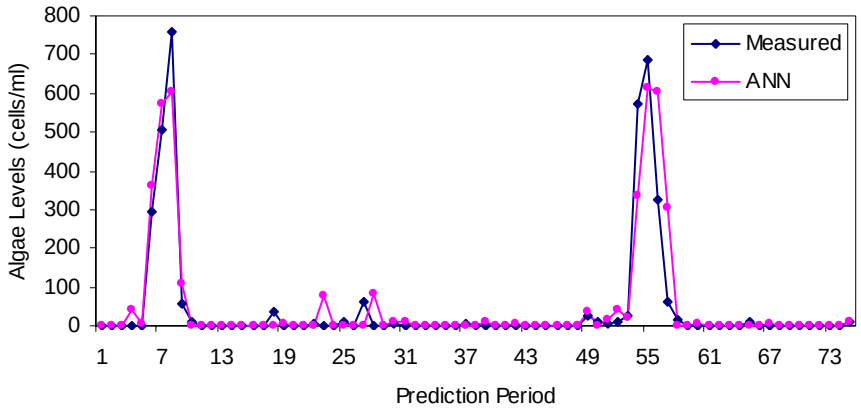

Figure 1.43. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs excluding Pompton river extractions

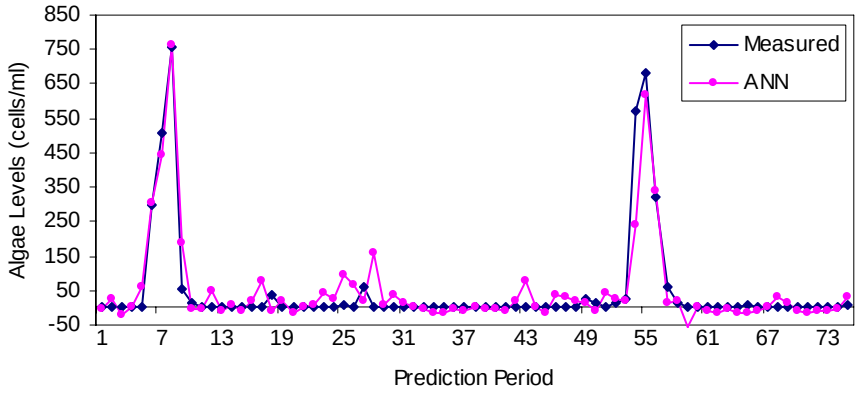

Figure 1.44. Station 612 time-series plots of measured cyanobacteria counts against ANN real-time predicted values using all variable inputs total organic carbon (TOC)

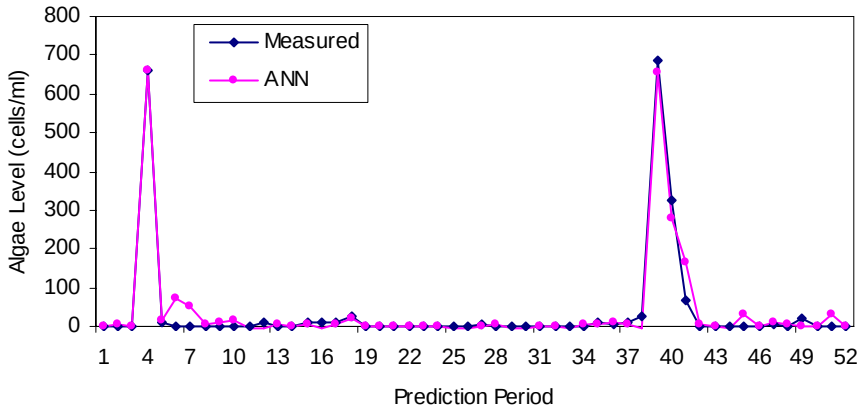

Figure 1.45. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs

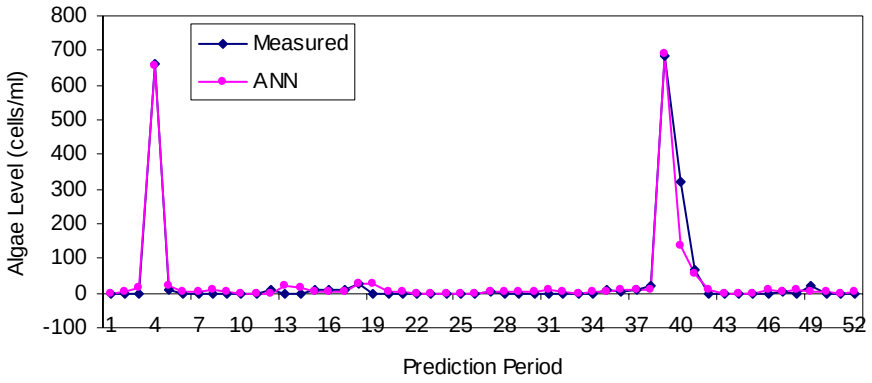

Figure 1.46. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding initial cyanobacteria counts

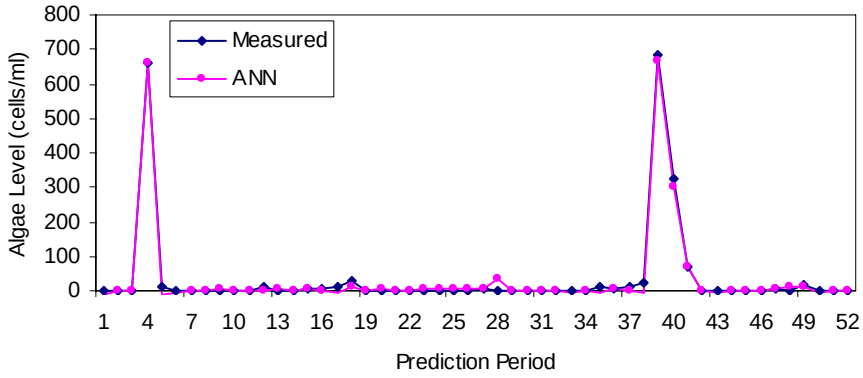

Figure 1.47. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding turbidity

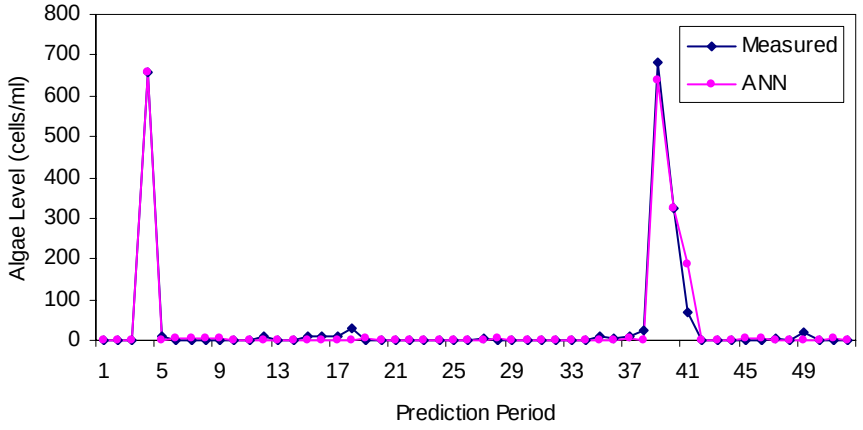

Figure 1.48. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding color

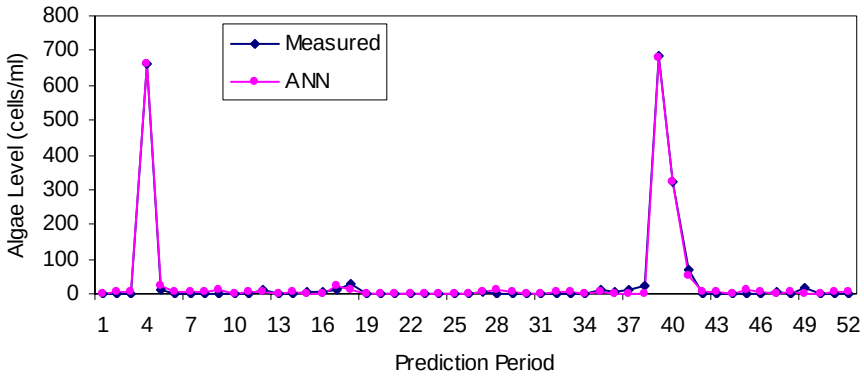

Figure 1.49. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding total organic carbon (TOC)

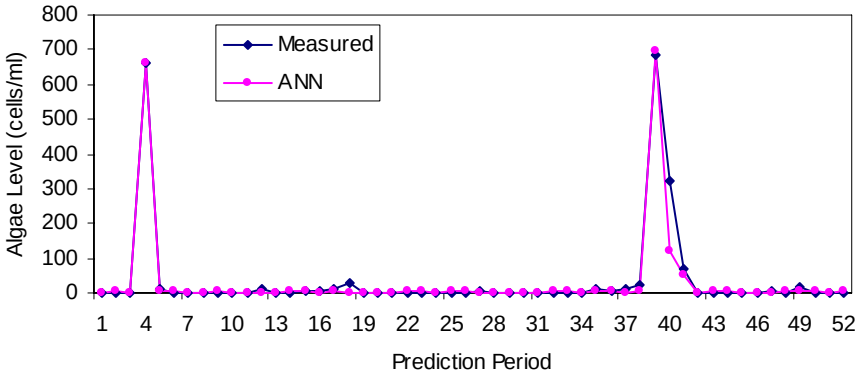

Figure 1.50. Station 612 time-series plots of measured cyanobacteria counts against ANN one-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

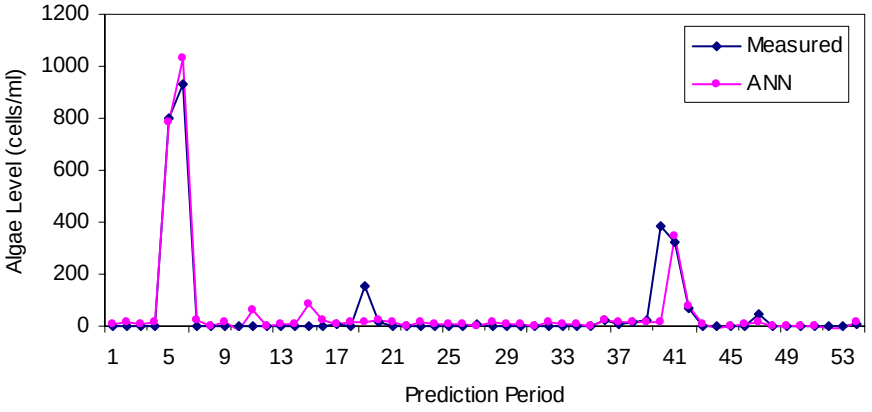

Figure 1.51. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs

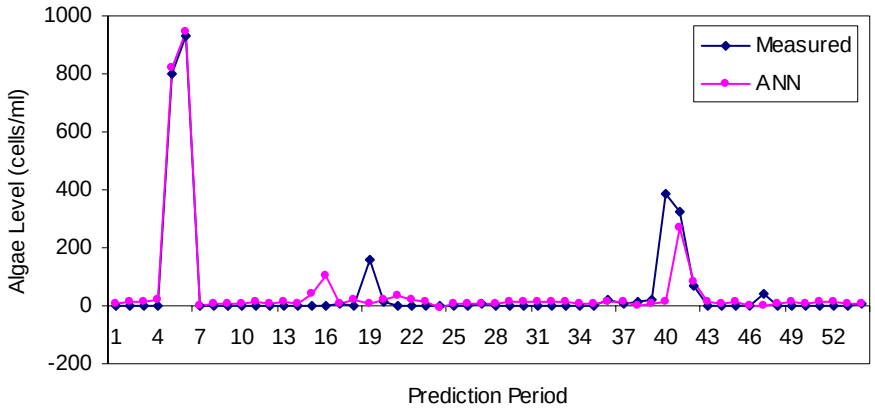

Figure 1.52. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding total amorphous materials

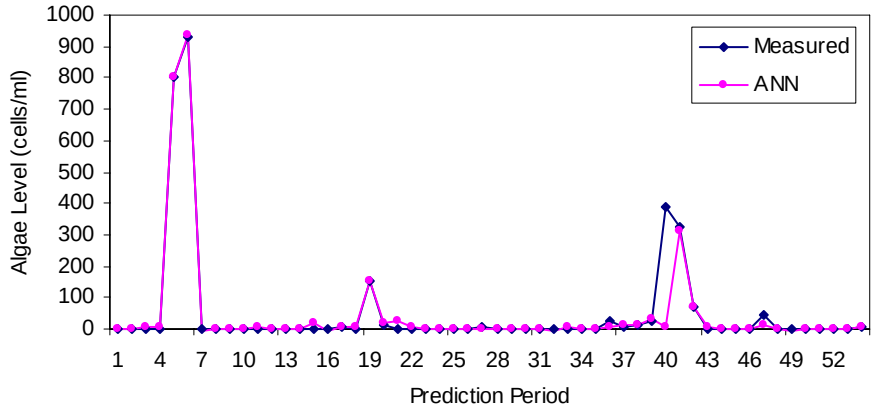

Figure 1.53. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding initial cyanobacteria counts

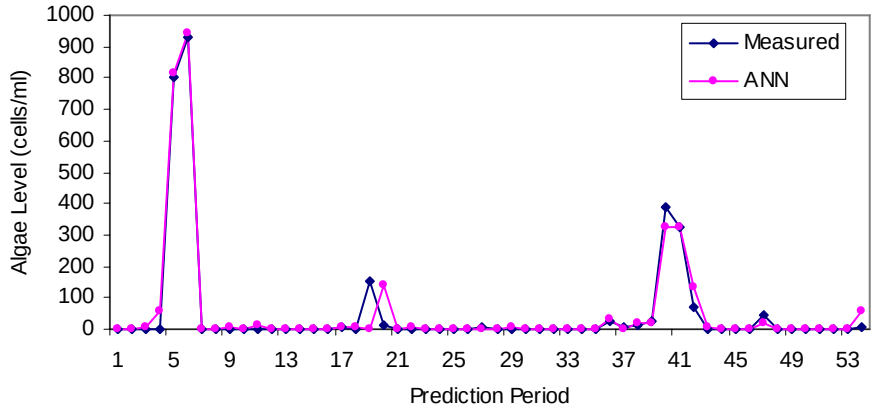

Figure 1.54. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding pH level

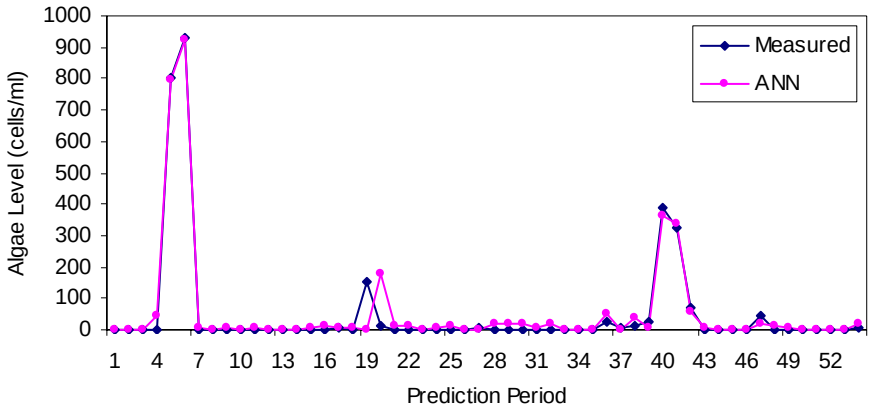

Figure 1.55. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding total algal counts

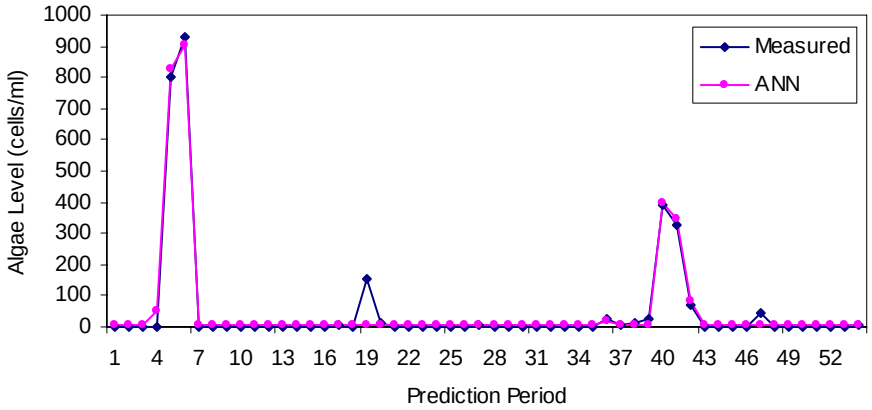

Figure 1.56. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding UV254

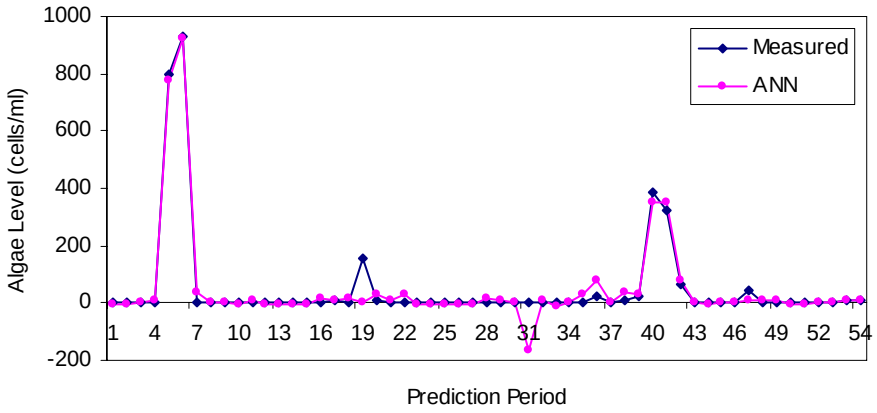

Figure 1.57. Station 612 time-series plots of measured cyanobacteria counts against ANN two-week ahead predicted values using all variable inputs excluding Passaic river extractions

2. CHRYOSPHYTA

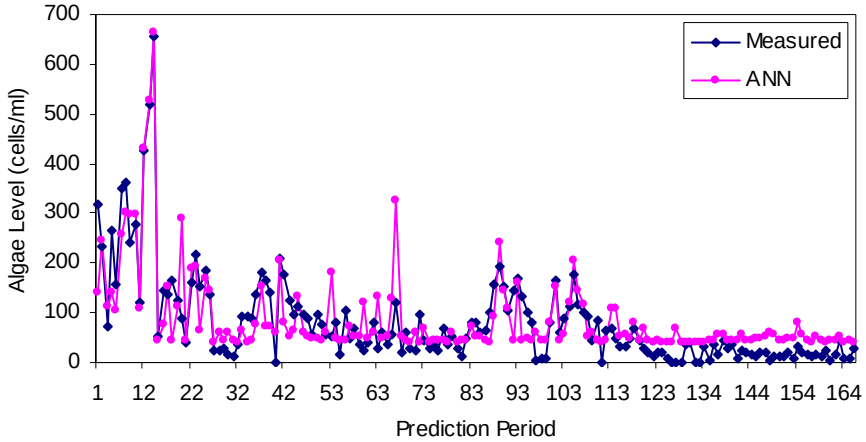

Figure 2.1. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs

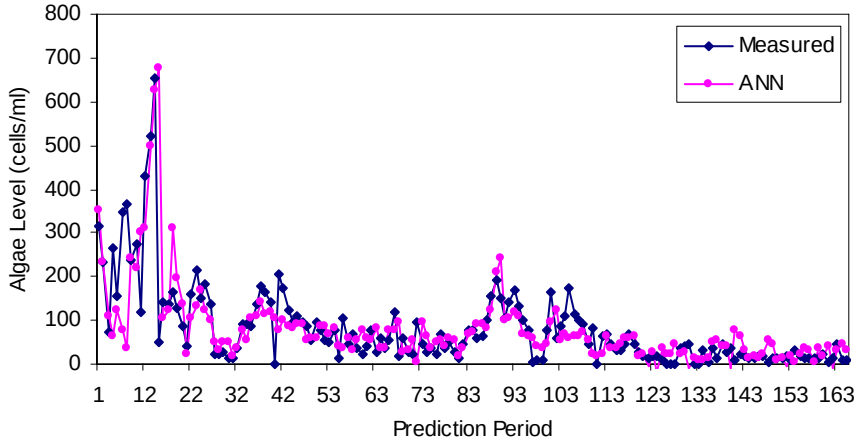

Figure 2.2. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding odor

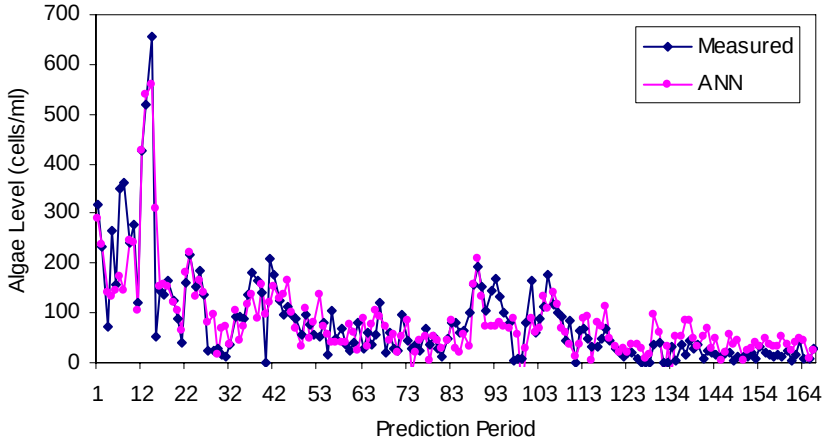

Figure 2.3. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding heating degree days

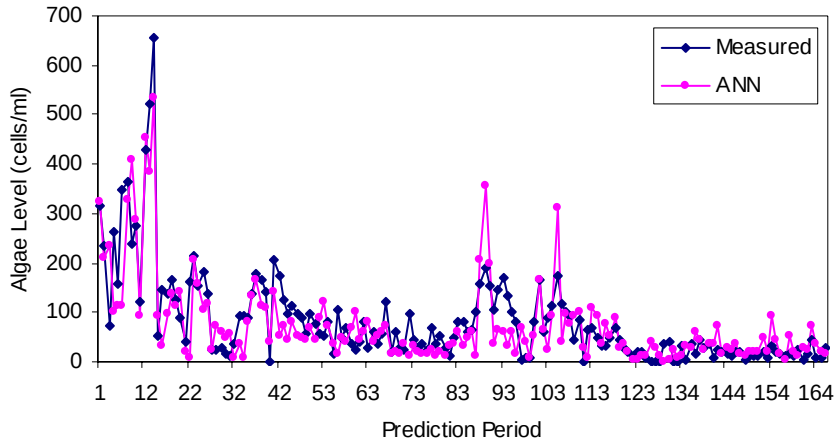

Figure 2.4. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding initial chrysophytes counts

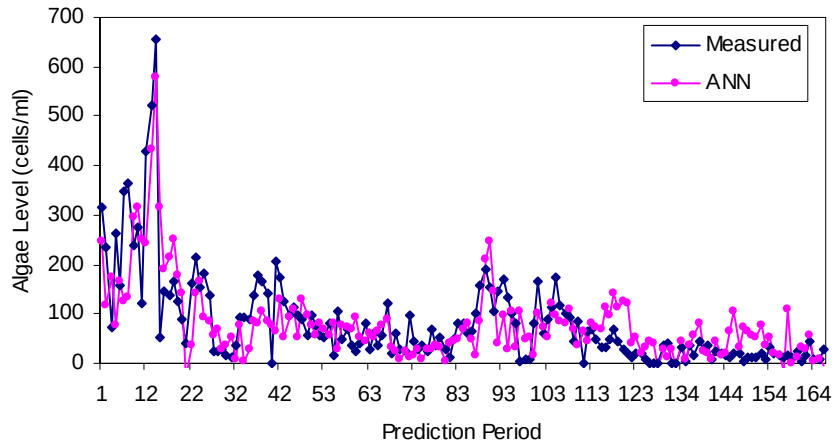

Figure 2.5. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding pH level

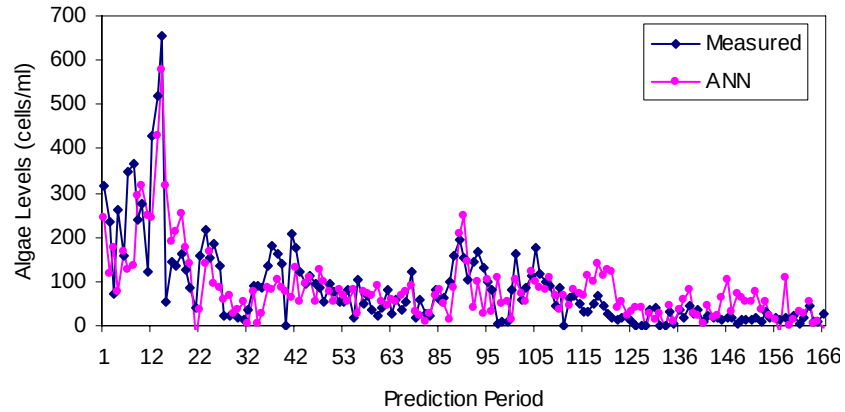

Figure 2.6. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding total suspended solids (TSS)

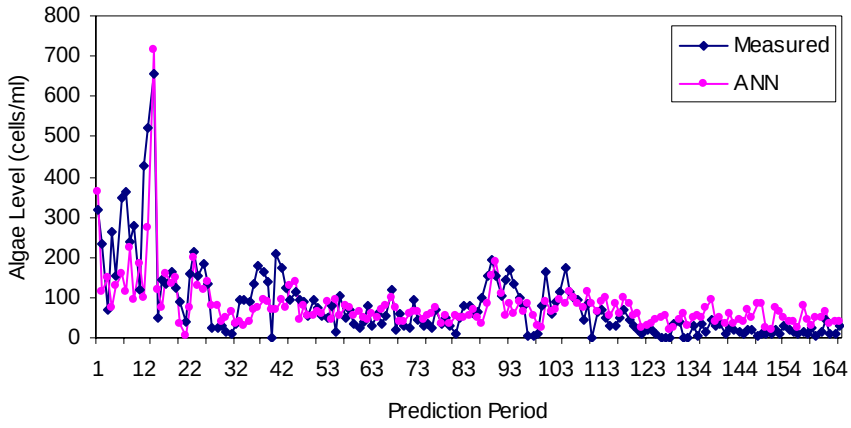

Figure 2.7. Station 100 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding current week's precipitation

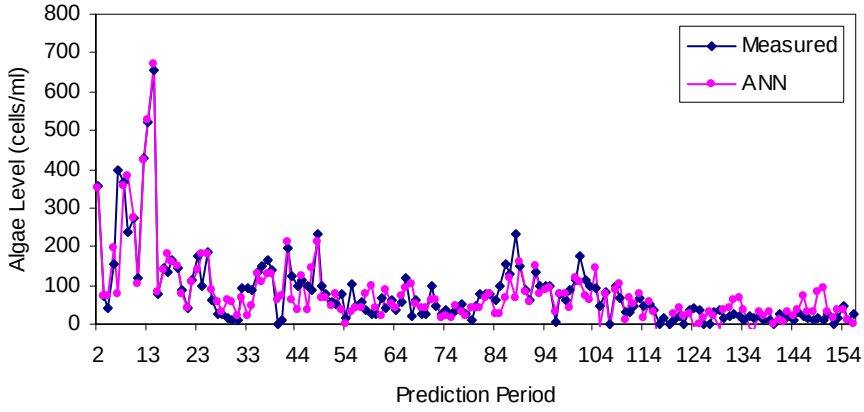

Figure 2.8. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs

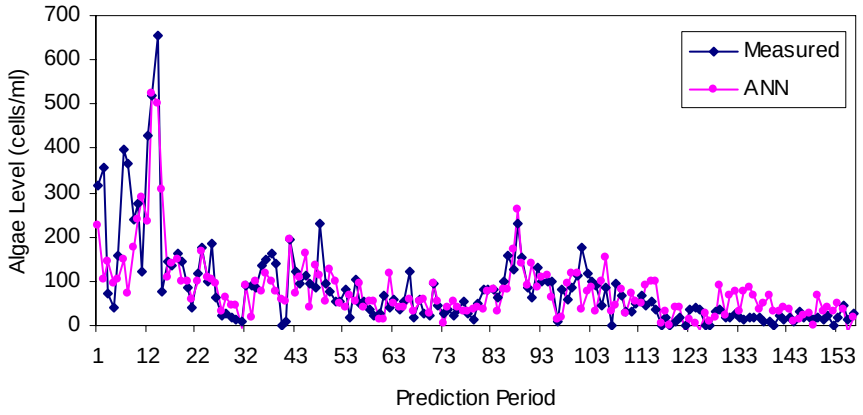

Figure 2.9. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding odor

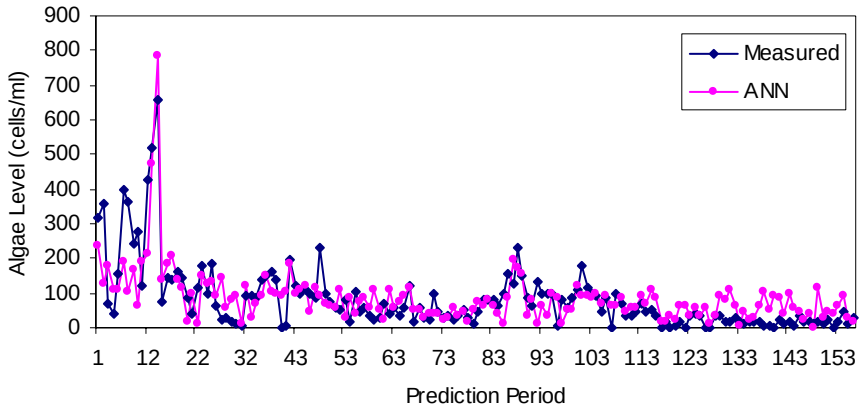

Figure 2.10. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

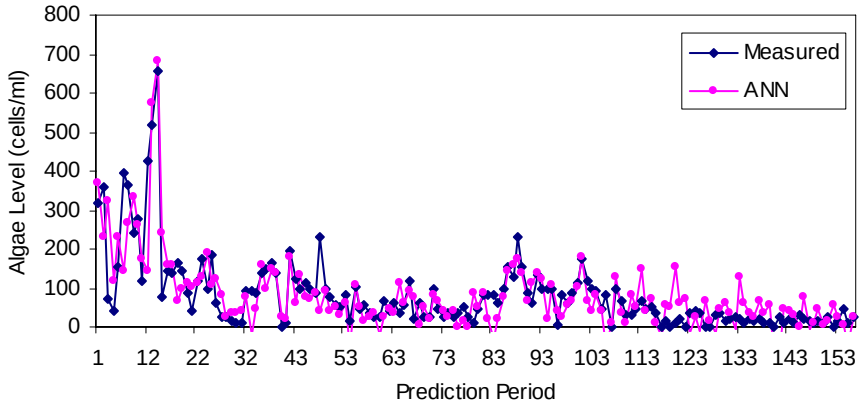

Figure 2.11. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total hardness

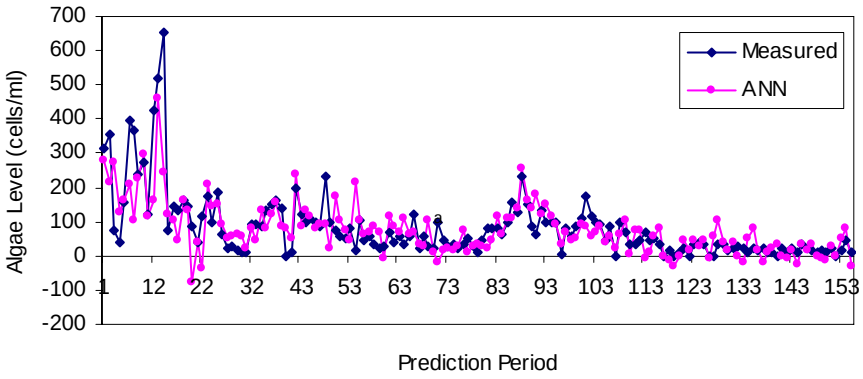

Figure 2.12. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding wind speed

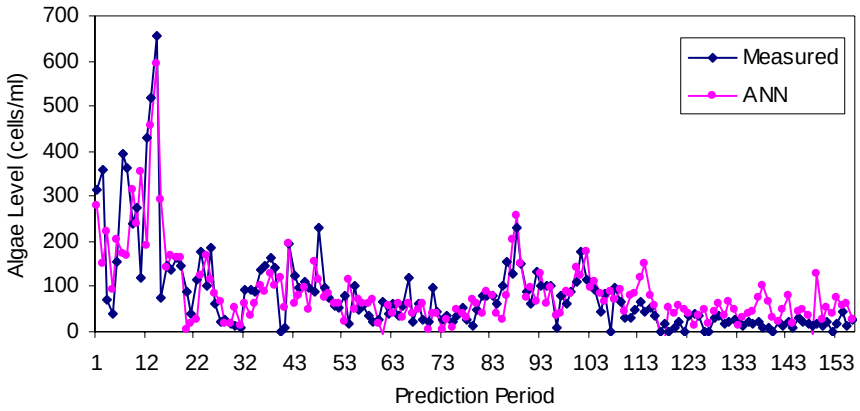

Figure 2.13. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding sky cover

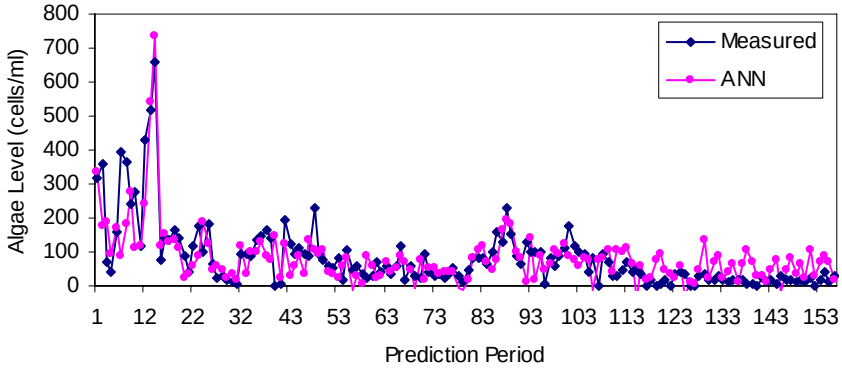

Figure 2.14. Station 100 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding current week's precipitation

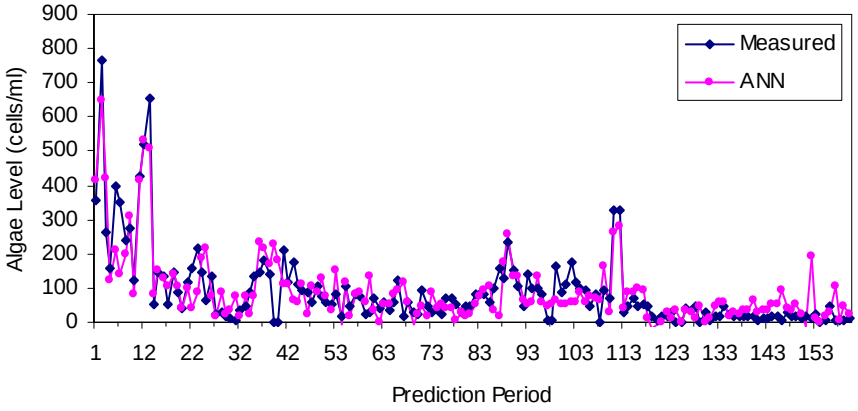

Figure 2.15. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs

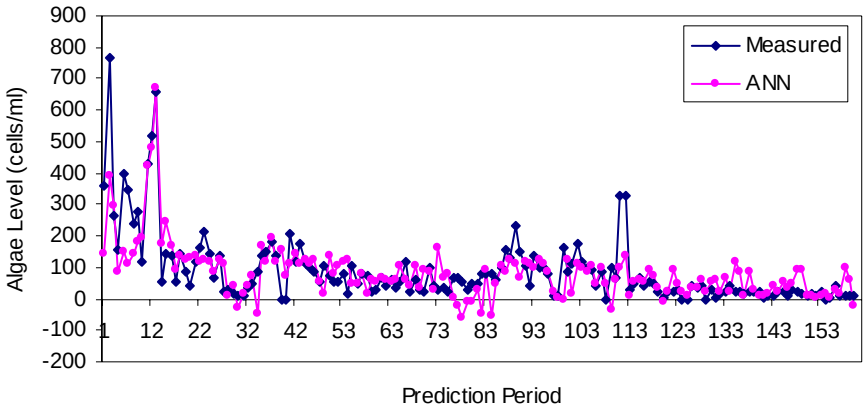

Figure2.17. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding odor

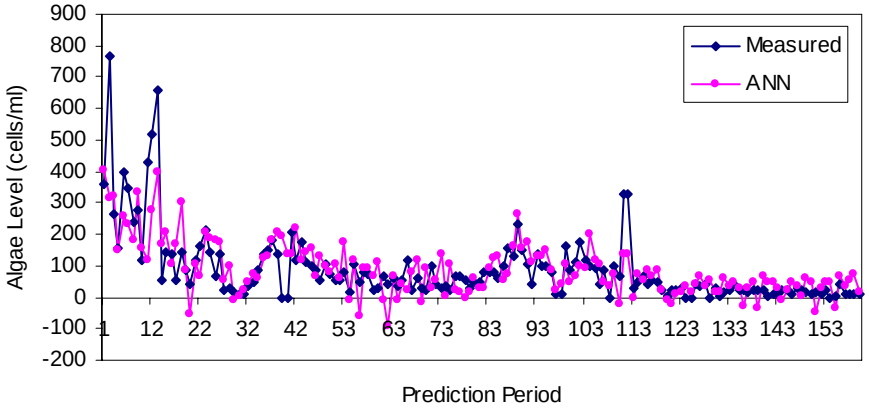

Figure 2.18. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding heating degree days

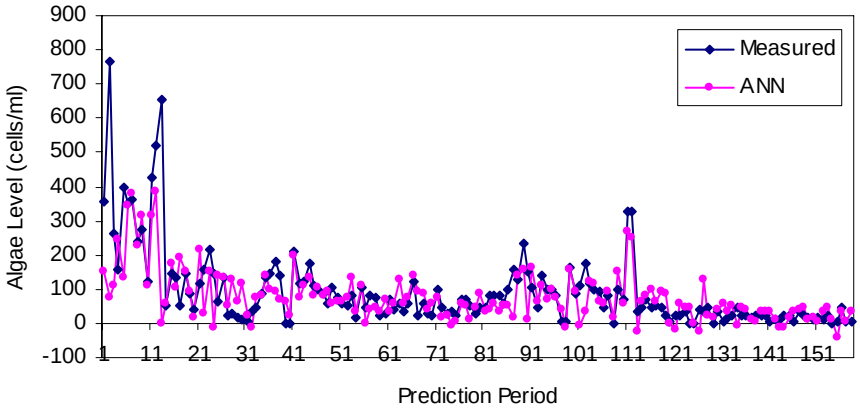

Figure 2.19. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

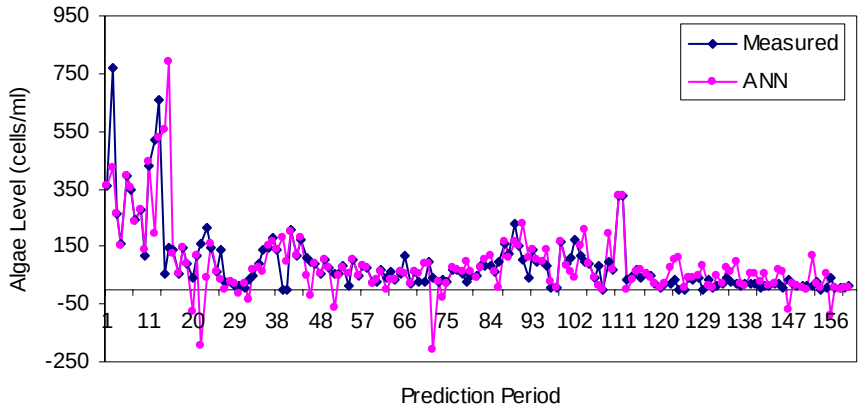

Figure 2.20. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total algal counts

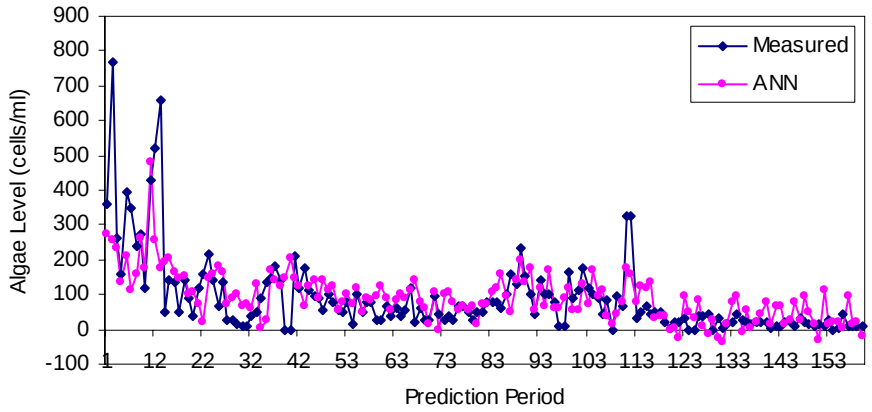

Figure 2.21. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding Passaic river extractions

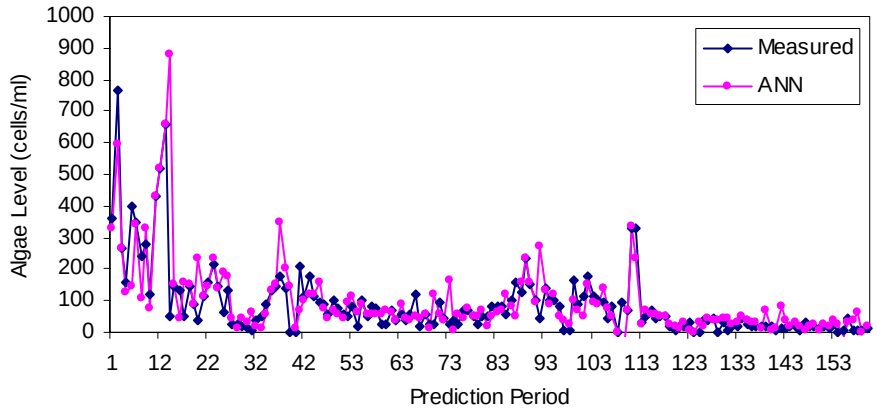

Figure 2.21. Station 100 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding sky cover

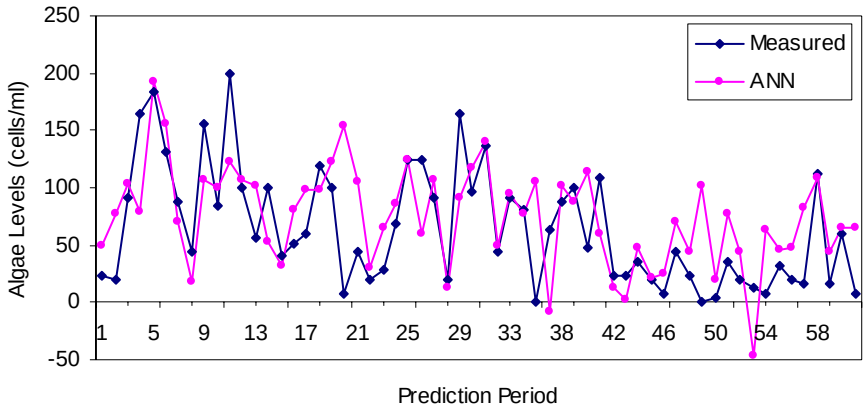

Figure 2.22. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs

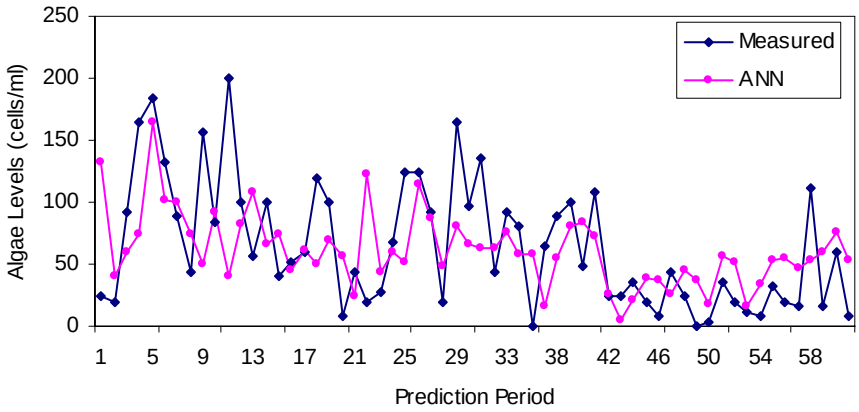

Figure 2.23. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding total amorphous materials

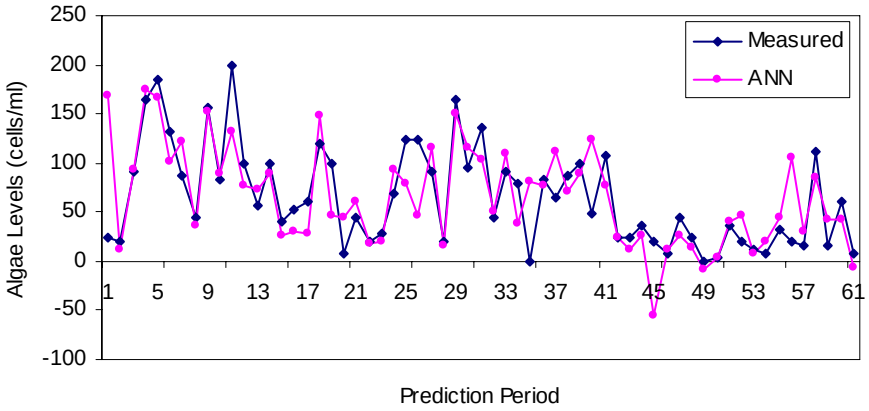

Figure 2.24. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding initial chrysophytes counts

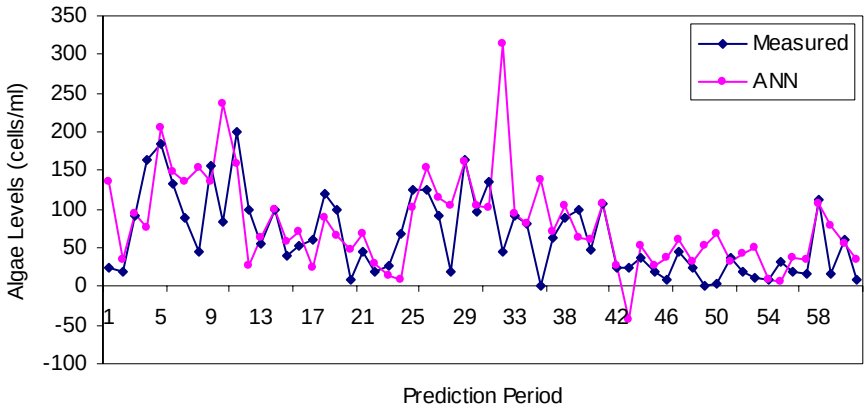

Figure 2.25. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding Pompton streamflow

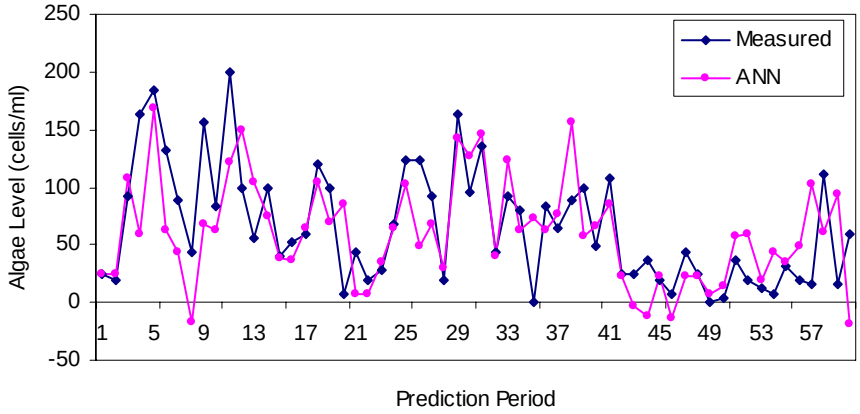

Figure 2.26. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding total hardness

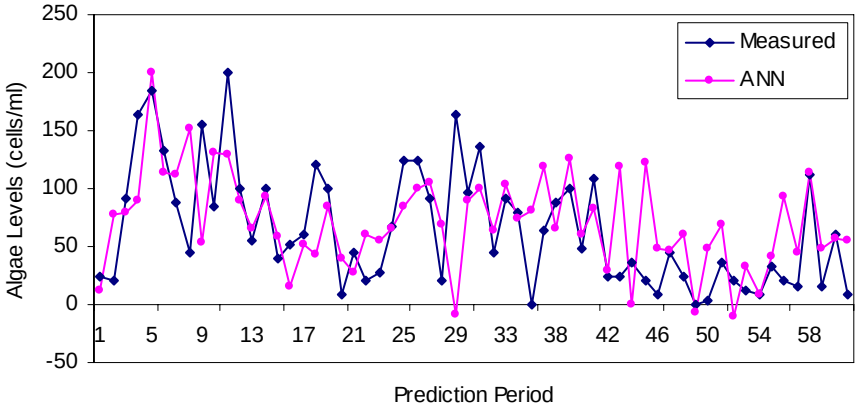

Figure 2.27. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding nitrite/nitrate

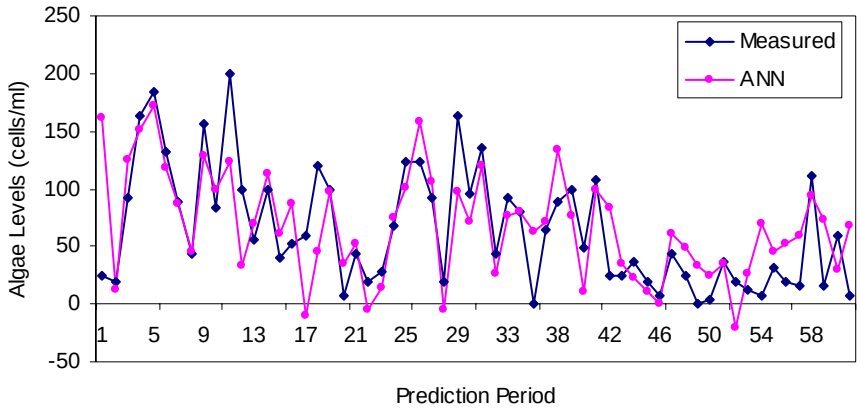

Figure 2.28. Station 101 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding extractions from JAPS

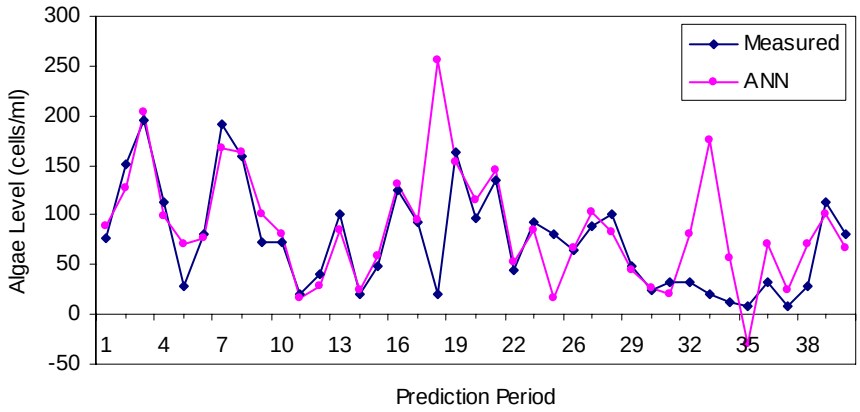

Figure 2.29. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs

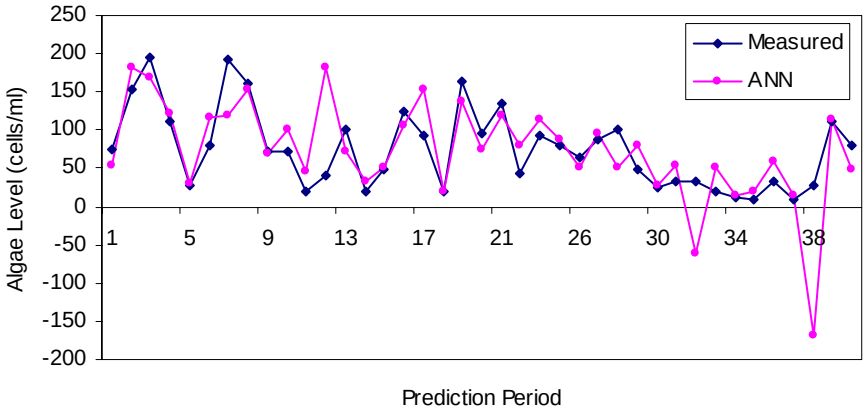

Figure 2.30. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total amorphous materials

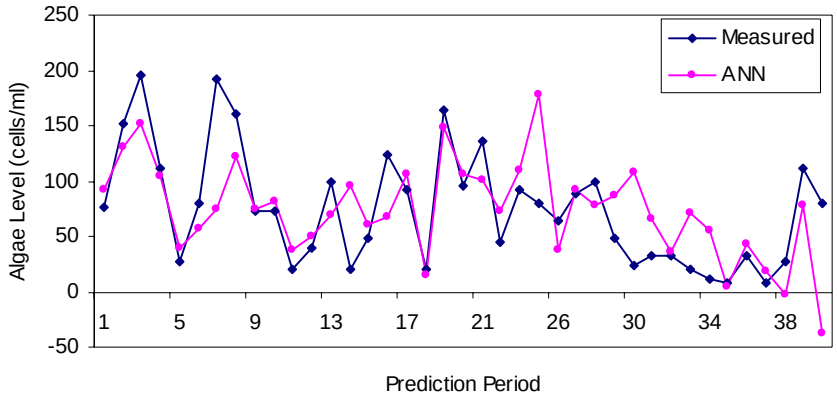

Figure 2.31. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding current week's precipitation

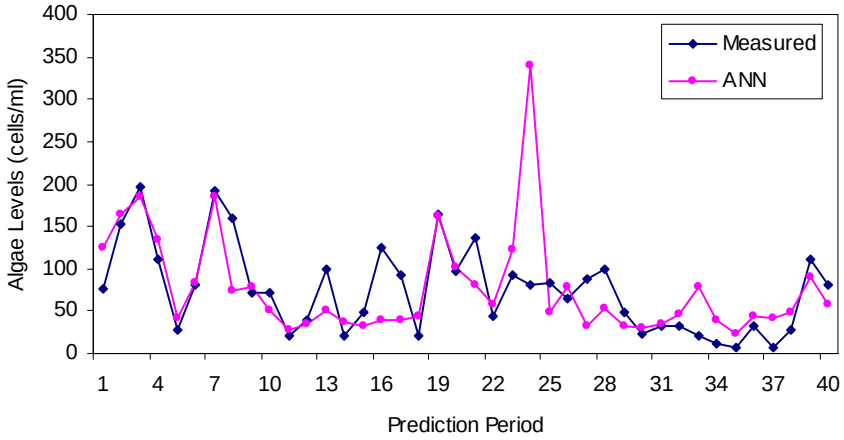

Figure 2.32. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

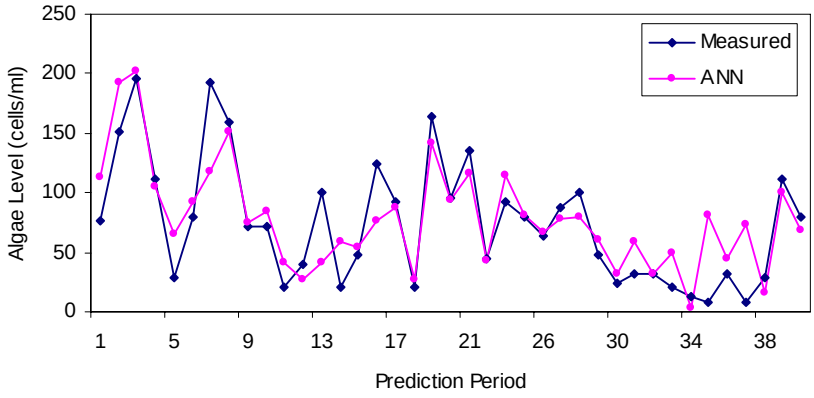

Figure 2.33. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding temperature

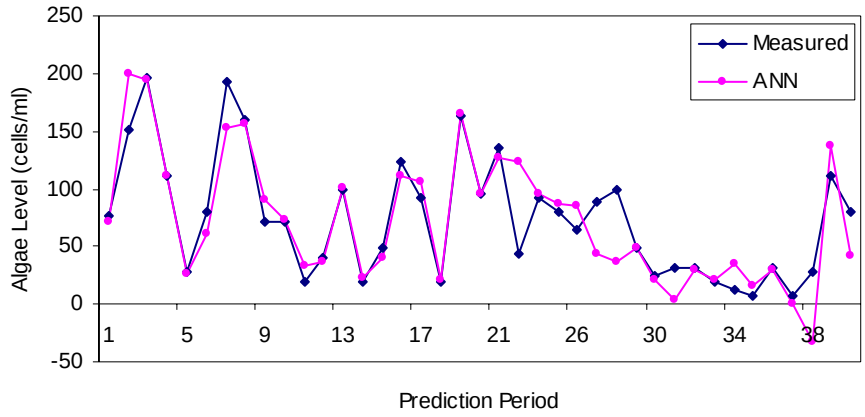

Figure 2.34. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding color

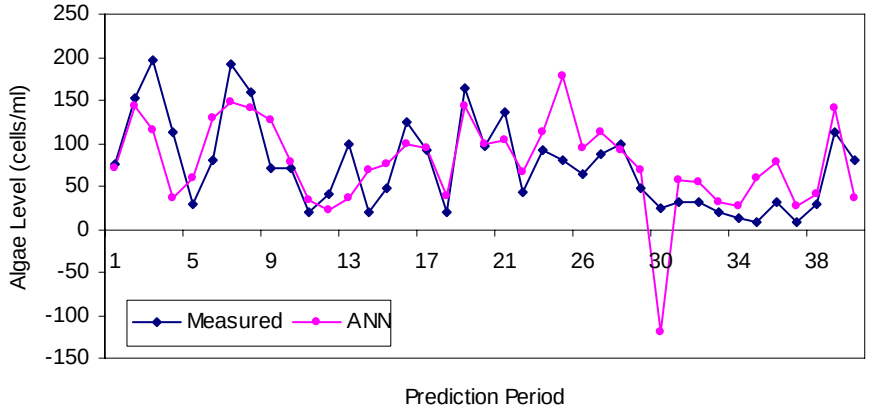

Figure 2.35. Station 101 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding extractions from JAPS

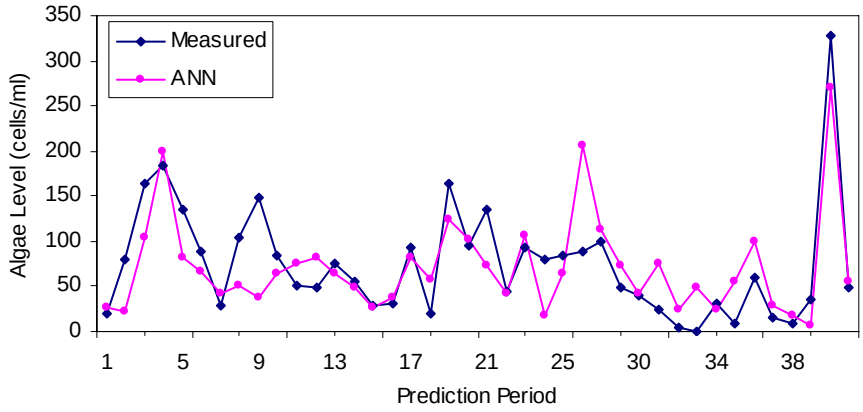

Figure 2.36. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs

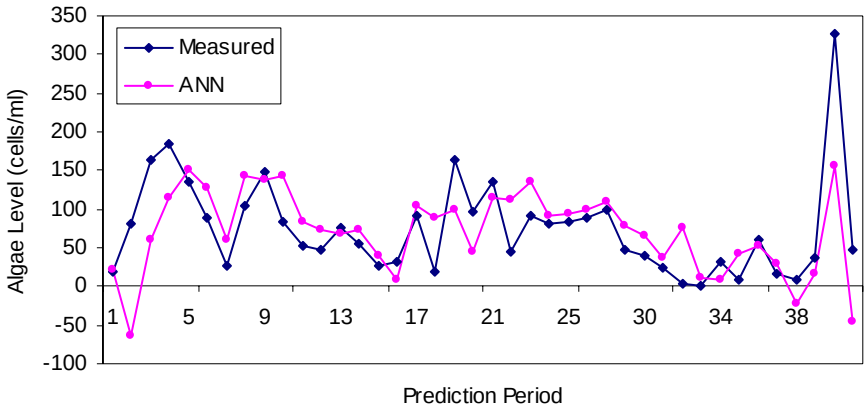

Figure 2.37. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total amorphous materials

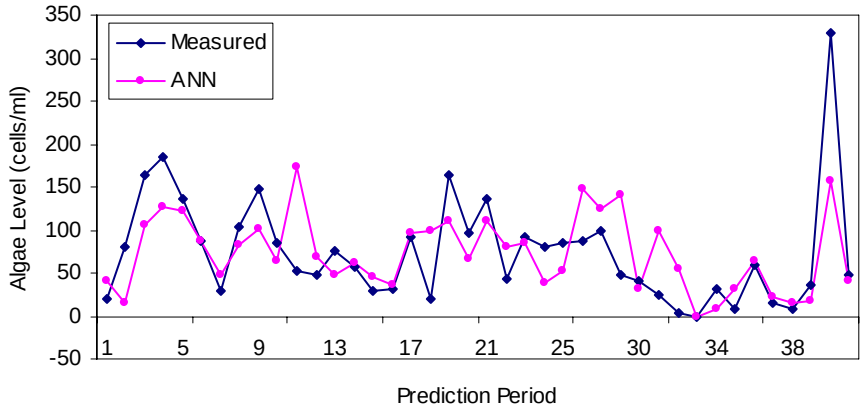

Figure 2.38. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding odor current week's precipitation

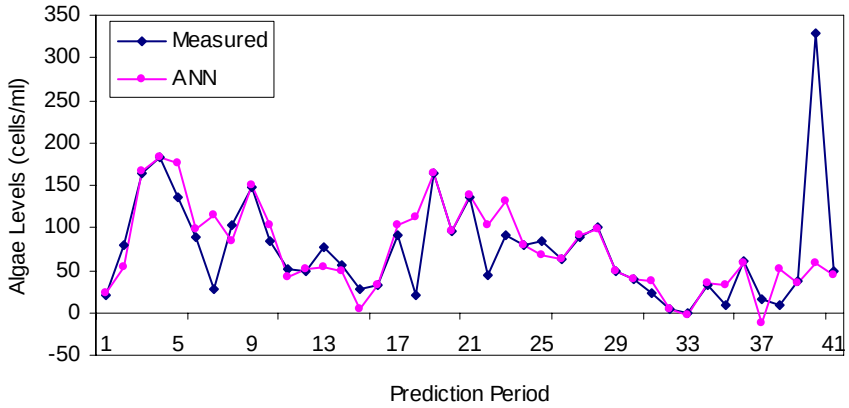

Figure 2.39. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding alkalinity

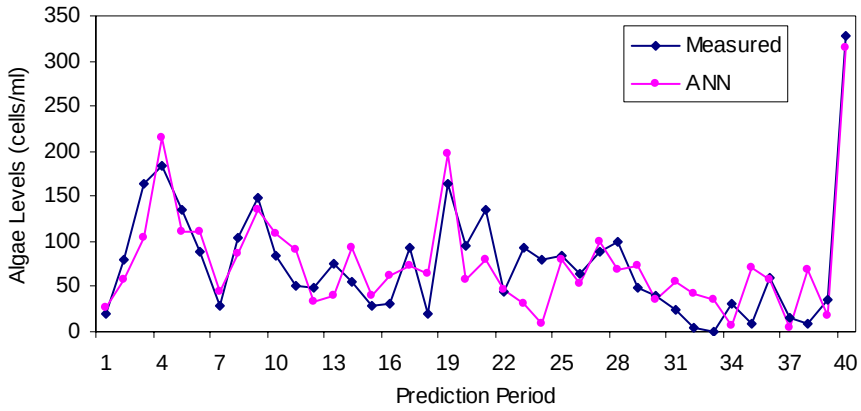

Figure 2.40. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding ammonia

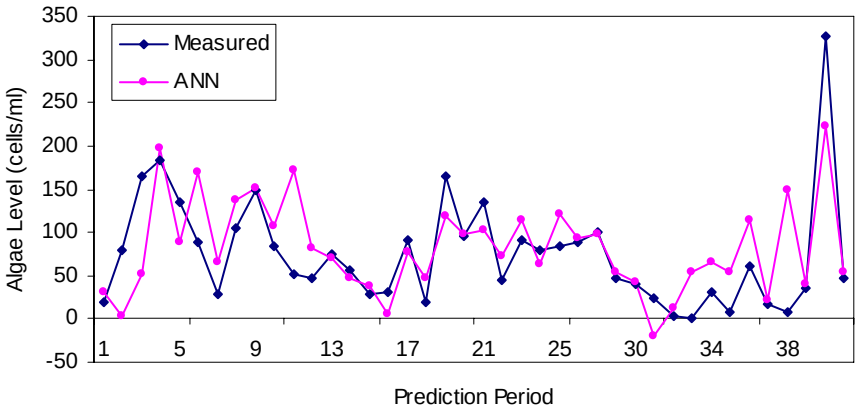

Figure 2.41. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding Passaic river extractions

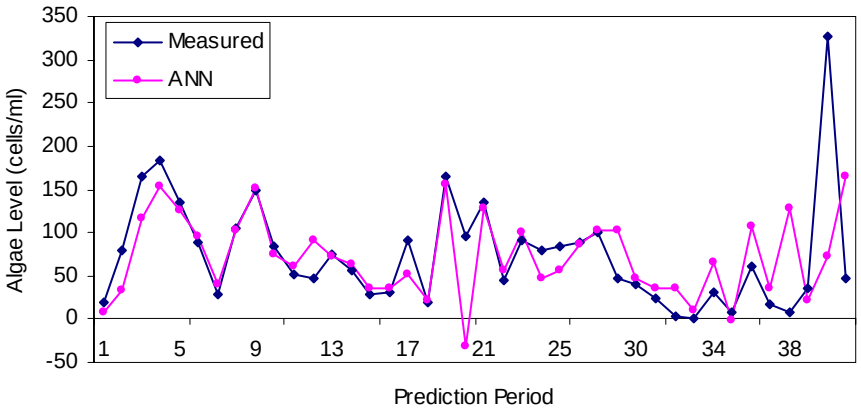

Figure 2.42. Station 101 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding heating degree days

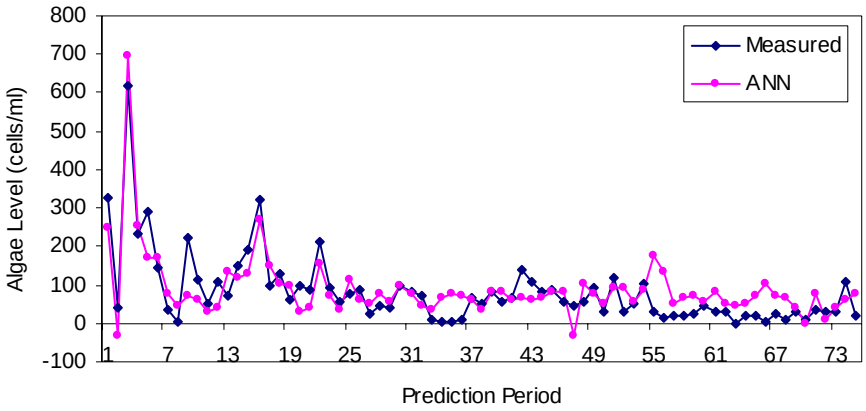

Figure 2.43. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs

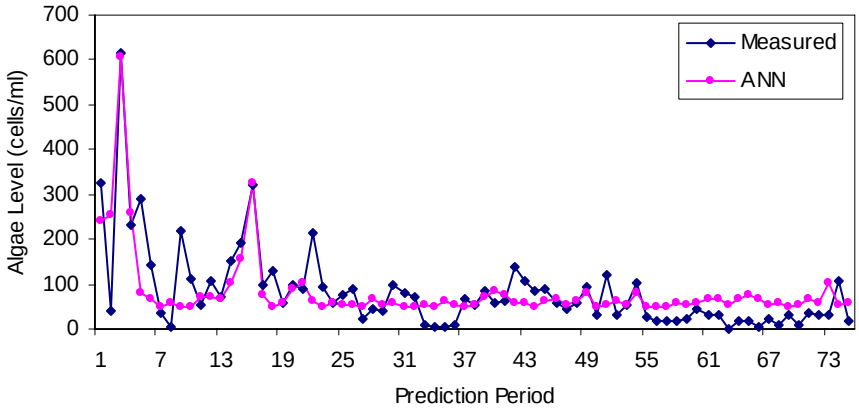

Figure 2.44. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding total amorphous materials

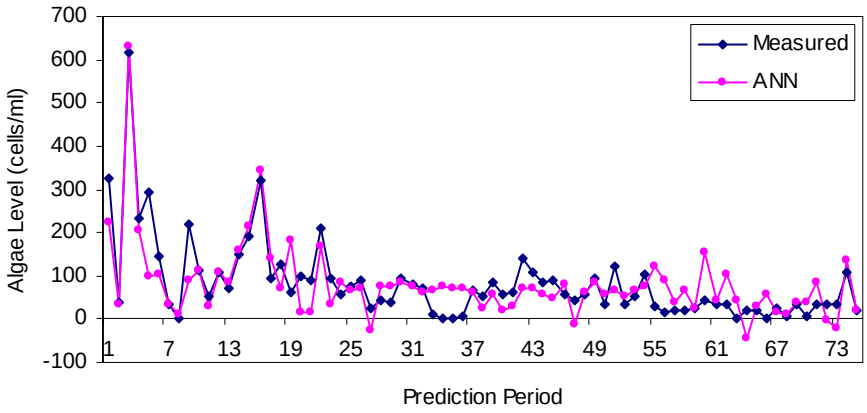

Figure 2.45. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding odor

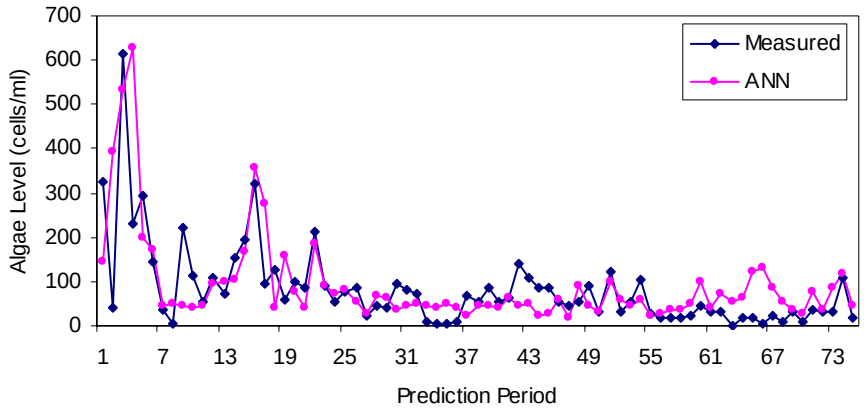

Figure 2.46. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding Pompton river extractions

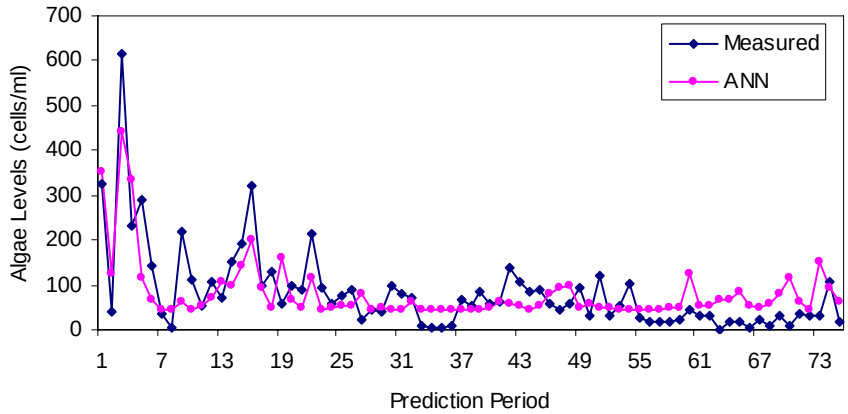

Figure 2.47. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding UV254

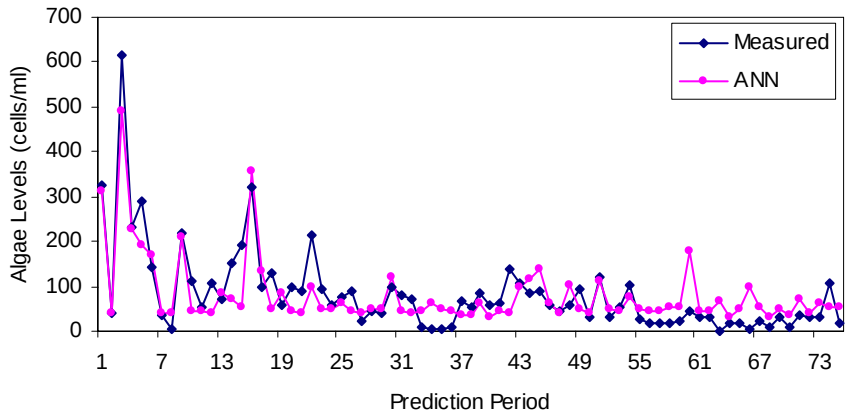

Figure 2.48. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding initial chrysophytes counts

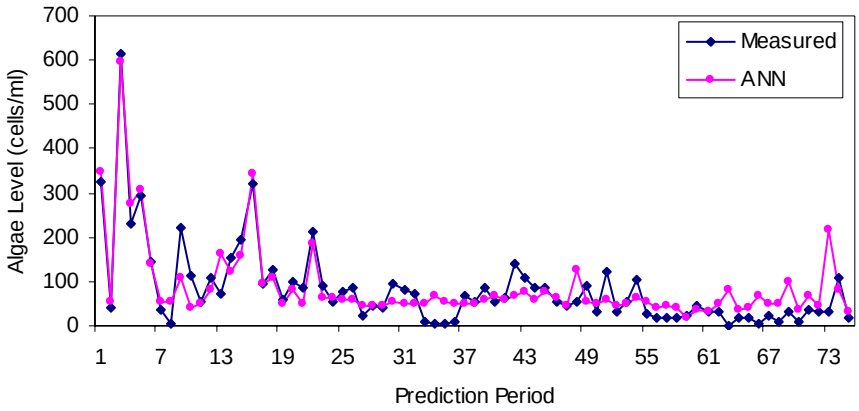

Figure 2.49. Station 612 time-series plots of measured chrysophytes counts against ANN real-time predicted values using all variable inputs excluding initial chlorophytes counts

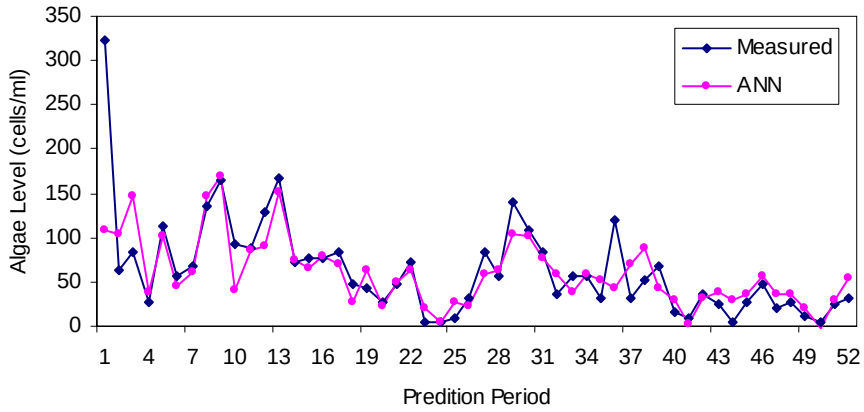

Figure 2.50. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs

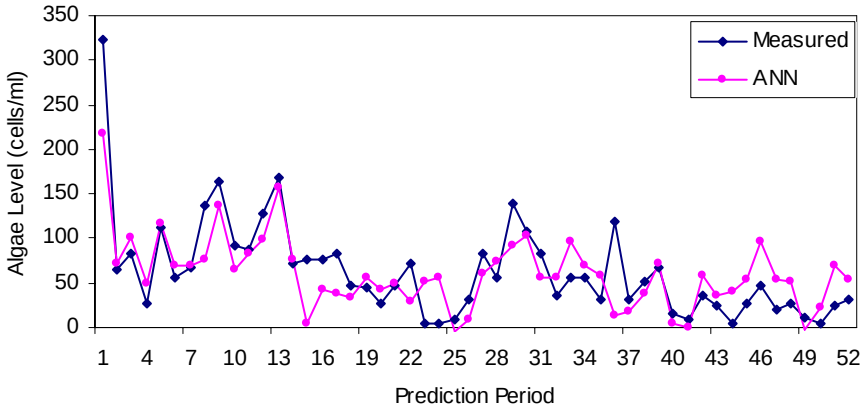

Figure 2.51. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

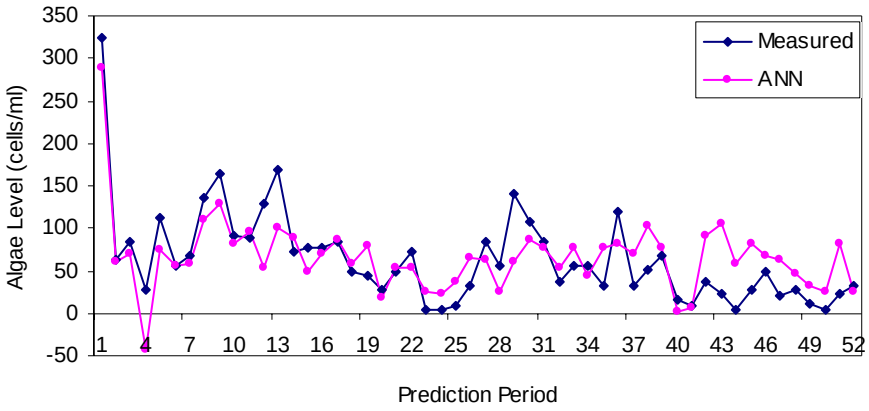

Figure 2.52. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total algal counts

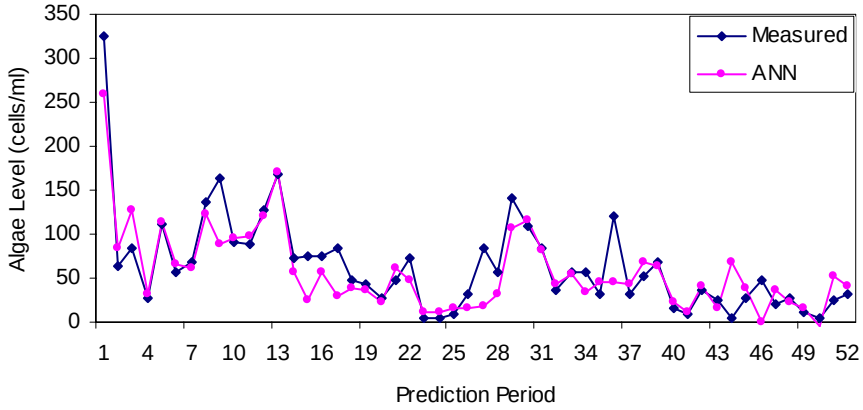

Figure 2.53. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding Passaic river extractions

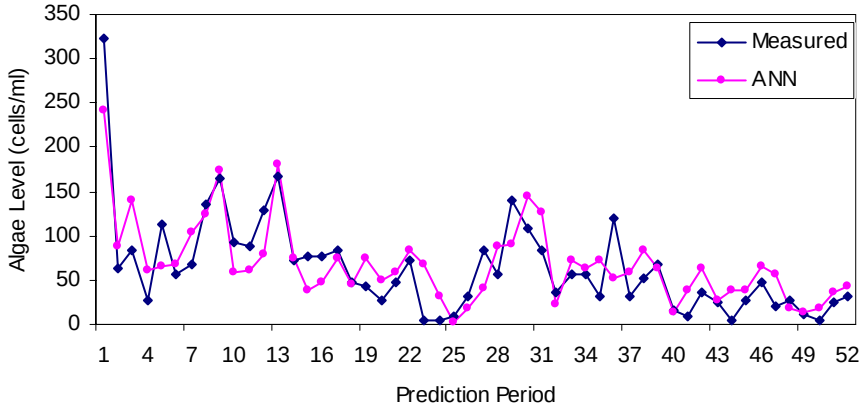

Figure 2.54. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding Pompton river extractions

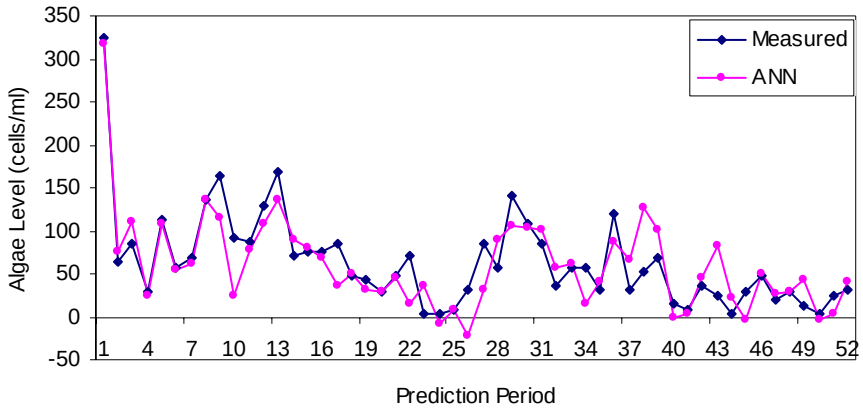

Figure 2.55. Station 612 time-series plots of measured chrysophytes counts against ANN one-week ahead predicted values using all variable inputs excluding ammonia

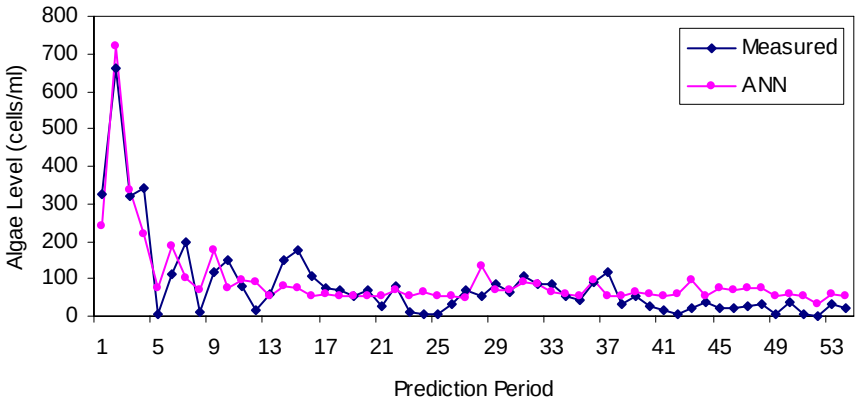

Figure 2.56. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs

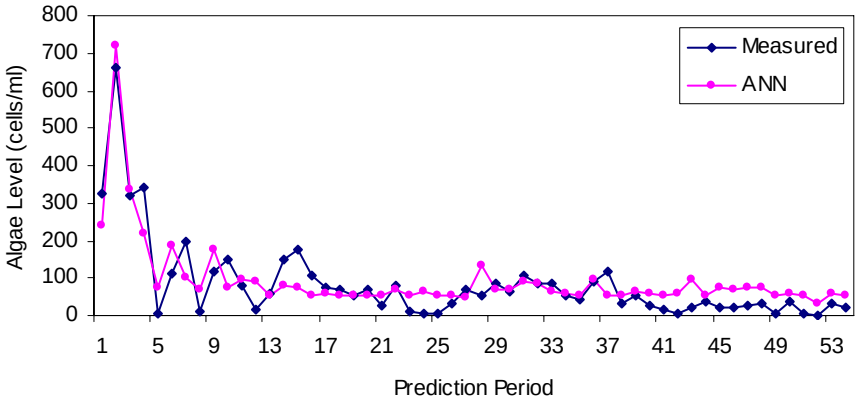

Figure 2.57. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding Pompton river extractions

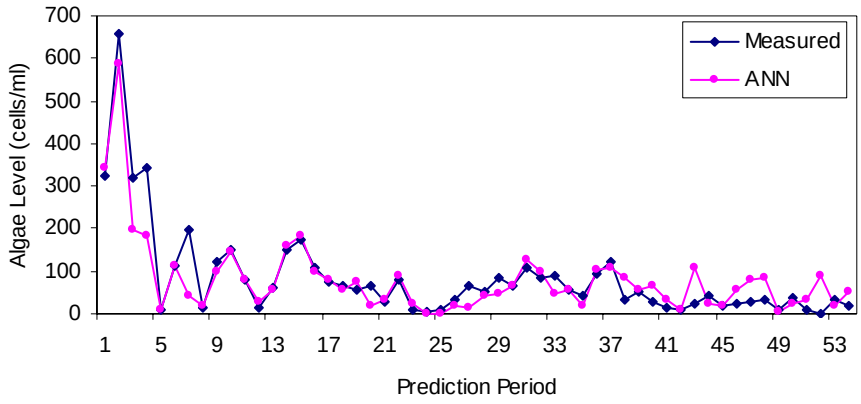

Figure 2.58. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding turbidity

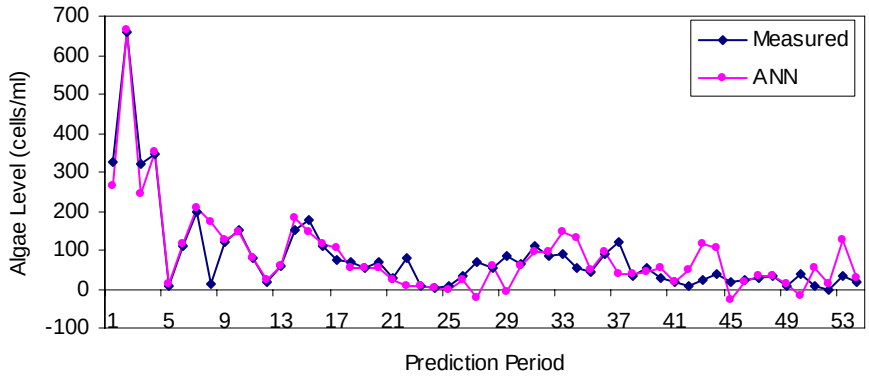

Figure 2.59. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding sulfate

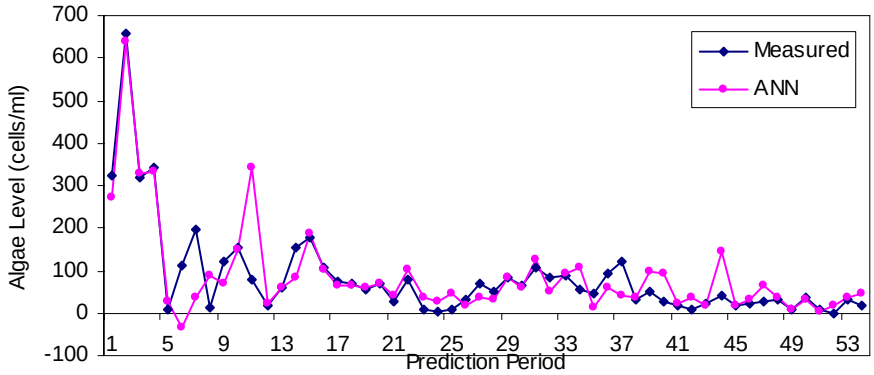

Figure 2.60. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding ammonia

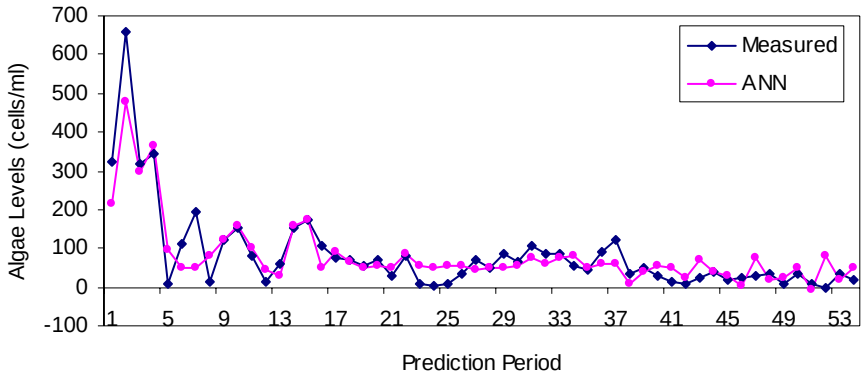

Figure 2.61. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total algal counts

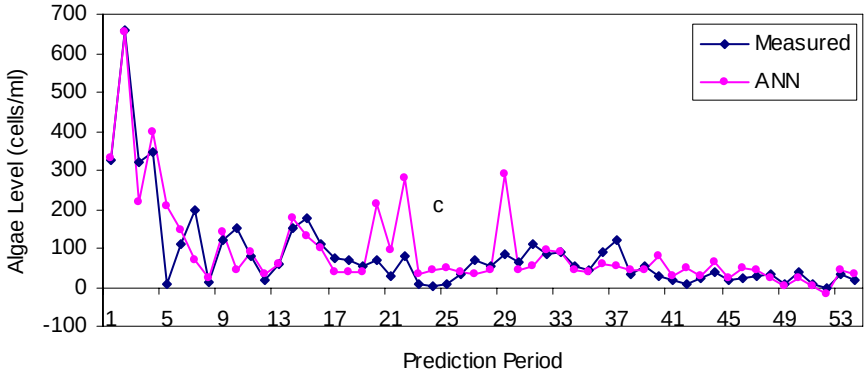

Figure 2.62. Station 612 time-series plots of measured chrysophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total amorphous materials

3. CHLOROPHYTA

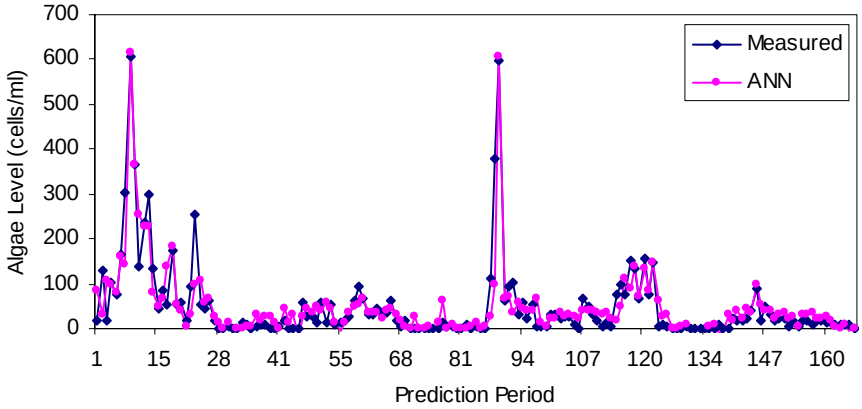

Figure 3.1. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs

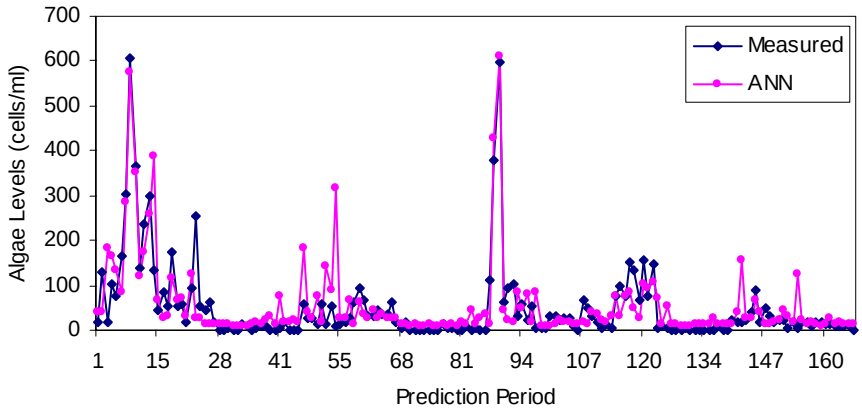

Figure 3.2. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding initial chlorophytes counts

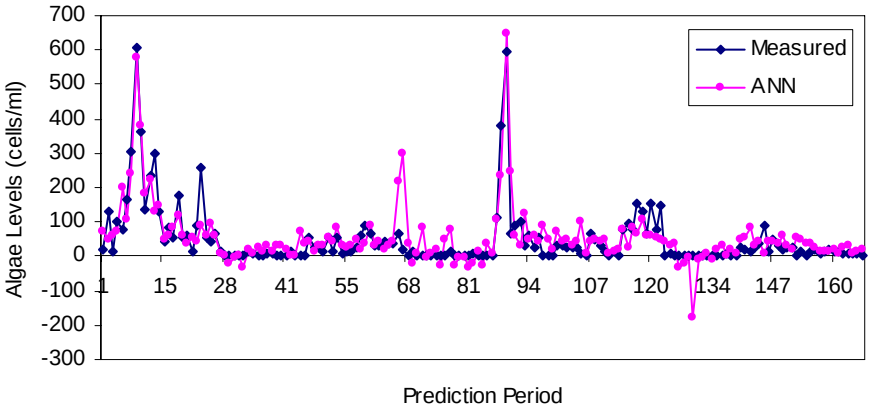

Figure 3.3. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding total hardness

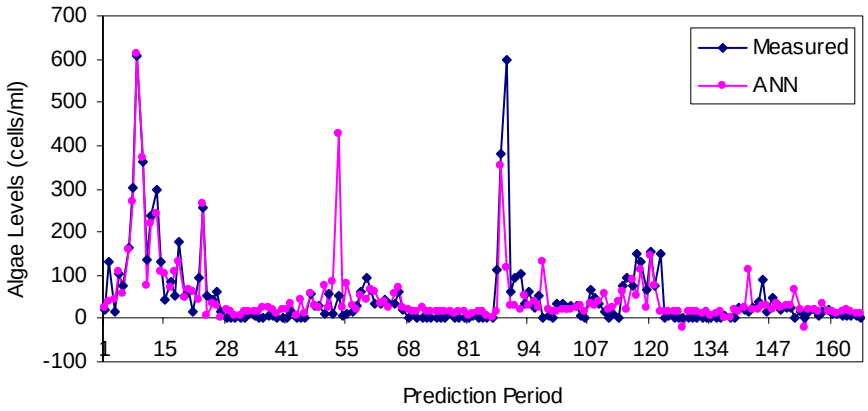

Figure 3.4. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding total algal counts

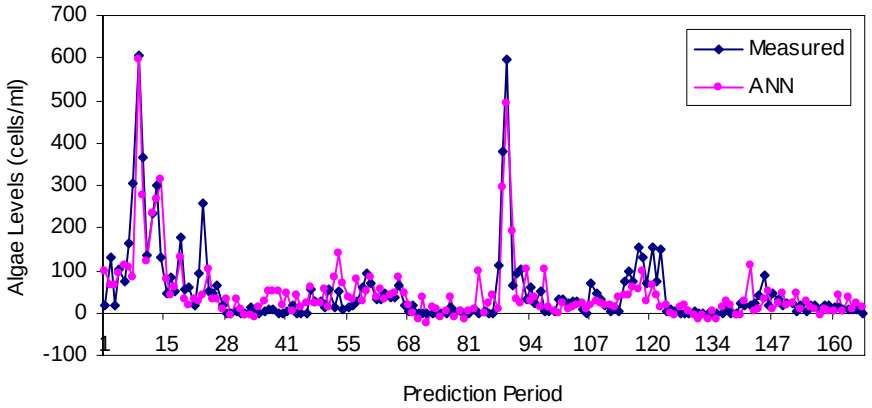

Figure 3.5. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding total organic carbon (TOC)

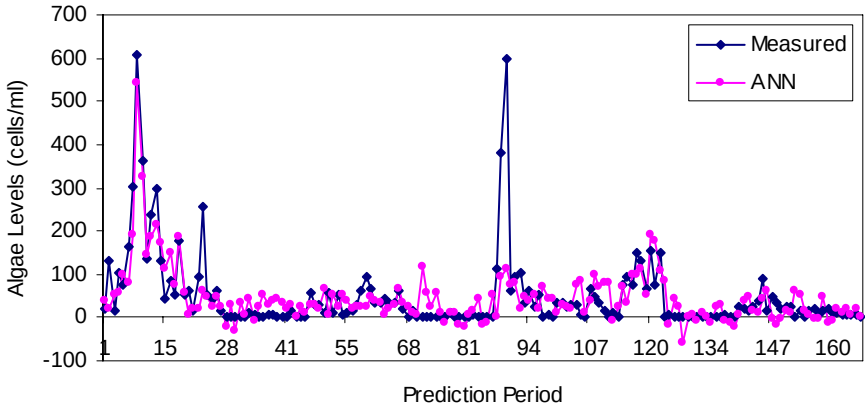

Figure 3.6. Station 100 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding biochemical oxygen demand (BOD)

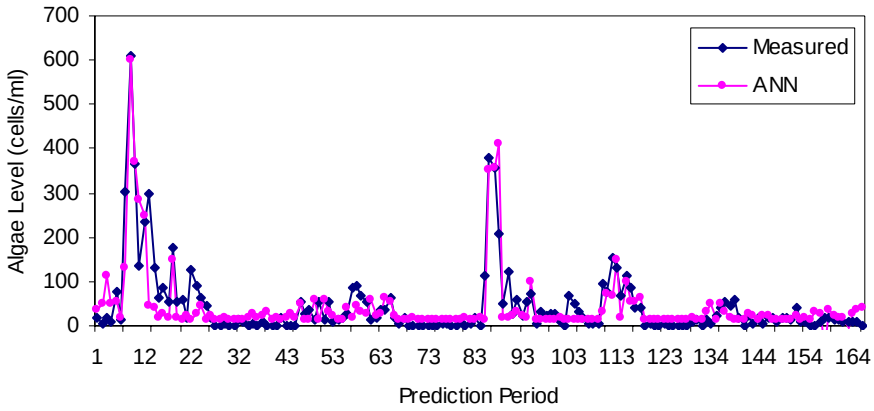

Figure 3.7. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs

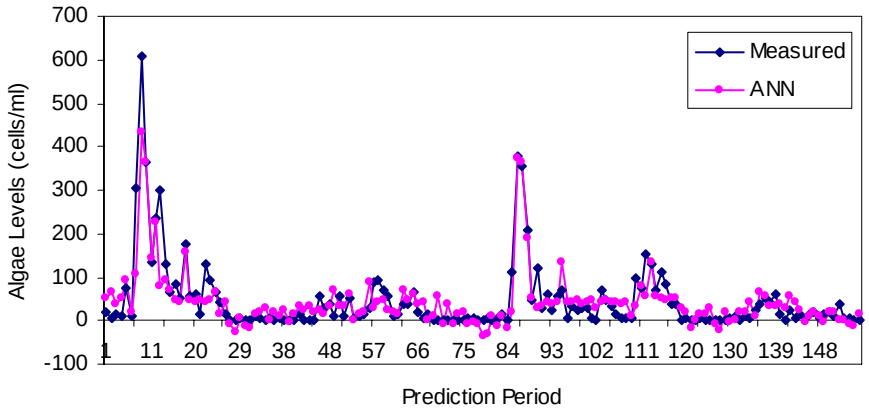

Figure 3.8. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chlorophytes counts

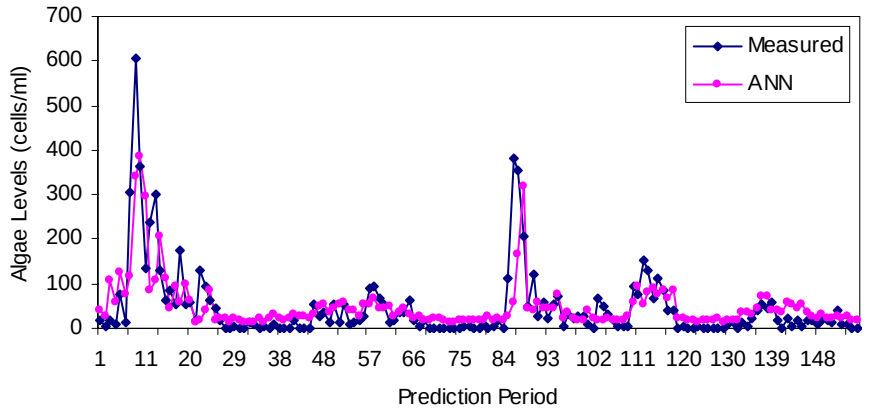

Figure 3.9. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total algal counts

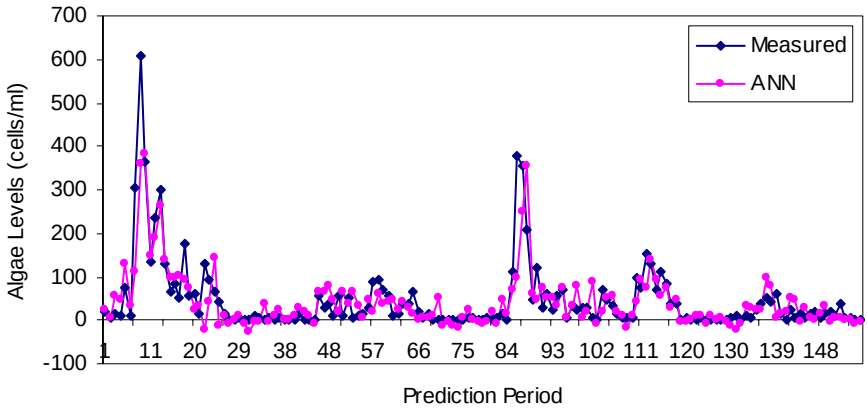

Figure 3.10. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding temperature

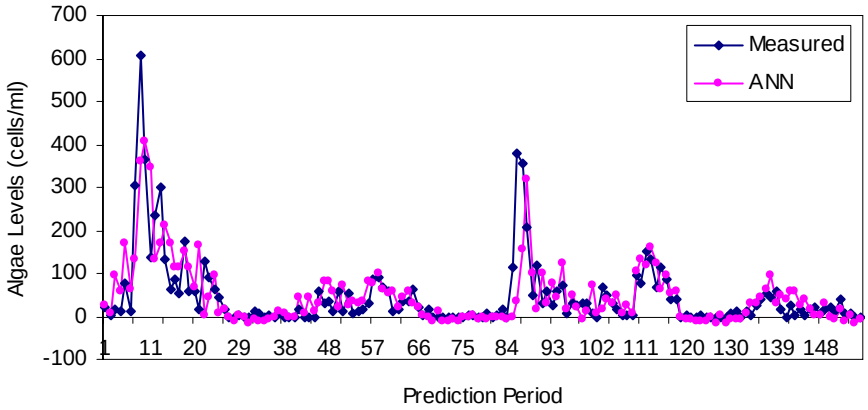

Figure 3.11. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding turbidity

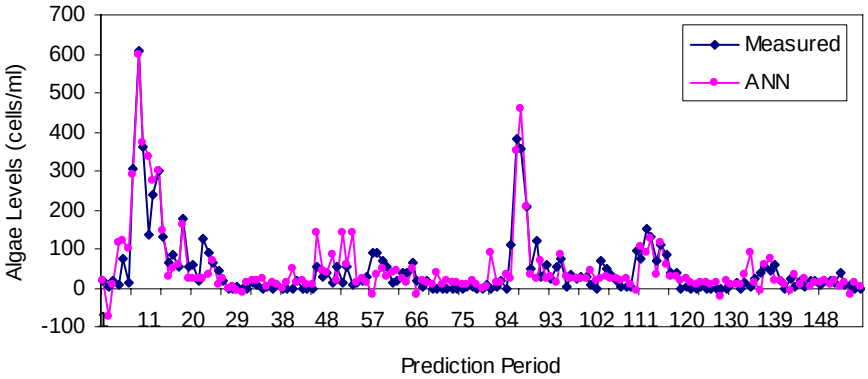

Figure 3.12. Station 100 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding biochemical oxygen demand (BOD)

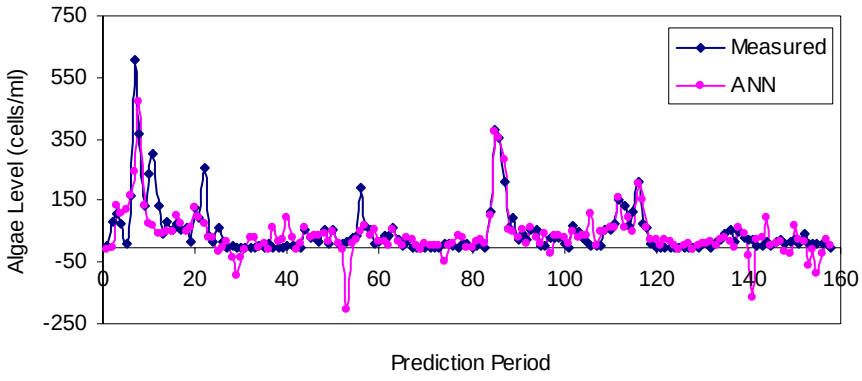

Figure 3.13. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs

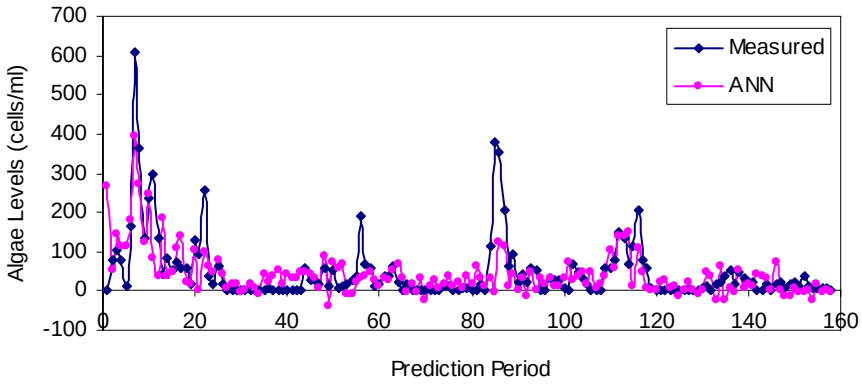

Figure 3.14. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding Pompton river extractions

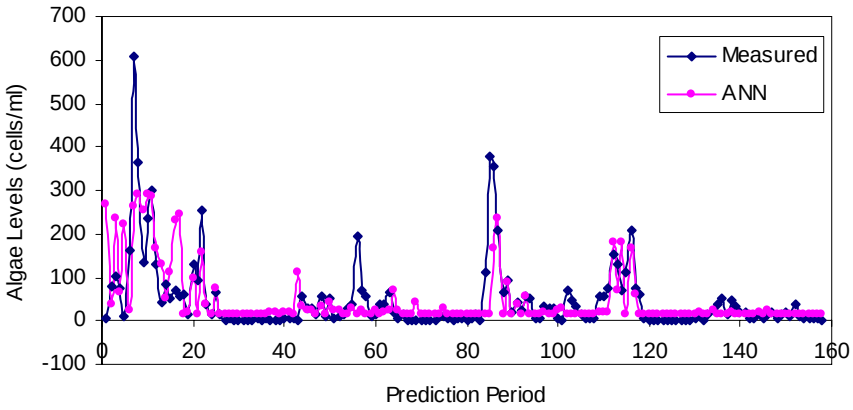

Figure 3.15. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total suspended solids (TSS)

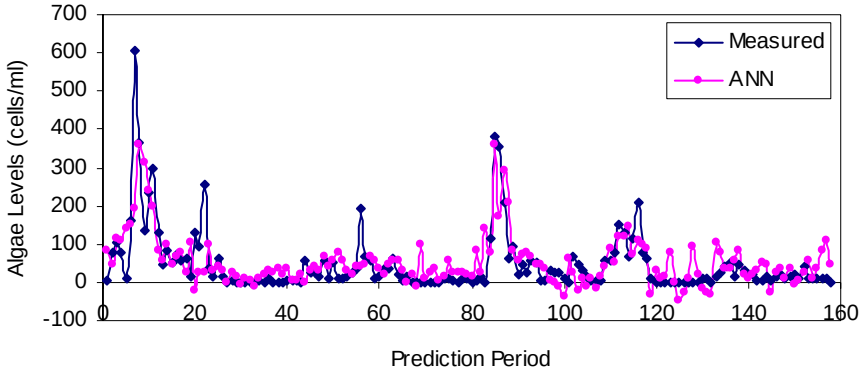

Figure 3.16. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding wind direction

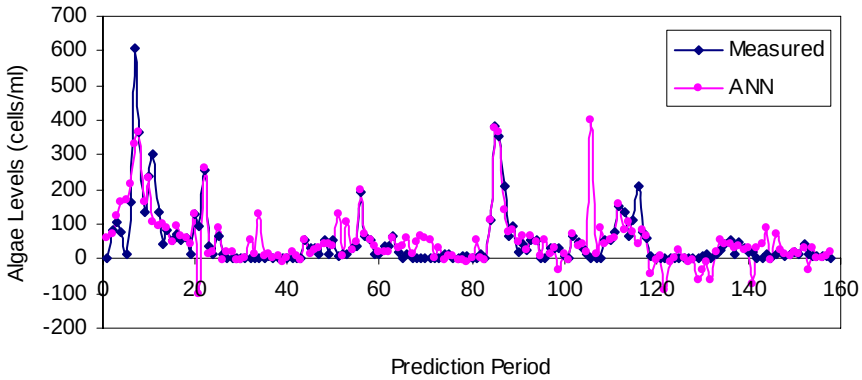

Figure 3.17. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding UV254

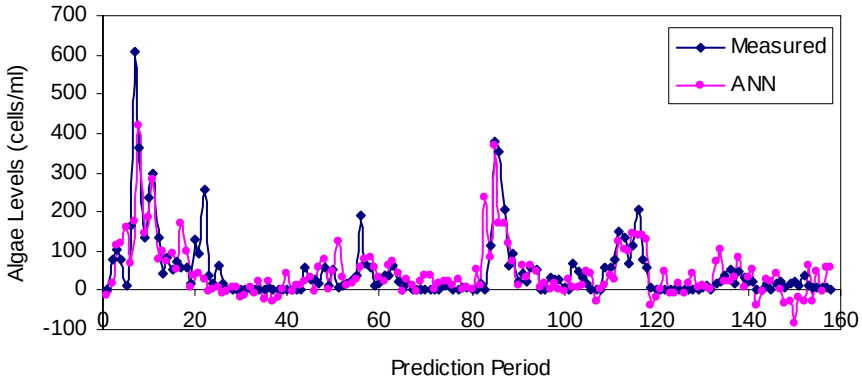

Figure 3.18. Station 100 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding biochemical oxygen demand (BOD)

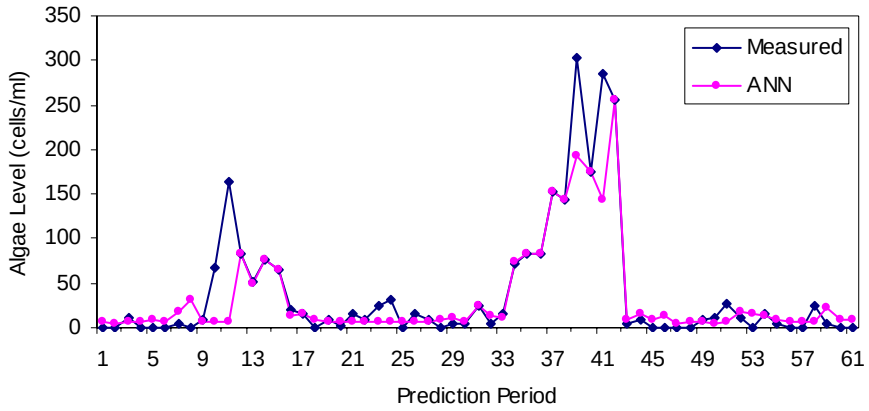

Figure 3.19. Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs

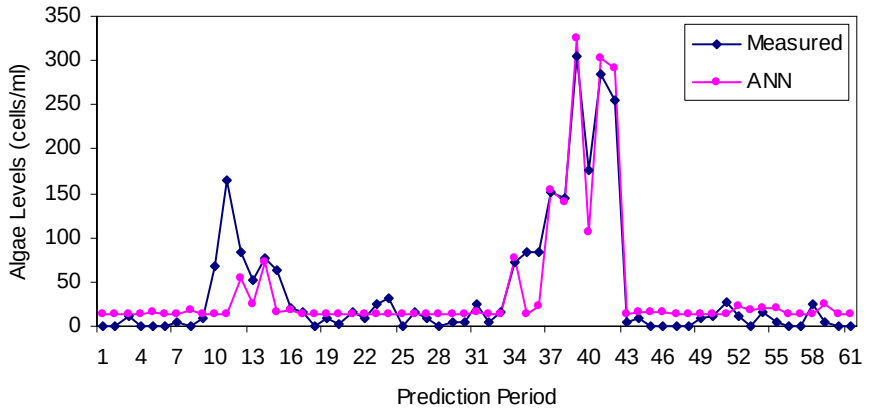

Figure 3.20. Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs initial chlorophytes counts

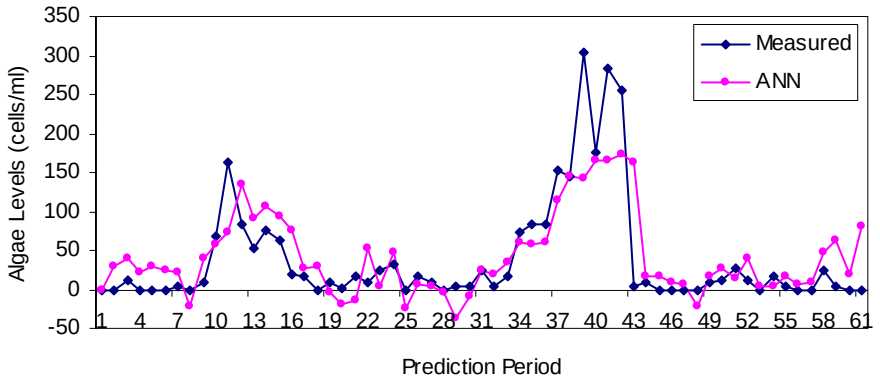

Figure 3.21. Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding heating degree days

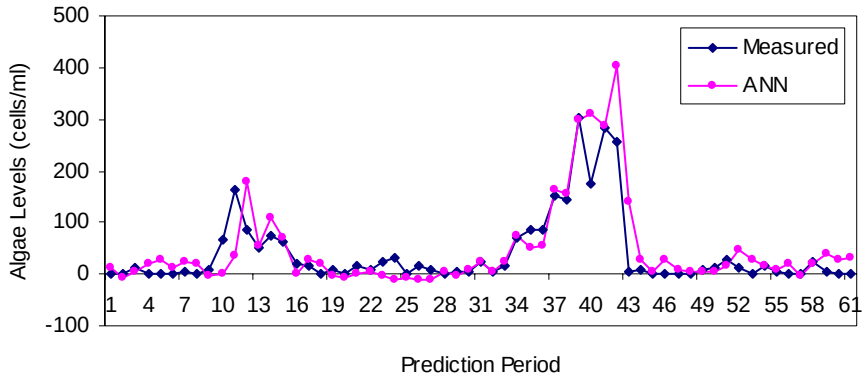

Figure 3.22. Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding total algal counts

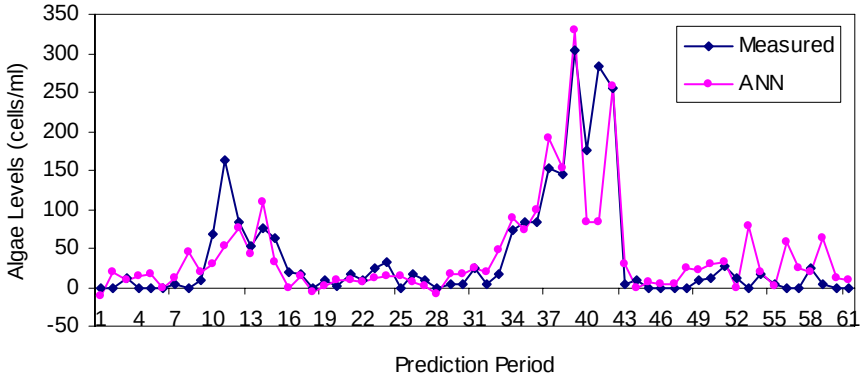

Figure 3.23 Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding sulfate

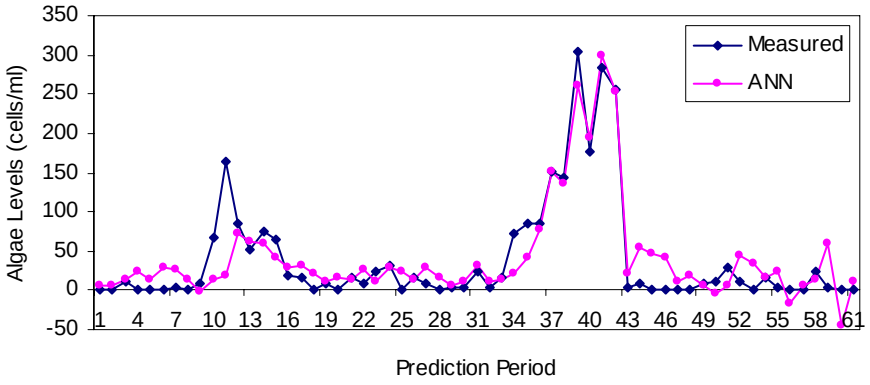

Figure 3.24. Station 101 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding conductivity

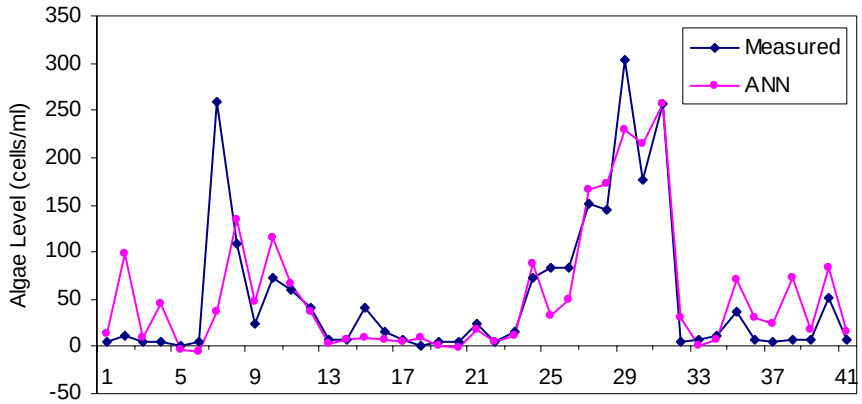

Figure 3.25. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs

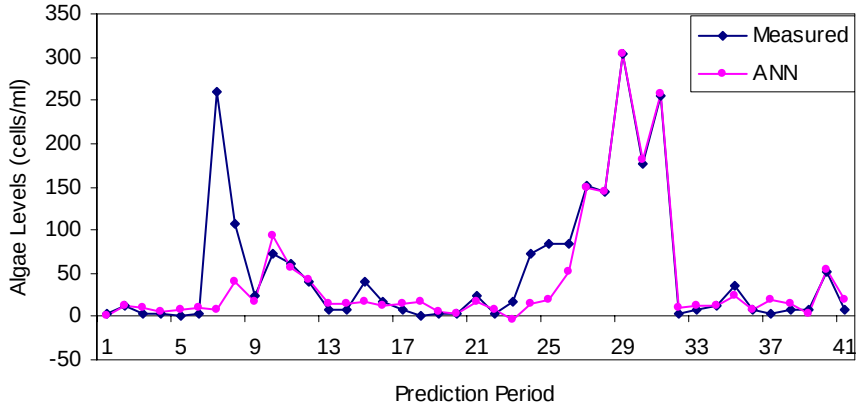

Figure 3.26. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chlorophytes counts

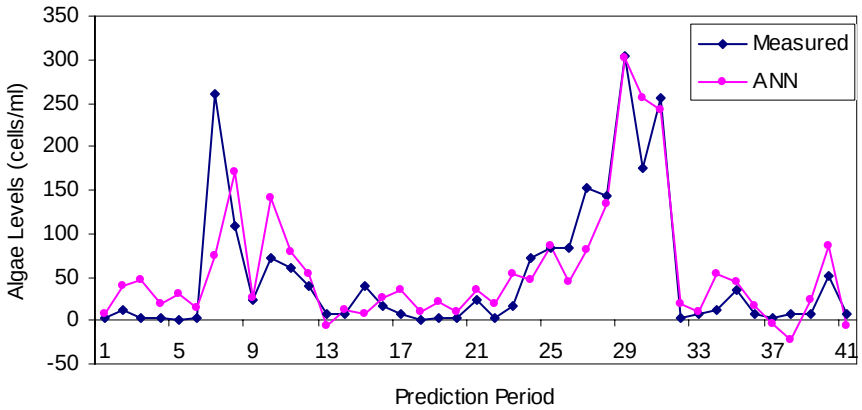

Figure 3.27. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial cyanobacteria counts

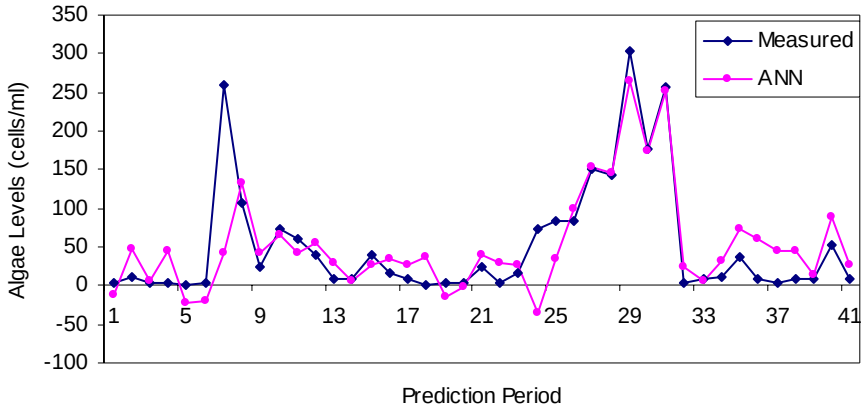

Figure 3.28. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding pH

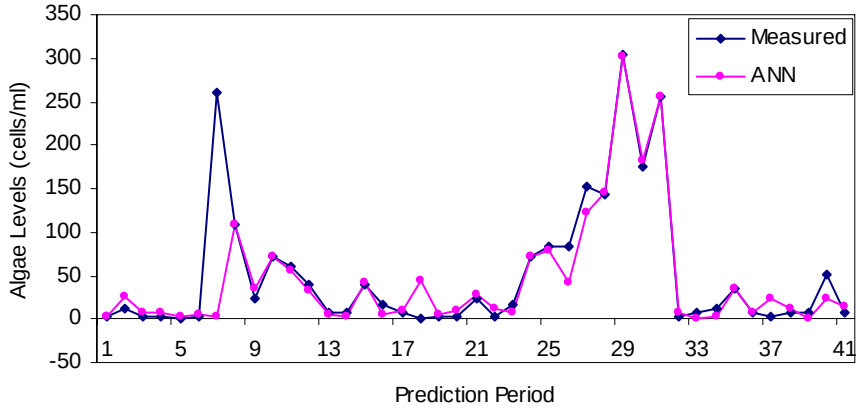

Figure 3.29. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding wind speed

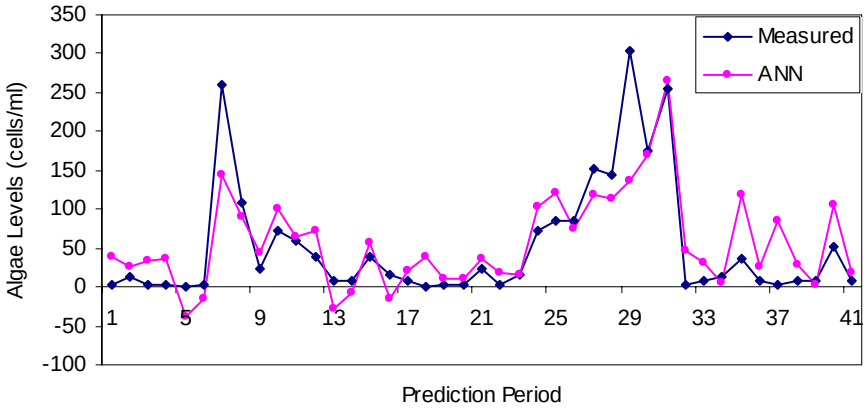

Figure 3.30. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding chloride

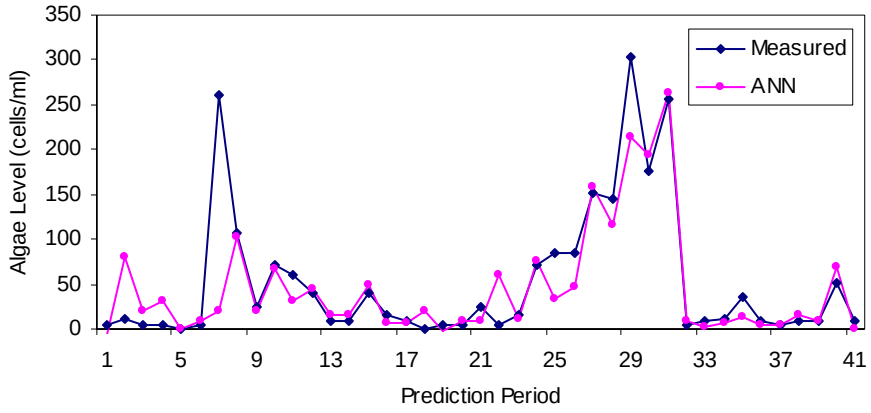

Figure 3.31. Station 101 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding odor

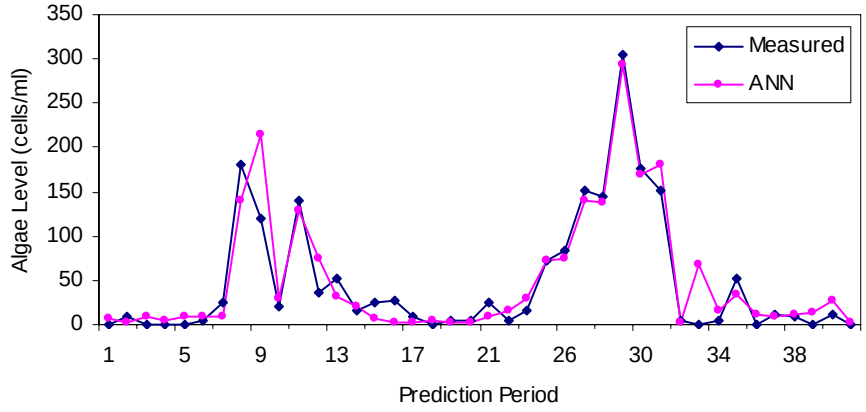

Figure 3.32. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs

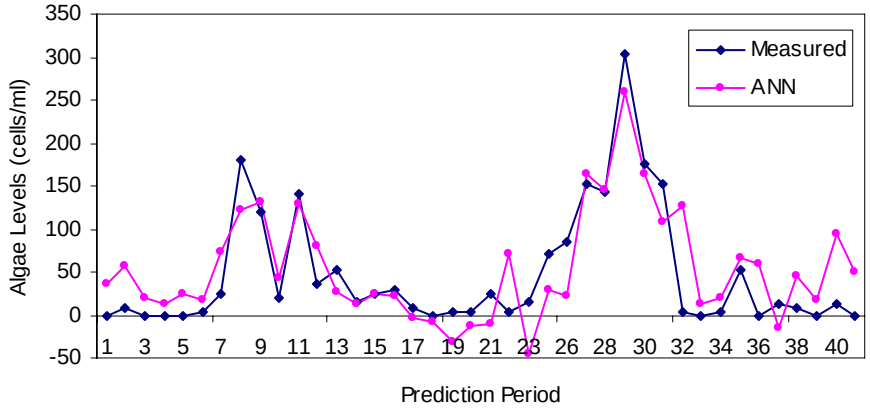

Figure 3.33. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding extractions from Point View Reservoir

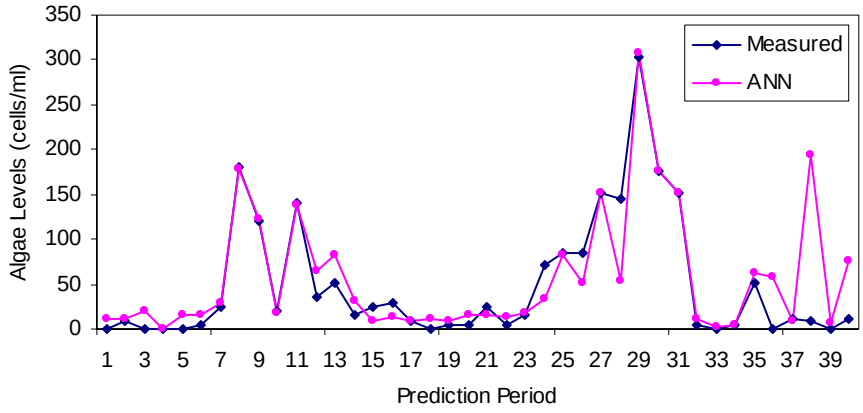

Figure 3.34. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding initial chlorophytes counts

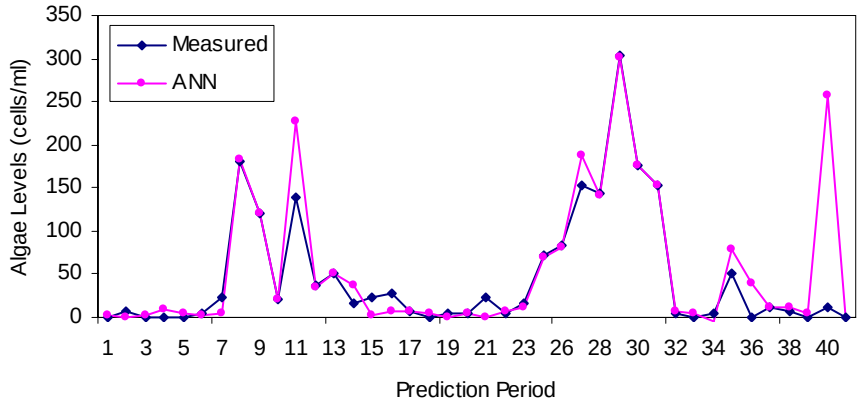

Figure 3.35. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding conductivity

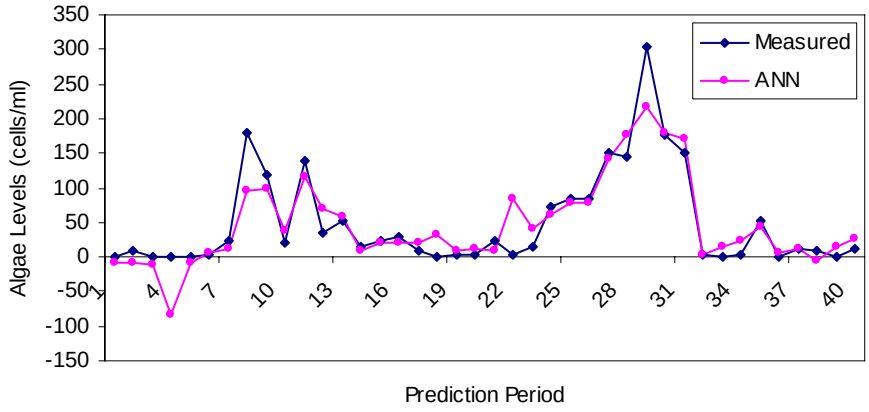

Figure 3.36. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding color

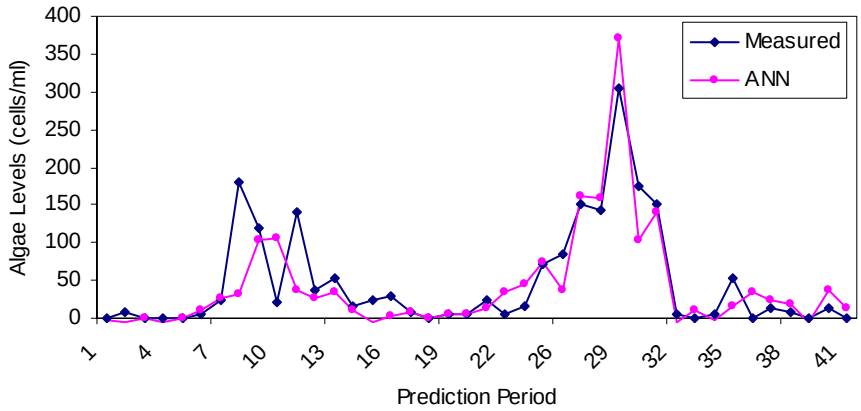

Figure 3.37. Station 101 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total hardness

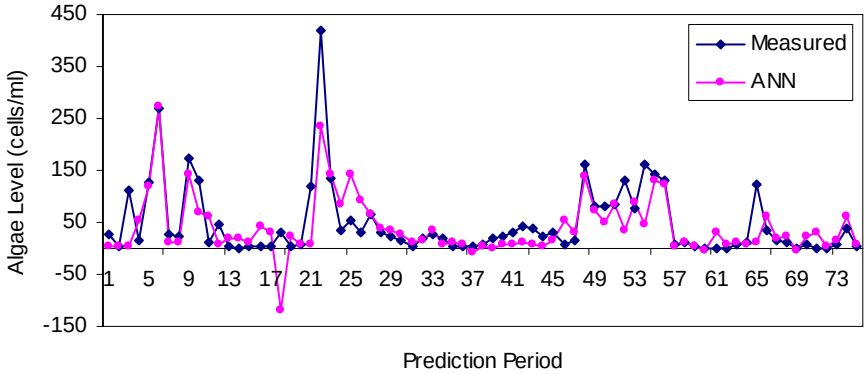

Figure 3.38. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs

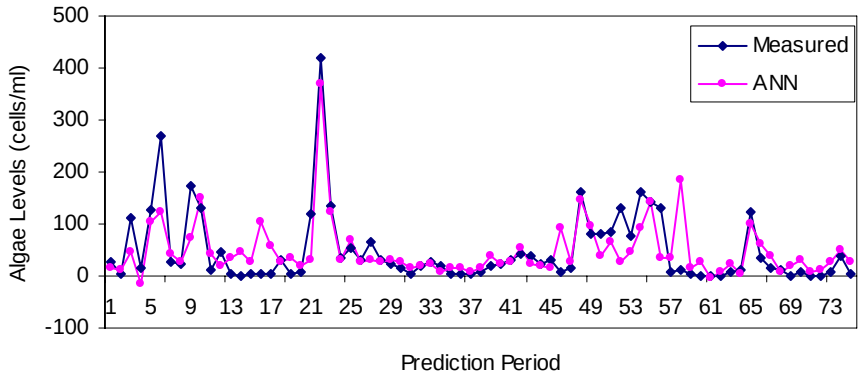

Figure 3.39. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding total algal counts

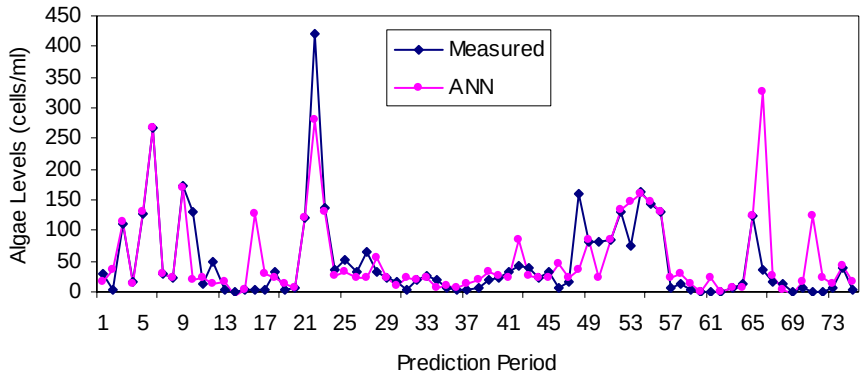

Figure 3.40. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding chloride

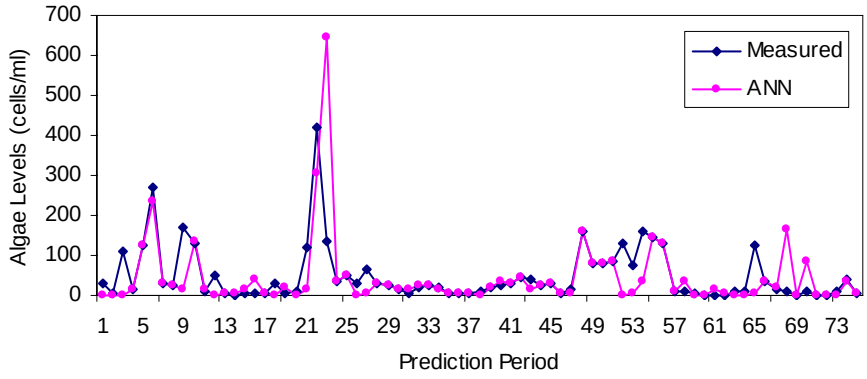

Figure 3.41. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding sky cover

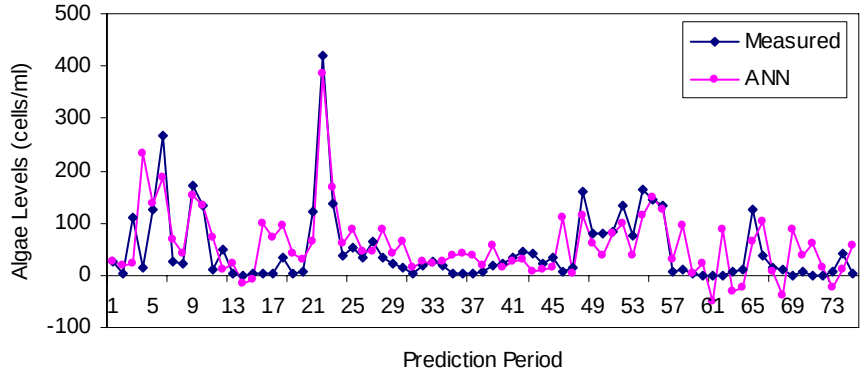

Figure 3.42. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding Pompton streamflow

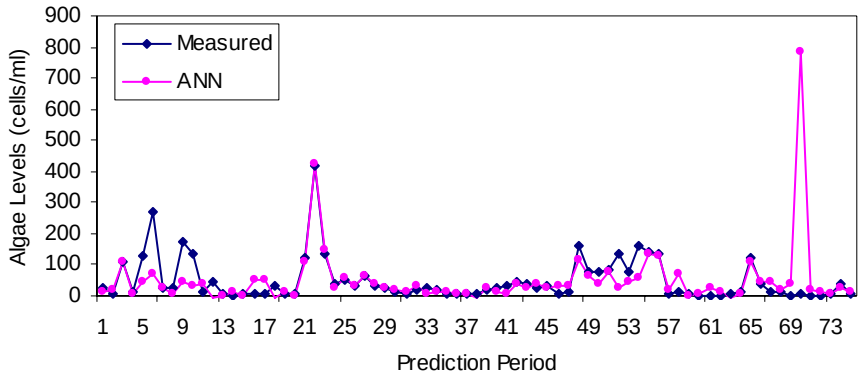

Figure 3.43. Station 612 time-series plots of measured chlorophytes counts against ANN real-time predicted values using all variable inputs excluding heating degree days

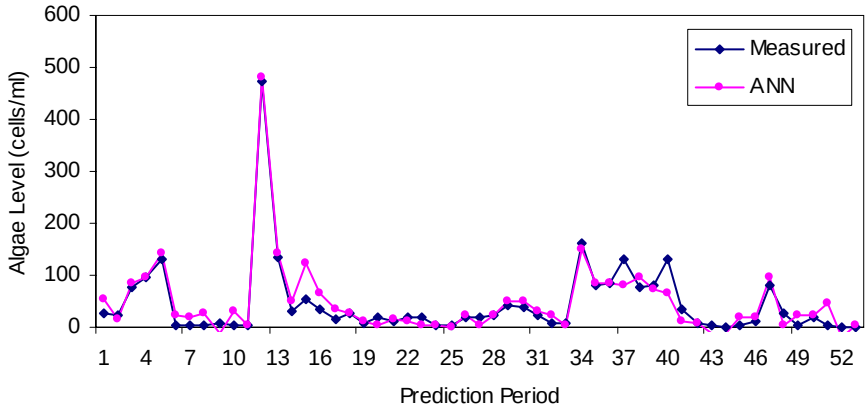

Figure 3.44. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs

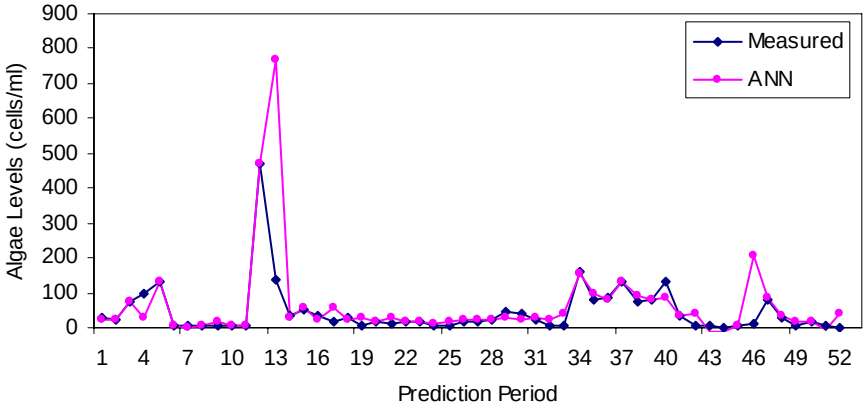

Figure 3.45. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total algal counts

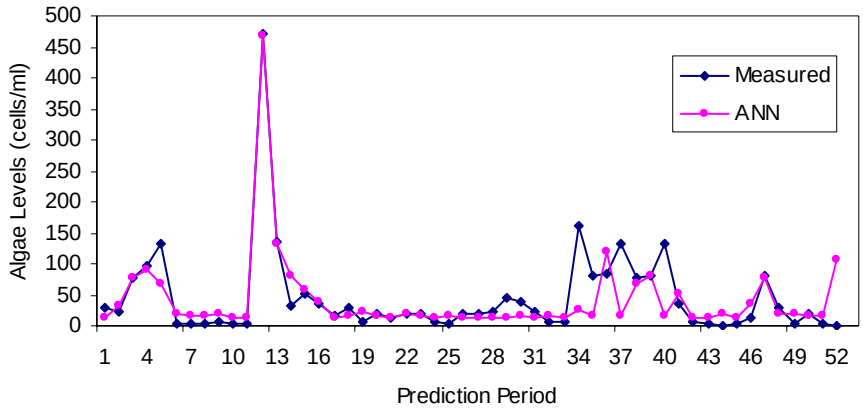

Figure 3.46. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chlorophytes counts

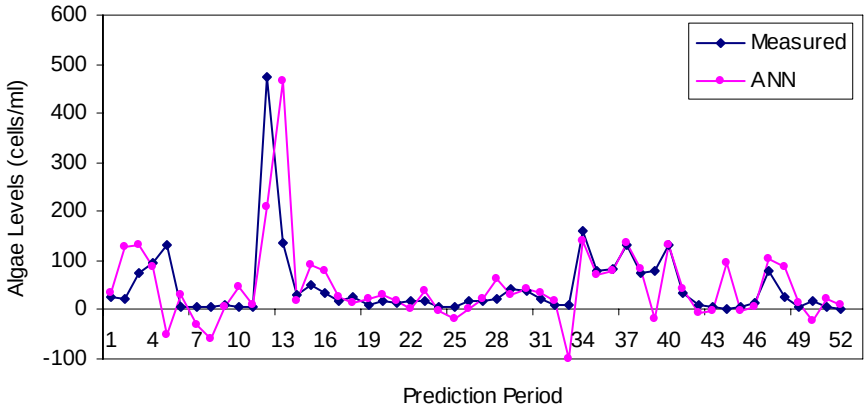

Figure 3.47. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding initial chrysophytes counts

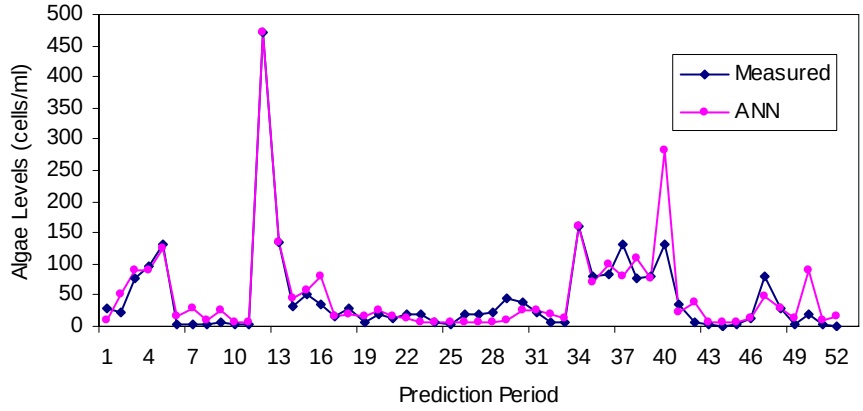

Figure 3.48. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding total phosphorus/orthophosphates

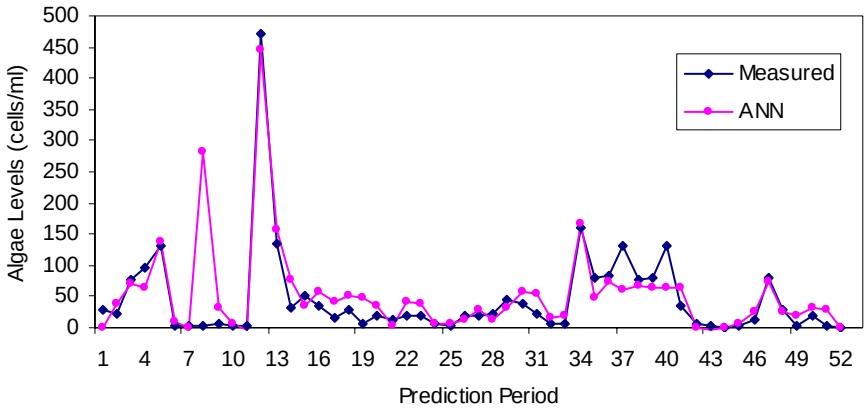

Figure 3.49. Station 612 time-series plots of measured chlorophytes counts against ANN one-week ahead predicted values using all variable inputs excluding Pompton river extractions

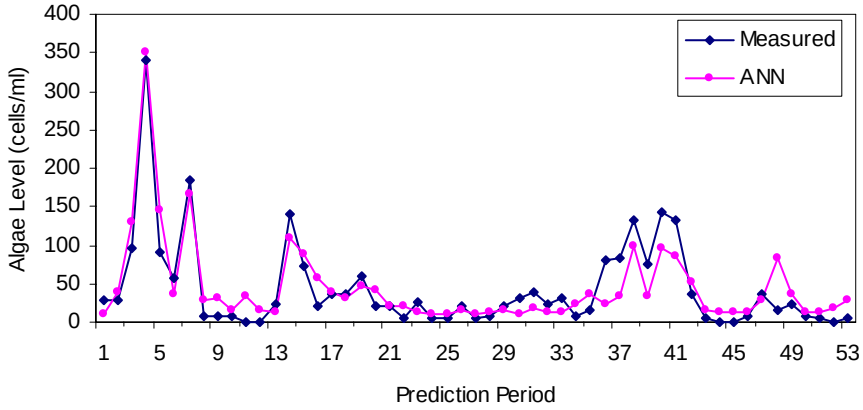

Figure 3.50. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs

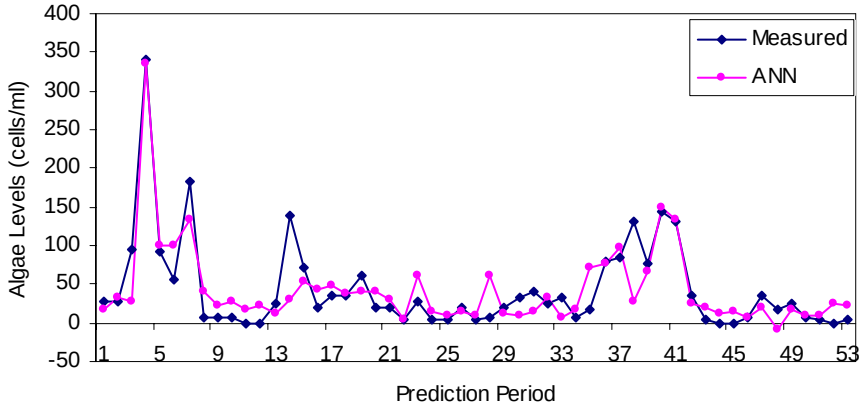

Figure 3.51. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding UV254

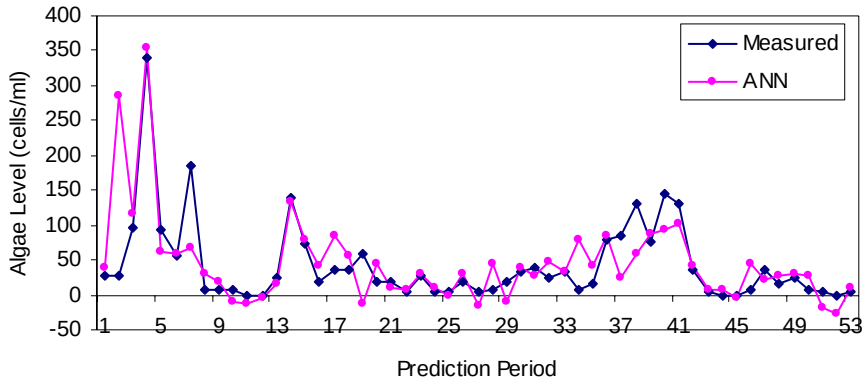

Figure 3.52. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding current week's precipitation

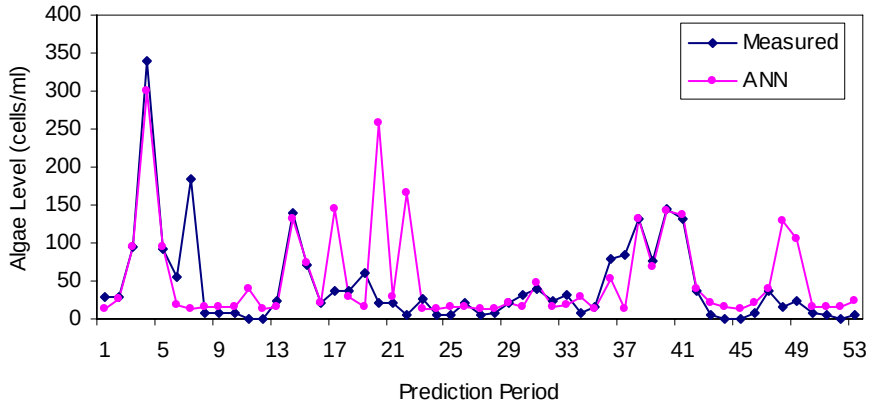

Figure 3.53. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding wind direction

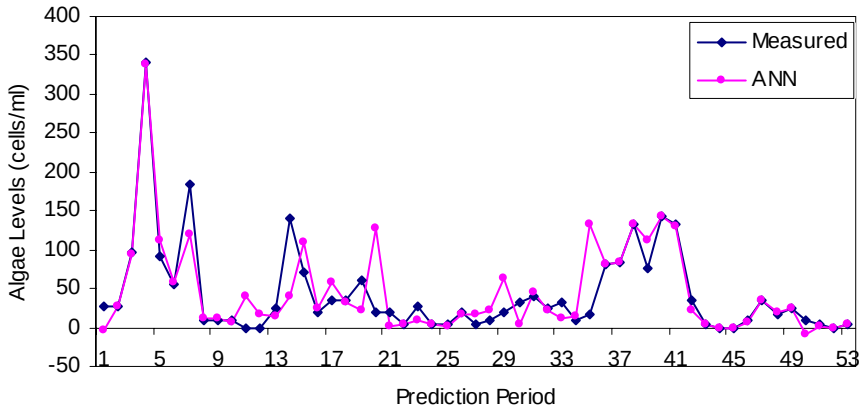

Figure 3.54. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding color

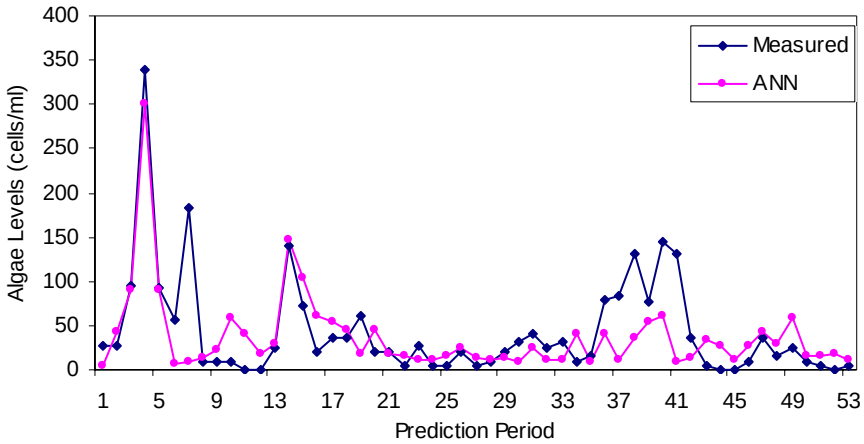

Figure 3.55. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total organic carbon (TOC)

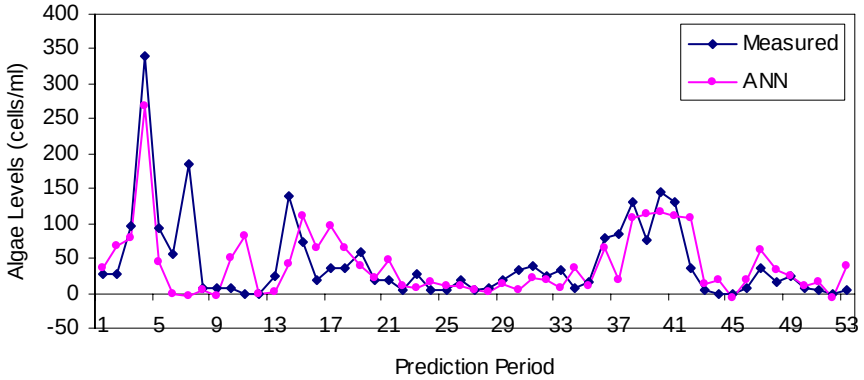

Figure 3.56. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding odor

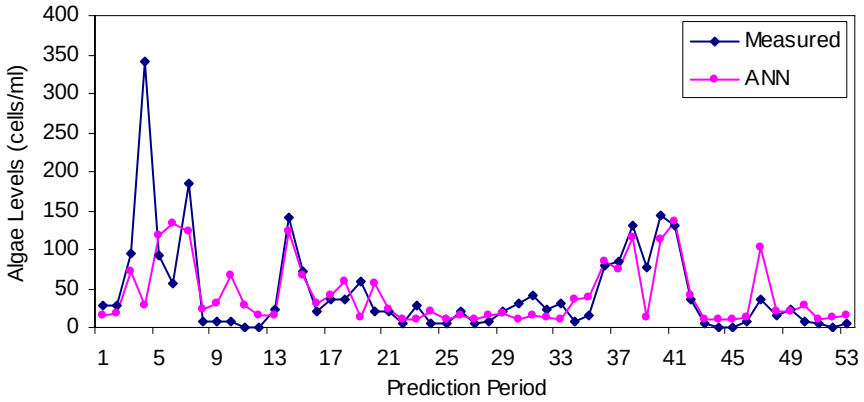

Figure 3.57. Station 612 time-series plots of measured chlorophytes counts against ANN two-week ahead predicted values using all variable inputs excluding total amorphous materials

4. ANN AND LINEAR MODELS

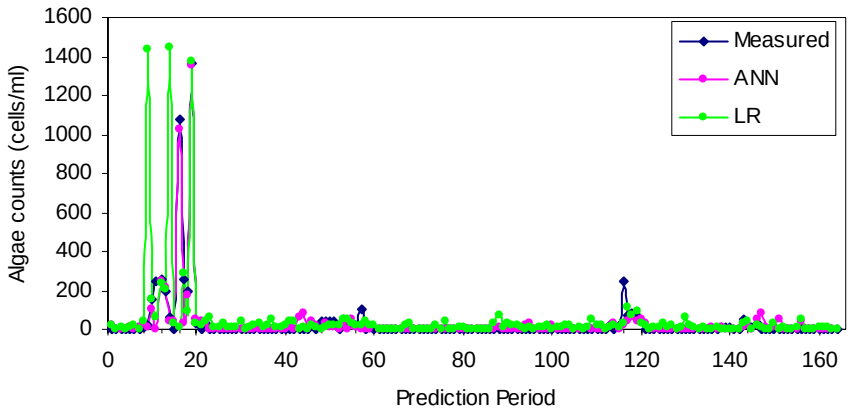

Figure 4.1. Comparison of ANN and LM performance for real-time predictions of cynophyta at Station 100

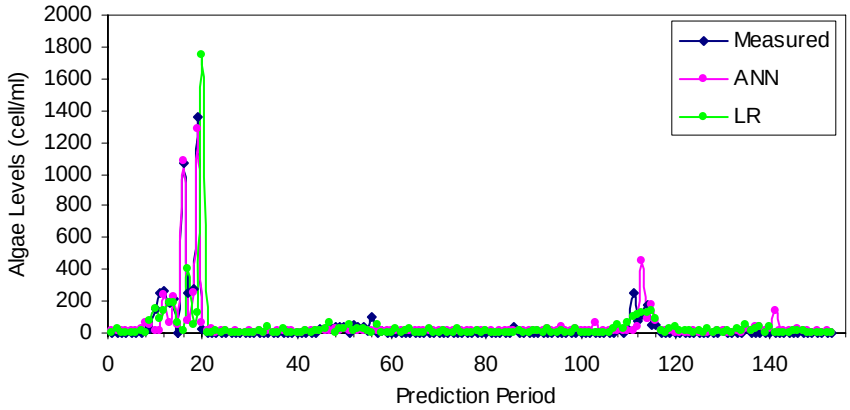

Figure 4.2. Comparison of ANN and LM performance for one-week ahead predictions of cynophyta at Station 100

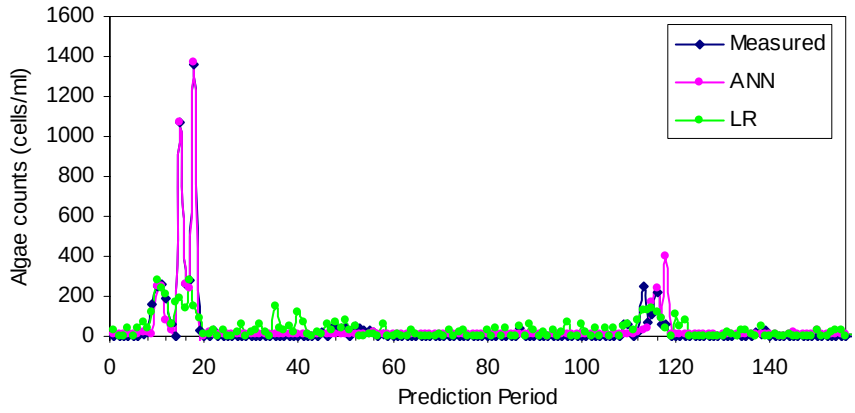

Figure 4.3. Comparison of ANN and LM performance for two-week ahead predictions of cynophyta at Station 100

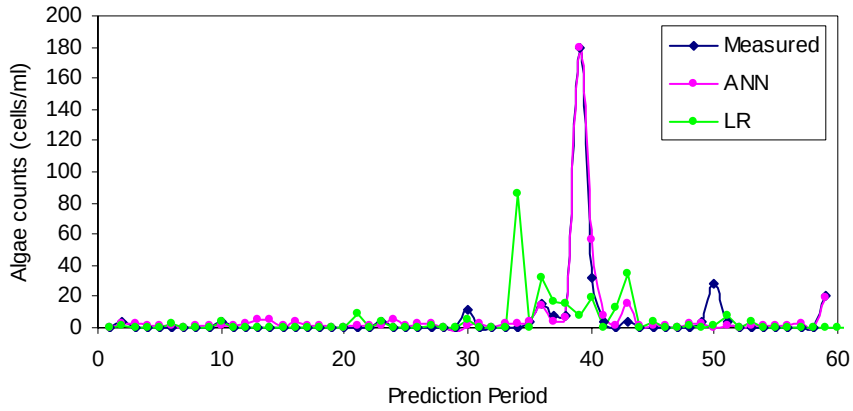

Figure 4.4. Comparison of ANN and LM performance for real-time predictions of cynophyta 101

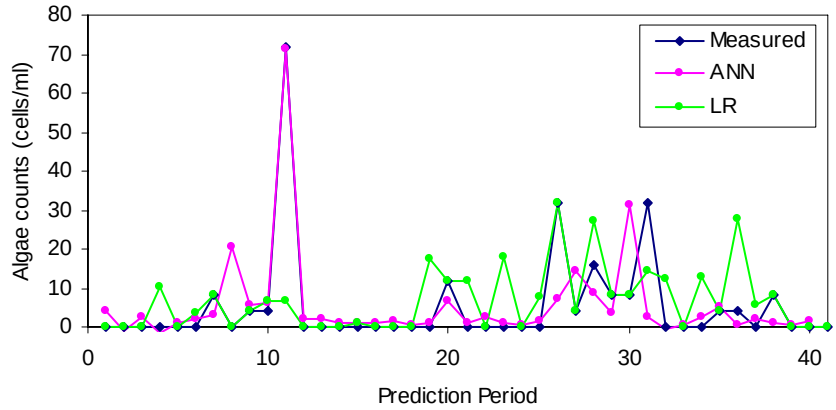

Figure 4.5. Comparison of ANN and LM performance for one-week ahead predictions of cynophyta at Station 101

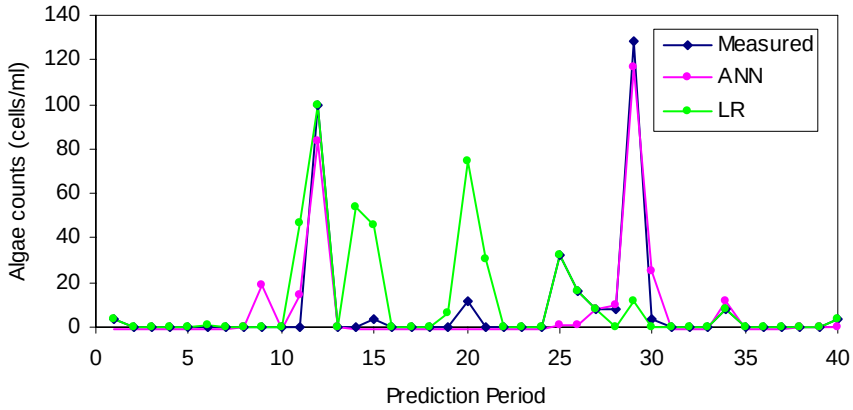

Figure 4.6. Comparison of ANN and LM performance for two-week ahead predictions of cynophyta at Station 101

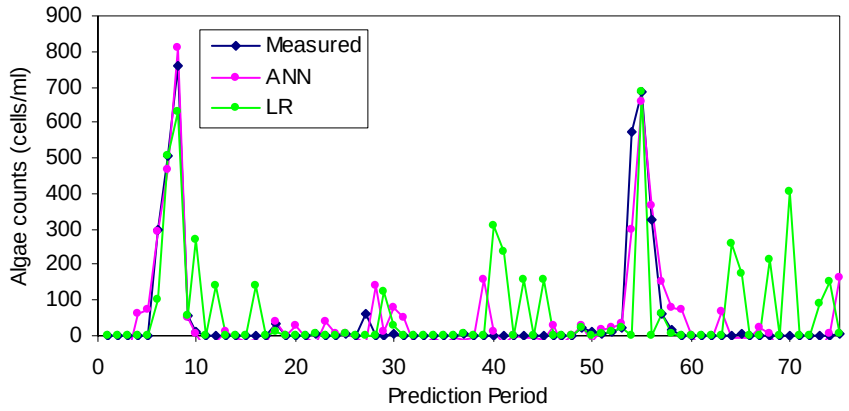

Figure 4.7. Comparison of ANN and LM performance for real-time predictions of cynophyta 612

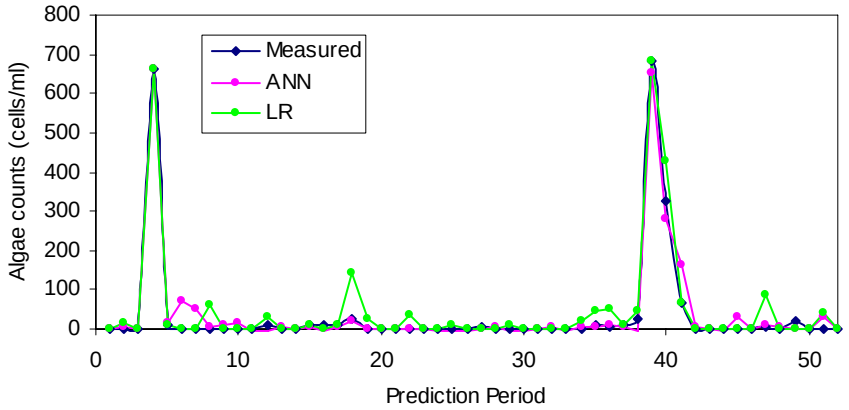

Figure 4.8. Comparison of ANN and LM performance for one-week ahead predictions of cynophyta at Station 612

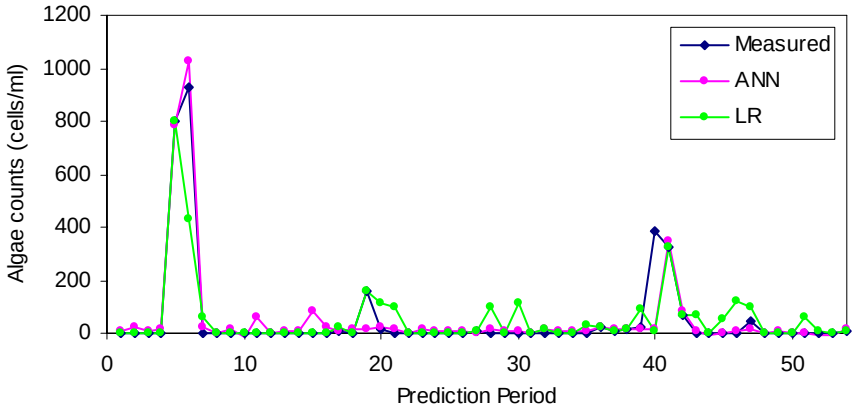

Figure 4.9. Comparison of ANN and LM performance for two-week ahead predictions of cynophyta at Station 612

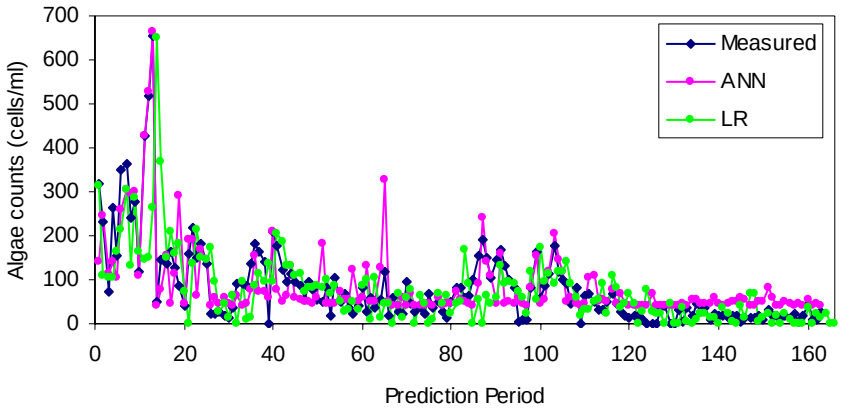

Figure 4.10. Comparison of ANN and LM performance for real-time predictions of chrysophyta at Station 100

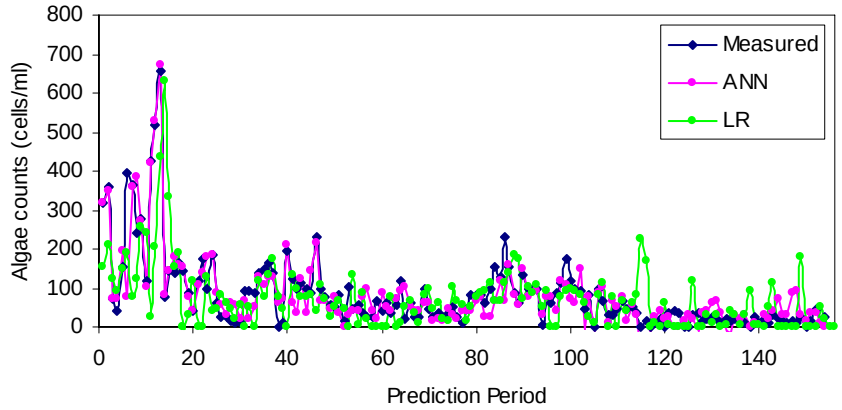

Figure 4.11. Comparison of ANN and LM performance for one-week ahead predictions of chrysophyta at Station 100

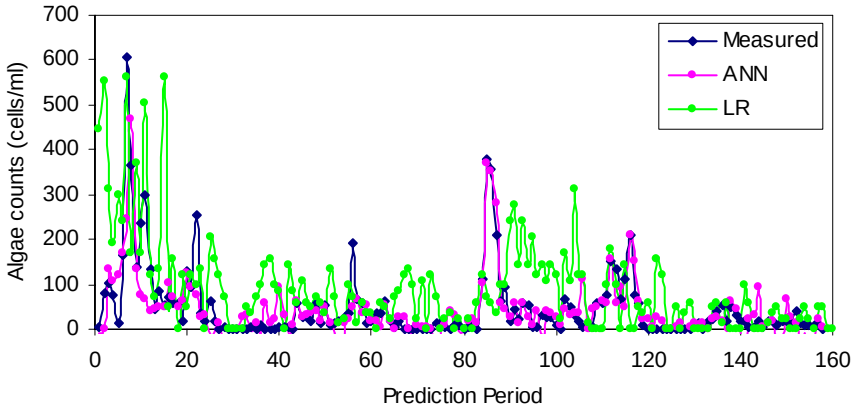

Figure 4.12. Comparison of ANN and LM performance for two-week ahead predictions of chrysophyta at Station 100

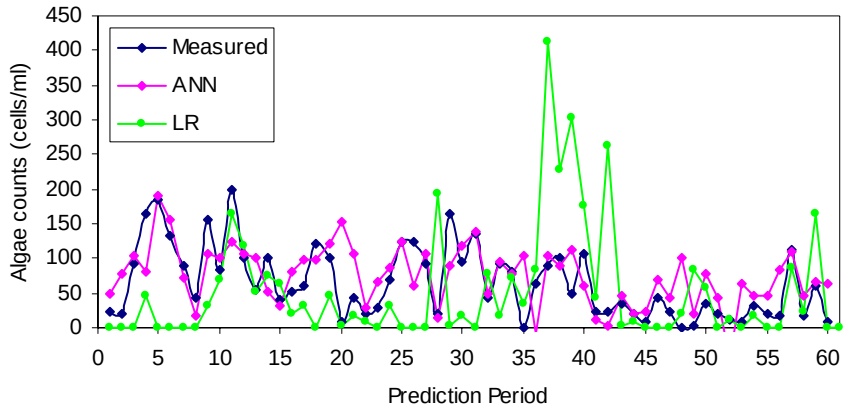

Figure 4.13. Comparison of ANN and LM performance for real-time predictions of chrysophyta at Station 101

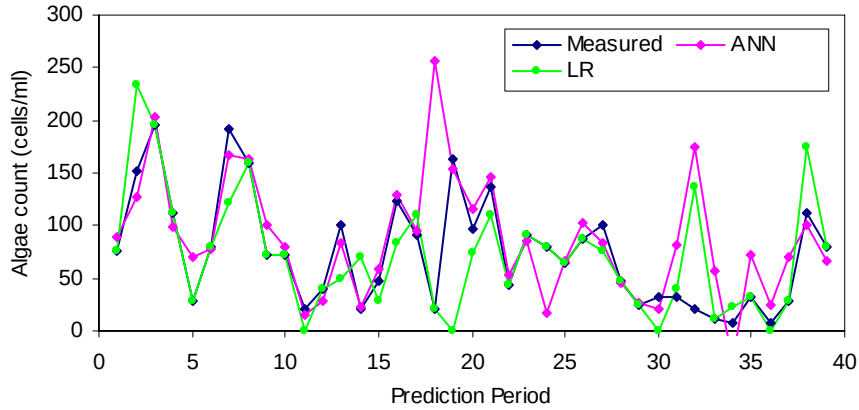

Figure 4.14. Comparison of ANN and LM performance for one-week ahead predictions of chrysophyta at Station 101

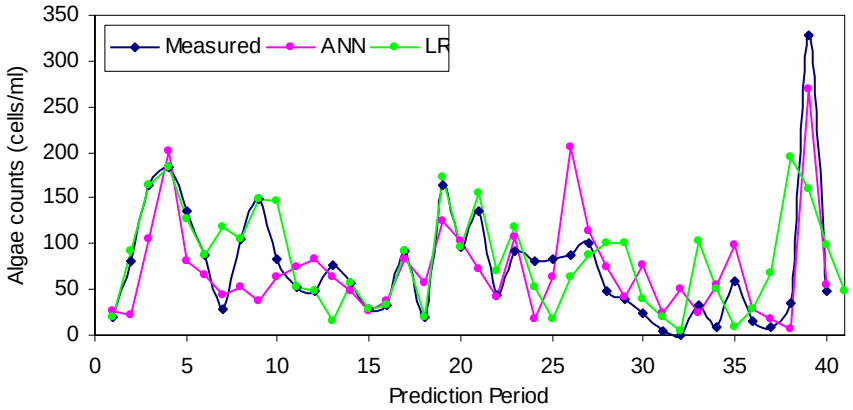

Figure 4.15. Comparison of ANN and LM performance for two-week ahead predictions of chrysophyta at Station 101

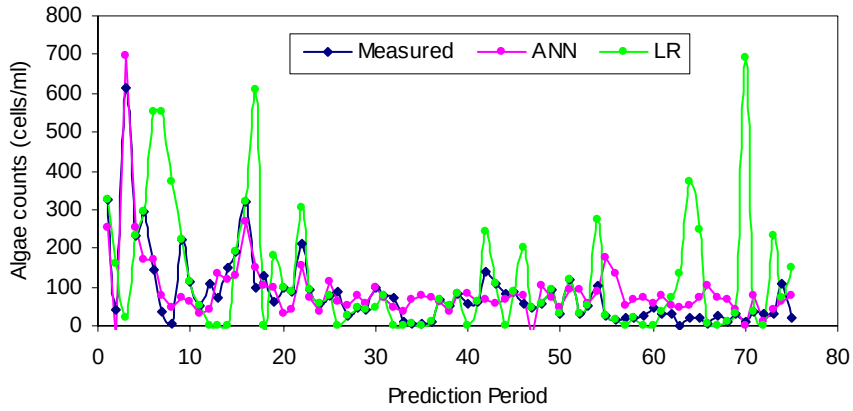

Figure 4.16. Comparison of ANN and LM performance for real-time predictions of chrysophyta 612

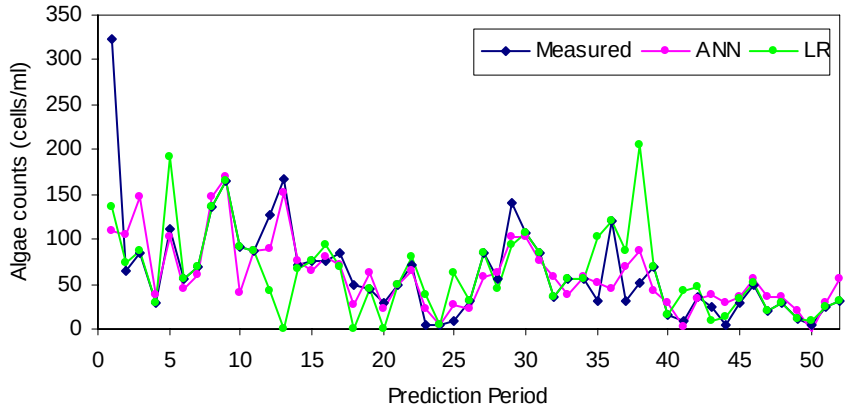

Figure 4.17. Comparison of ANN and LM performance for one-week ahead predictions of chrysophyta at Station 612

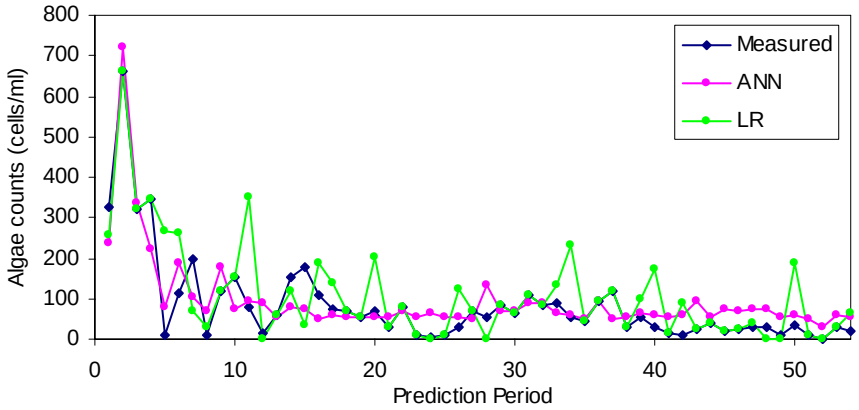

Figure 4.18. Comparison of ANN and LM performance for two-week ahead predictions of chrysophyta at Station 612

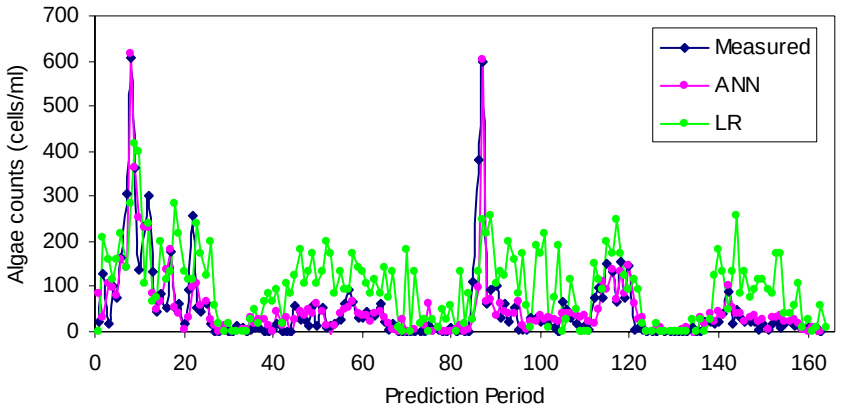

Figure 4.19. Comparison of ANN and LM performance for real-time predictions of chlorophyta at Station 100

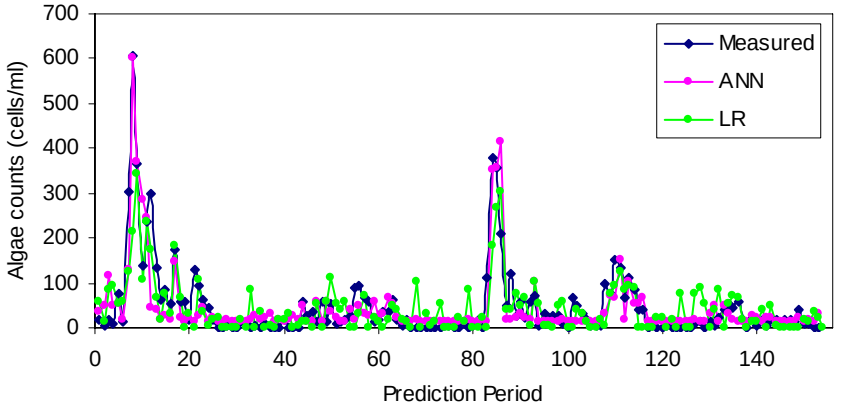

Figure 4.20. Comparison of ANN and LM performance for one-week ahead predictions of chlorophyta at Station 100

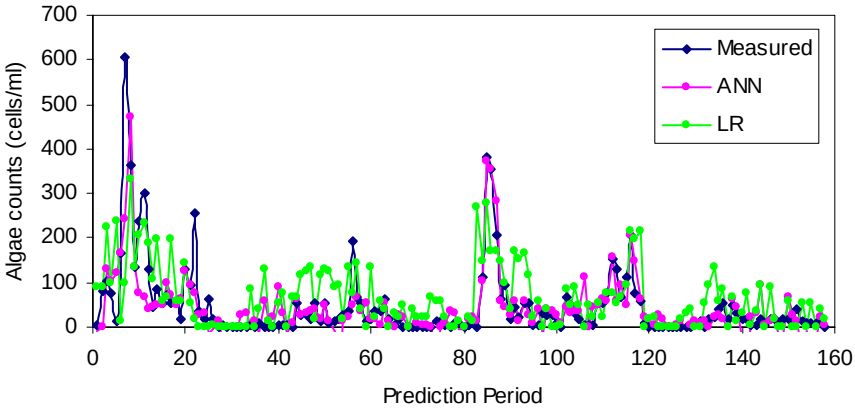

Figure 4.21. Comparison of ANN and LM performance for two-week ahead predictions of chlorophyta at Station 100

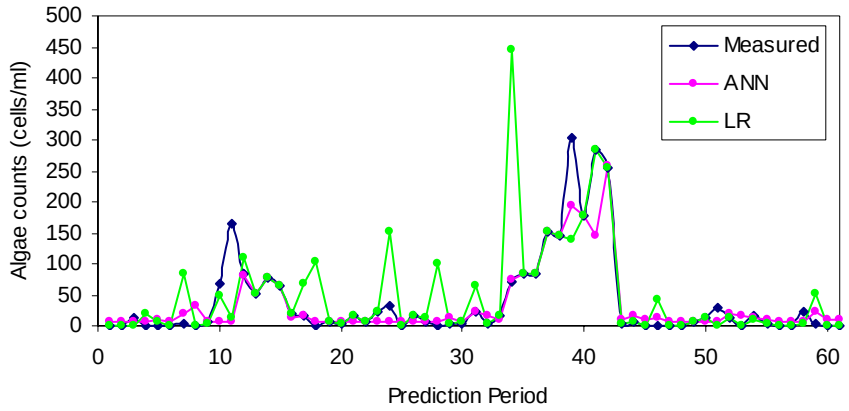

Figure 4.22. Comparison of ANN and LM performance for real-time predictions of chlorophyta at Station 101

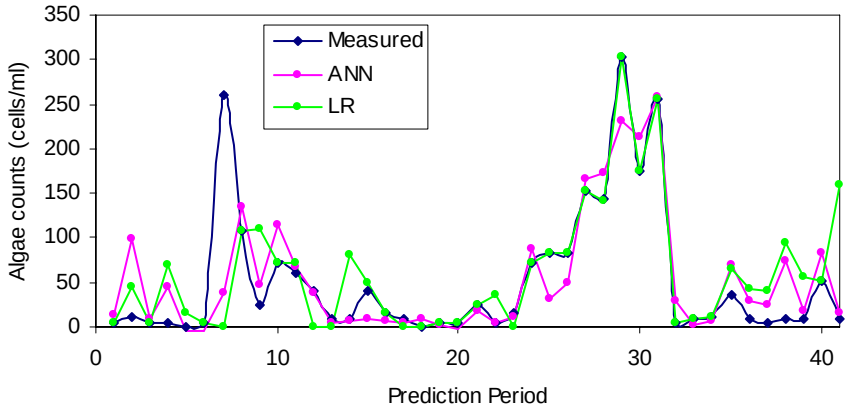

Figure 4.23. Comparison of ANN and LM performance for one-week ahead predictions of chlorophyta at Station 101

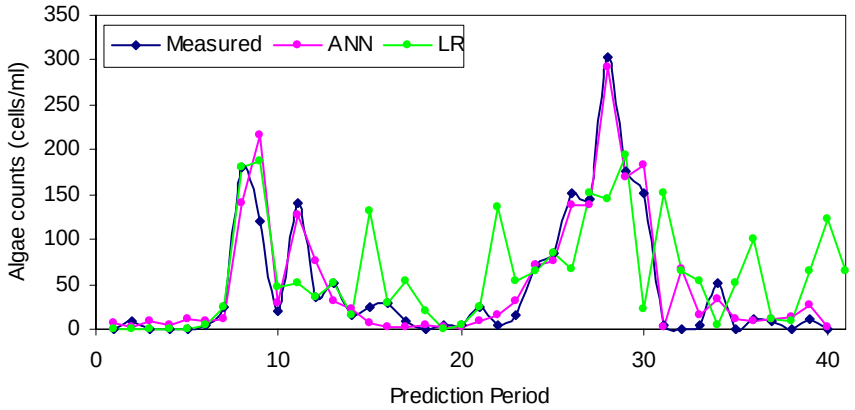

Figure 4.24. Comparison of ANN and LM performance for two-week ahead predictions of chlorophyta at Station 101

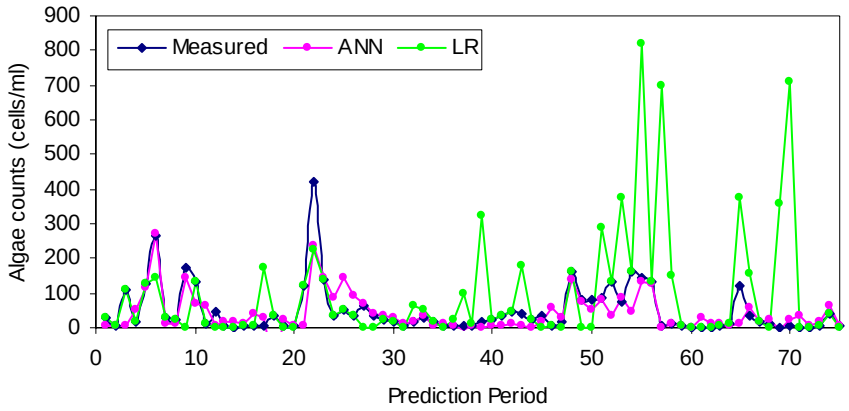

Figure 4.25. Comparison of ANN and LM performance for real-time predictions of chlorophyta 612

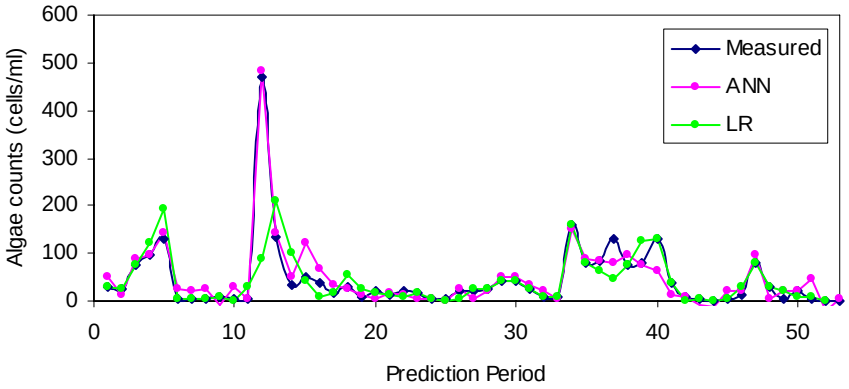

Figure 4.26. Comparison of ANN and LM performance for one-week ahead predictions of chlorophyta at Station 612

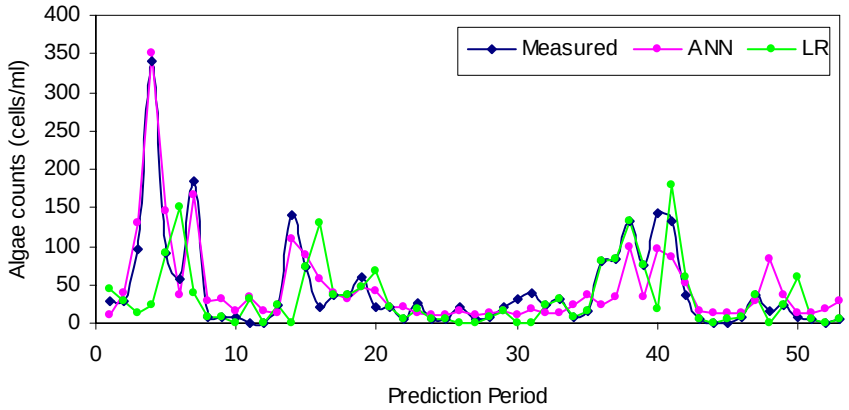

Figure 4.27. Comparison of ANN and LM performance for two-week ahead predictions of chlorophyta at Station 612

APPENDIX A-3b

PVWC (INITIAL) ORIGINAL MODELING
Descriptive Statistics

Table 1.1. Station 100 Cyanobacteria real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	30.8049	43.2683	14.3415	22.3415	0.0000
Data S.D.	140.9585	190.6406	44.1724	64.6912	0.0000
Error Mean	-5.2411	-1.4556	-1.0608	-16.9926	0.0000
Error S.D.	36.2954	15.4255	25.1513	63.0612	0.0000
Abs E. Mean	15.0101	9.4369	14.4890	26.6774	0.0000
S.D. Ratio	0.2575	0.0809	0.5694	0.9748	0.0000
Correlation	0.9663	0.9969	0.8278	0.2262	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	30.9939	48.8675	11.6000	13.3000	0.0000
Data S.D.	141.3695	192.2820	41.0249	41.0793	0.0000
Error Mean	1.0812	-0.8989	6.5687	-0.2975	0.0000
Error S.D.	37.3378	41.5170	19.4465	41.0622	0.0000
Abs E. Mean	19.3423	20.7306	16.3231	19.4806	0.0000
S.D. Ratio	0.2641	0.2159	0.4740	0.9996	0.0000
Correlation	0.9647	0.9766	0.8823	0.2627	0.0000

Dissolved Oxygen

	Overall	Training	Selection	Test	Ignored
Data Mean	30.9939	24.7711	55.2000	19.7000	0.0000
Data S.D.	141.3695	121.1184	217.1768	55.1463	0.0000
Error Mean	-2.7977	1.1349	-8.0891	-5.6664	0.0000
Error S.D.	53.2336	53.2098	56.4765	49.1422	0.0000
Abs E. Mean	23.0986	21.7209	25.5909	23.4651	0.0000
S.D. Ratio	0.3766	0.4393	0.2600	0.8911	0.0000
Correlation	0.9264	0.8997	0.9660	0.4538	0.0000

pH

	Overall	Training	Selection	Test	Ignored
Data Mean	30.9939	48.5783	20.4000	5.1000	0.0000
Data S.D.	141.3695	191.5619	57.0600	24.8191	0.0000
Error Mean	-0.0604	-2.8898	-0.5409	6.2909	0.0000
Error S.D.	37.3376	40.6135	39.6462	25.0864	0.0000
Abs E. Mean	18.2182	20.7787	16.4459	14.6776	0.0000
S.D. Ratio	0.2641	0.2120	0.6948	1.0108	0.0000
Correlation	0.9645	0.9773	0.7193	0.0316	0.0000

Total Suspended Solids

	Overall	Training	Selection	Test	Ignored
Data Mean	30.9939	42.0723	22.2000	16.8000	0.0000
Data S.D.	141.3695	190.3953	61.5399	43.5908	0.0000
Error Mean	3.1258	-0.3695	2.5914	10.9131	0.0000
Error S.D.	80.7604	103.5839	33.4427	55.7625	0.0000
Abs E. Mean	28.4746	32.2353	18.7758	30.3699	0.0000
S.D. Ratio	0.5713	0.5440	0.5434	1.2792	0.0000
Correlation	0.8216	0.8392	0.8442	0.2629	0.0000

Conductivity

	Overall	Training	Selection	Test	Ignored
Data Mean	30.9939	43.0843	17.1000	19.8000	0.0000
Data S.D.	141.3695	191.5440	50.1357	46.6386	0.0000
Error Mean	-3.5551	-0.2989	-3.1614	-10.7055	0.0000
Error S.D.	36.9936	30.5400	35.6780	47.9082	0.0000
Abs E. Mean	16.8260	14.8965	14.7847	22.8710	0.0000
S.D. Ratio	0.2617	0.1594	0.7116	1.0272	0.0000
Correlation	0.9652	0.9873	0.7189	-0.0237	0.0000

Table 1.2. Station 100 Cyanobacteria one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	57.0909	4.3158	22.5263	0.0000
Data S.D.	147.7265	202.8920	13.3734	46.7866	0.0000
Error Mean	2.8397	-5.0062	9.5798	11.9977	0.0000
Error S.D.	50.2739	47.8924	14.5439	71.1555	0.0000
Abs E. Mean	22.5577	20.9680	12.8323	35.5042	0.0000
S.D. Ratio	0.3403	0.2360	1.0875	1.5209	0.0000
Correlation	0.9406	0.9721	0.4277	0.4501	0.0000

Wind Direction

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	42.2857	51.3684	5.4737	0.0000
Data S.D.	147.7265	134.2058	223.1196	18.4772	0.0000
Error Mean	2.3903	3.4805	-2.2141	4.7854	0.0000
Error S.D.	40.3738	45.3101	43.8810	21.1689	0.0000
Abs E. Mean	20.4058	23.9482	21.1242	12.5093	0.0000
S.D. Ratio	0.2733	0.3376	0.1967	1.1457	0.0000
Correlation	0.9619	0.9455	0.9825	0.0517	0.0000

Total Suspended Solids (TSS)

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	26.1299	76.9474	12.6316	0.0000
Data S.D.	147.7265	125.0099	227.7236	43.8613	0.0000
Error Mean	-2.6729	1.2074	-16.0458	2.8376	0.0000
Error S.D.	53.2249	35.2656	82.6977	42.5141	0.0000
Abs E. Mean	28.2330	20.4630	49.2627	22.9477	0.0000
S.D. Ratio	0.3603	0.2821	0.3631	0.9693	0.0000
Correlation	0.9329	0.9598	0.9319	0.2637	0.0000

Point View Reservoir extractions

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	48.9351	17.3684	26.0000	0.0000
Data S.D.	147.7265	198.5892	56.8305	62.7627	0.0000
Error Mean	2.9118	-1.8807	4.9938	10.5407	0.0000
Error S.D.	54.5845	46.0908	41.3797	76.6179	0.0000
Abs E. Mean	27.9003	25.2276	22.4538	38.7626	0.0000
S.D. Ratio	0.3695	0.2321	0.7281	1.2208	0.0000
Correlation	0.9299	0.9729	0.6881	0.5296	0.0000

Pompton river extractions

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	48.7792	24.3158	19.3684	0.0000
Data S.D.	147.7265	198.7651	58.2364	60.6458	0.0000
Error Mean	-0.0930	3.5900	-3.8351	-3.8136	0.0000
Error S.D.	46.2659	29.8340	44.1997	69.3251	0.0000
Abs E. Mean	23.1426	19.1068	21.9736	32.4892	0.0000
S.D. Ratio	0.3132	0.1501	0.7590	1.1431	0.0000
Correlation	0.9506	0.9908	0.6513	0.0781	0.0000

Conductivity

	Overall	Training	Selection	Test	Ignored
Data Mean	35.3987	55.8961	18.6316	10.6316	0.0000
Data S.D.	147.7265	202.3272	50.9636	23.9522	0.0000
Error Mean	4.7113	-0.2957	1.5922	17.9763	0.0000
Error S.D.	47.3344	33.9298	25.6343	76.1234	0.0000
Abs E. Mean	24.2607	21.5504	18.2383	35.7750	0.0000
S.D. Ratio	0.3204	0.1677	0.5030	3.1781	0.0000
Correlation	0.9495	0.9859	0.8688	0.5409	0.0000

Table 1.3. Station 100 Cyanobacteria two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	34.1519	52.9500	17.4359	12.3077	0.0000
Data S.D.	144.9949	198.2365	44.2602	33.4834	0.0000
Error Mean	0.4918	0.0567	-4.2156	6.0917	0.0000
Error S.D.	39.3925	20.5181	39.4083	61.7752	0.0000
Abs E. Mean	15.4884	10.8503	17.4121	23.0785	0.0000
S.D. Ratio	0.2717	0.1035	0.8904	1.8450	0.0000
Correlation	0.9635	0.9946	0.4713	0.3993	0.0000

Nitrite/Nitrate

	Overall	Training	Selection	Test	Ignored
Data Mean	34.3694	37.1646	55.0769	8.0000	0.0000
Data S.D.	145.4302	160.2645	177.9230	17.8196	0.0000
Error Mean	-8.2052	0.5455	-33.4653	-0.6706	0.0000
Error S.D.	54.0639	14.0452	100.5277	20.2778	0.0000
Abs E. Mean	17.0314	9.4543	38.0793	11.3322	0.0000
S.D. Ratio	0.3718	0.0876	0.5650	1.1380	0.0000
Correlation	0.9340	0.9962	0.9690	0.3371	0.0000

Sulfate

	Overall	Training	Selection	Test	Ignored
Data Mean	34.3694	29.8734	66.0513	11.7949	0.0000
Data S.D.	145.4302	127.0915	221.7966	40.9322	0.0000
Error Mean	-6.6985	0.0760	-9.3822	-17.7373	0.0000
Error S.D.	84.7236	30.0655	139.6979	85.6028	0.0000
Abs E. Mean	36.2144	15.5827	65.8222	48.3988	0.0000
S.D. Ratio	0.5826	0.2366	0.6298	2.0913	0.0000
Correlation	0.8128	0.9717	0.8207	0.2144	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	34.3694	43.4430	34.4615	15.8974	0.0000
Data S.D.	145.4302	193.9435	76.6671	50.6328	0.0000
Error Mean	1.7922	-0.2277	0.1154	7.5605	0.0000
Error S.D.	34.7015	22.1206	49.5889	36.7840	0.0000
Abs E. Mean	15.5638	12.0900	22.0381	16.1262	0.0000
S.D. Ratio	0.2386	0.1141	0.6468	0.7265	0.0000
Correlation	0.9712	0.9935	0.7813	0.7473	0.0000

Total Hardness

	Overall	Training	Selection	Test	Ignored
Data Mean	34.3694	55.7975	13.0256	12.3077	0.0000
Data S.D.	145.4302	199.5000	31.6872	40.5540	0.0000
Error Mean	3.0688	-0.8548	6.9189	7.1664	0.0000
Error S.D.	38.5788	45.9555	26.4207	30.8647	0.0000
Abs E. Mean	22.2787	25.1518	19.1012	19.6363	0.0000
S.D. Ratio	0.2653	0.2304	0.8338	0.7611	0.0000
Correlation	0.9642	0.9731	0.5798	0.7152	0.0000

Pompton streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	34.3694	55.4430	10.9744	15.0769	0.0000
Data S.D.	145.4302	199.0242	40.1200	38.4250	0.0000
Error Mean	3.1206	-0.7622	2.2304	11.8758	0.0000
Error S.D.	42.0770	39.5844	26.0976	56.2511	0.0000
Abs E. Mean	21.1968	22.0534	13.6955	26.9628	0.0000
S.D. Ratio	0.2893	0.1989	0.6505	1.4639	0.0000
Correlation	0.9574	0.9800	0.7777	0.2590	0.0000

Table 1.4. Station 100 Chrysophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test
Data Mean	64.8000	63.2000	67.2000	65.6000
Data S.D.	50.3841	52.4229	42.5131	53.2826
Error Mean	3.6557	4.9346	-4.8659	9.6195
Error S.D.	46.7237	45.1607	35.3006	57.4095
Abs E. Mean	37.9294	35.9151	31.7894	48.0979
S.D. Ratio	0.9274	0.8615	0.8303	1.0775
Correlation	0.3895	0.5085	0.5577	-0.1214

Total Hardness

	Overall	Training	Selection	Test
Data Mean	65.1148	62.0645	57.3333	79.2000
Data S.D.	50.0289	48.3948	54.8776	45.2595
Error Mean	-4.5113	-5.7449	1.7005	-8.1735
Error S.D.	42.0202	27.4280	37.9699	64.2566
Abs E. Mean	32.3079	20.3698	29.3889	59.8990
S.D. Ratio	0.8399	0.5668	0.6919	1.4197
Correlation	0.6096	0.8241	0.7392	-0.0245

Initial Chrysophyta Level

	Overall	Training	Selection	Test
Data Mean	65.1148	70.0645	59.2000	60.8000
Data S.D.	50.0289	56.7768	41.7280	40.8757
Error Mean	-0.0289	-9.8078	0.6521	19.5000
Error S.D.	36.5532	20.1248	26.3320	57.6521
Abs E. Mean	25.4176	16.7660	19.7815	48.9338
S.D. Ratio	0.7306	0.3545	0.6310	1.4104
Correlation	0.7323	0.9360	0.7909	0.2879

Nitrite/Nitrate

	Overall	Training	Selection	Test
Data Mean	64.8000	70.0000	50.4000	68.8000
Data S.D.	50.3841	50.3190	50.4021	47.6700
Error Mean	5.8804	3.9776	4.2128	11.3536
Error S.D.	47.3924	25.6178	46.8696	73.7215
Abs E. Mean	34.9030	20.8512	38.8955	59.0140
S.D. Ratio	0.9406	0.5091	0.9299	1.5465
Correlation	0.4753	0.8641	0.4422	-0.2981

Total Amorphous Materials

	Overall	Training	Selection	Test
Data Mean	64.8000	69.8667	50.6667	68.8000
Data S.D.	50.3841	51.0031	38.1063	56.8544
Error Mean	-3.5385	-7.6505	8.0487	-6.9016
Error S.D.	46.7331	32.2720	39.3492	70.1798
Abs E. Mean	35.8692	25.9508	36.4225	55.1527
S.D. Ratio	0.9275	0.6327	1.0326	1.2344
Correlation	0.4119	0.7861	0.2051	-0.2532

Flow from Jackson Ave Pumping Station

	Overall	Training	Selection	Test
Data Mean	64.8000	73.4667	66.4000	45.8667
Data S.D.	50.3841	56.4976	45.3208	34.7138
Error Mean	2.4564	-4.9594	-0.8803	20.6248
Error S.D.	37.7578	25.3921	30.7232	54.9359
Abs E. Mean	28.3943	19.4124	24.4657	50.2867
S.D. Ratio	0.7494	0.4494	0.6779	1.5825
Correlation	0.6937	0.8976	0.7510	0.1622

Pompton streamflow (from USGS)

	Overall	Training	Selection	Test
Data Mean	64.8000	68.2667	53.8667	68.8000
Data S.D.	50.3841	45.9789	59.3811	47.3331
Error Mean	15.7180	5.1207	8.7155	43.9151
Error S.D.	55.4648	16.8947	43.3941	93.7163
Abs E. Mean	35.9094	14.1654	36.9337	78.3730
S.D. Ratio	1.1008	0.3674	0.7308	1.9799
Correlation	0.5016	0.9303	0.7241	-0.0803

Table 1.5. Station 100 Chrysophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	90.9487	62.3421	83.6842	0.0000
Data S.D.	97.2699	99.7102	105.7202	78.7769	0.0000
Error Mean	-3.2509	-1.5680	1.3756	-11.3317	0.0000
Error S.D.	44.9296	22.8360	34.6979	76.2499	0.0000
Abs E. Mean	28.6428	17.1061	28.9044	52.0617	0.0000
S.D. Ratio	0.4619	0.2290	0.3282	0.9679	0.0000
Correlation	0.8918	0.9734	0.9480	0.5115	0.0000

Wind Speed

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	77.0897	69.7368	104.7368	0.0000
Data S.D.	97.2699	88.5994	73.3616	127.0122	0.0000
Error Mean	-6.9635	-4.7518	1.7726	-20.2394	0.0000
Error S.D.	68.2829	38.9103	53.7970	112.3884	0.0000
Abs E. Mean	41.9655	28.7009	37.7528	73.4056	0.0000
S.D. Ratio	0.7020	0.4392	0.7333	0.8849	0.0000
Correlation	0.7147	0.8984	0.6909	0.4865	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	88.6282	71.0526	79.7368	0.0000
Data S.D.	97.2699	104.2958	85.9985	91.6793	0.0000
Error Mean	-3.3314	4.0926	-8.1008	-13.8007	0.0000
Error S.D.	61.8868	61.5279	33.0838	80.0677	0.0000
Abs E. Mean	40.2746	41.5329	27.1355	50.8308	0.0000
S.D. Ratio	0.6362	0.5899	0.3847	0.8733	0.0000
Correlation	0.7715	0.8103	0.9244	0.4990	0.0000

Sky Cover

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	87.2436	83.2632	70.3684	0.0000
Data S.D.	97.2699	110.1221	88.8990	73.1802	0.0000
Error Mean	4.0759	0.3996	-2.9842	18.6823	0.0000
Error S.D.	61.9603	58.3171	56.0610	71.7205	0.0000
Abs E. Mean	42.9695	41.0196	36.6129	53.3286	0.0000
S.D. Ratio	0.6370	0.5296	0.6306	0.9801	0.0000
Correlation	0.7739	0.8484	0.7763	0.4937	0.0000

Initial Chrysophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	90.3333	74.1842	73.1053	0.0000
Data S.D.	97.2699	113.7336	79.9730	71.5111	0.0000
Error Mean	3.0249	0.0082	13.2667	-1.0249	0.0000
Error S.D.	63.9288	61.3918	66.6541	65.1432	0.0000
Abs E. Mean	45.7157	43.0401	50.1270	46.7965	0.0000
S.D. Ratio	0.6572	0.5398	0.8335	0.9110	0.0000
Correlation	0.7567	0.8437	0.5556	0.4440	0.0000

current week Precipitation

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	82.4231	88.9474	74.5789	0.0000
Data S.D.	97.2699	98.0849	113.4806	74.9300	0.0000
Error Mean	-1.8838	-5.6682	2.3909	1.6097	0.0000
Error S.D.	60.7576	56.0250	53.8952	74.5176	0.0000
Abs E. Mean	43.7427	39.3184	41.1841	55.3826	0.0000
S.D. Ratio	0.6246	0.5712	0.4749	0.9945	0.0000
Correlation	0.7863	0.8209	0.8877	0.3597	0.0000

Total Hardness

	Overall	Training	Selection	Test	Ignored
Data Mean	82.0974	81.3974	87.7368	77.8947	0.0000
Data S.D.	97.2699	97.9239	110.1694	80.4552	0.0000
Error Mean	-2.9816	-1.0031	4.1711	-14.1956	0.0000
Error S.D.	62.3756	38.4226	73.7072	84.3781	0.0000
Abs E. Mean	42.7348	30.4564	51.4829	59.1900	0.0000
S.D. Ratio	0.6413	0.3924	0.6690	1.0488	0.0000
Correlation	0.7930	0.9227	0.7682	0.4565	0.0000

Table 1.6. Station 100 Chrysophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	102.6750	80.9231	67.8974	0.0000
Data S.D.	113.0870	138.8088	90.2848	56.9335	0.0000
Error Mean	0.8378	1.7151	-8.0414	7.9173	0.0000
Error S.D.	60.4706	67.0429	41.7679	60.9853	0.0000
Abs E. Mean	42.8754	45.2890	33.9301	46.8699	0.0000
S.D. Ratio	0.5347	0.4830	0.4626	1.0712	0.0000
Correlation	0.8470	0.8758	0.8866	0.4618	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	83.1000	124.6667	64.3077	0.0000
Data S.D.	113.0870	113.3596	141.5593	58.8114	0.0000
Error Mean	-6.9045	1.8873	-32.2851	0.4416	0.0000
Error S.D.	72.9442	44.3924	106.1018	73.4817	0.0000
Abs E. Mean	47.9659	31.2105	75.4818	54.8201	0.0000
S.D. Ratio	0.6450	0.3916	0.7495	1.2494	0.0000
Correlation	0.7645	0.9201	0.6711	0.1608	0.0000

Heating Degree Days

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	107.7750	72.0000	66.3590	0.0000
Data S.D.	113.0870	133.9664	72.0456	91.0011	0.0000
Error Mean	-1.6666	-1.4491	-4.2269	0.4475	0.0000
Error S.D.	78.6075	87.5626	55.6216	78.7461	0.0000
Abs E. Mean	52.0436	57.0099	42.2350	51.6649	0.0000
S.D. Ratio	0.6951	0.6536	0.7720	0.8653	0.0000
Correlation	0.7198	0.7580	0.6830	0.5418	0.0000

Passaic streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	98.7250	76.6154	80.3077	0.0000
Data S.D.	113.0870	119.4220	83.3333	123.2430	0.0000
Error Mean	2.9764	-0.5649	6.7224	6.4948	0.0000
Error S.D.	86.0001	84.7789	68.7729	102.1663	0.0000
Abs E. Mean	53.9514	50.0241	52.6163	63.3425	0.0000
S.D. Ratio	0.7605	0.7099	0.8253	0.8290	0.0000
Correlation	0.6501	0.7069	0.5821	0.5622	0.0000

Initial Chrysophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	90.6625	67.8000	113.9500	113.1000	0.0000
Data S.D.	114.4833	70.3673	118.8995	162.1555	0.0000
Error Mean	-15.0450	0.9554	-24.0241	-38.0665	0.0000
Error S.D.	92.7843	25.8343	72.7429	163.3606	0.0000
Abs E. Mean	46.3406	20.6837	56.8764	87.1186	0.0000
S.D. Ratio	0.8105	0.3671	0.6118	1.0074	0.0000
Correlation	0.5899	0.9304	0.7923	0.2143	0.0000

Sky Cover

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	88.9750	91.8974	85.0256	0.0000
Data S.D.	113.0870	118.0402	136.3630	67.8987	0.0000
Error Mean	7.5946	-0.1118	4.7532	26.2439	0.0000
Error S.D.	85.8650	17.6661	76.4764	151.3366	0.0000
Abs E. Mean	38.2118	13.9078	49.5192	76.7586	0.0000
S.D. Ratio	0.7593	0.1497	0.5608	2.2289	0.0000
Correlation	0.7375	0.9888	0.8302	0.1817	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	88.7215	90.9750	98.5641	74.2564	0.0000
Data S.D.	113.0870	91.1570	164.4571	86.0378	0.0000
Error Mean	-0.2177	-0.0131	-2.8613	2.0064	0.0000
Error S.D.	95.8973	4.0154	87.8924	171.7167	0.0000
Abs E. Mean	42.7556	2.9590	61.6873	105.4580	0.0000
S.D. Ratio	0.8480	0.0440	0.5344	1.9958	0.0000
Correlation	0.6685	0.9990	0.8543	0.2135	0.0000

Table 1.7. Station 100 Chlorophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	49.4217	45.6250	49.8000	0.0000
Data S.D.	89.9537	97.4249	83.4181	79.4239	0.0000
Error Mean	-0.5792	-0.2966	5.2505	-6.9952	0.0000
Error S.D.	39.1030	16.4139	37.7812	64.5683	0.0000
Abs E. Mean	20.7492	11.3348	24.2694	36.7638	0.0000
S.D. Ratio	0.4347	0.1685	0.4529	0.8130	0.0000
Correlation	0.9006	0.9858	0.8943	0.5833	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	55.6145	38.3500	44.2250	0.0000
Data S.D.	89.9537	99.8020	53.8941	95.7850	0.0000
Error Mean	0.1248	0.3928	-1.9076	1.6014	0.0000
Error S.D.	57.5137	32.8315	29.3900	101.8456	0.0000
Abs E. Mean	26.5767	22.1663	17.4745	44.8304	0.0000
S.D. Ratio	0.6394	0.3290	0.5453	1.0633	0.0000
Correlation	0.7753	0.9444	0.8388	0.2758	0.0000

Initial Chlorophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	51.5422	57.6750	33.3500	0.0000
Data S.D.	89.9537	97.2421	102.2835	50.5715	0.0000
Error Mean	6.3150	0.7216	-2.5500	26.7861	0.0000
Error S.D.	52.8662	28.8796	46.7847	83.1081	0.0000
Abs E. Mean	30.8767	21.0095	32.8738	49.3542	0.0000
S.D. Ratio	0.5877	0.2970	0.4574	1.6434	0.0000
Correlation	0.8297	0.9550	0.8897	0.2648	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	45.0843	61.8250	42.6000	0.0000
Data S.D.	89.9537	89.3421	115.2922	53.6846	0.0000
Error Mean	-3.0006	0.3000	1.1937	-14.0438	0.0000
Error S.D.	47.8429	31.5432	67.7859	50.0579	0.0000
Abs E. Mean	31.8244	24.9038	44.2092	33.7999	0.0000
S.D. Ratio	0.5319	0.3531	0.5879	0.9324	0.0000
Correlation	0.8471	0.9362	0.8100	0.4190	0.0000

Total Hardness

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	60.1928	37.1000	35.9750	0.0000
Data S.D.	89.9537	115.6112	41.3979	54.3592	0.0000
Error Mean	4.8251	-0.7545	4.0520	17.1758	0.0000
Error S.D.	52.0168	39.8375	37.6857	78.0698	0.0000
Abs E. Mean	32.7735	27.3862	26.2975	50.4281	0.0000
S.D. Ratio	0.5783	0.3446	0.9103	1.4362	0.0000
Correlation	0.8295	0.9388	0.4726	0.3471	0.0000

Biochemical Oxygen Demand

	Overall	Training	Selection	Test	Ignored
Data Mean	48.5828	51.3373	52.9500	38.5000	0.0000
Data S.D.	89.9537	86.7405	89.7396	95.7693	0.0000
Error Mean	-4.1358	2.0550	-14.4076	-6.7098	0.0000
Error S.D.	60.3392	38.7771	62.0664	87.5919	0.0000
Abs E. Mean	35.2551	29.5281	35.6151	46.7787	0.0000
S.D. Ratio	0.6708	0.4470	0.6916	0.9146	0.0000
Correlation	0.7419	0.8951	0.7224	0.4059	0.0000

Table 1.8. Station 100 Chlorophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	38.6364	50.0000	56.5263	0.0000
Data S.D.	83.0502	66.1519	79.8986	110.8291	0.0000
Error Mean	-7.4825	1.7095	-11.6637	-21.9271	0.0000
Error S.D.	57.6621	29.5597	64.1710	84.2698	0.0000
Abs E. Mean	30.5657	20.8668	33.9851	46.7992	0.0000
S.D. Ratio	0.6943	0.4468	0.8032	0.7604	0.0000
Correlation	0.7335	0.8961	0.6121	0.7288	0.0000

Temperature

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	44.0909	51.5789	43.8947	0.0000
Data S.D.	83.0502	84.9767	85.2330	76.3619	0.0000
Error Mean	-4.6061	-0.0885	-5.9300	-12.4362	0.0000
Error S.D.	48.0385	42.3408	58.1950	46.5594	0.0000
Abs E. Mean	28.0413	24.9599	32.7444	29.5821	0.0000
S.D. Ratio	0.5784	0.4983	0.6828	0.6097	0.0000
Correlation	0.8162	0.8676	0.7445	0.7947	0.0000

Initial Chlorphyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	41.1169	53.0526	48.4474	0.0000
Data S.D.	83.0502	71.3815	76.7700	106.9975	0.0000
Error Mean	-3.2430	0.6761	-13.4831	-0.9445	0.0000
Error S.D.	39.4288	19.9830	45.0893	57.2362	0.0000
Abs E. Mean	24.6439	15.7371	29.8754	37.4605	0.0000
S.D. Ratio	0.4748	0.2799	0.5873	0.5349	0.0000
Correlation	0.8831	0.9602	0.8103	0.8747	0.0000

Turbidity

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	43.0649	56.4474	41.1053	0.0000
Data S.D.	83.0502	86.9187	90.3539	64.4045	0.0000
Error Mean	0.1661	-2.7283	3.9638	2.2335	0.0000
Error S.D.	58.9832	69.3690	46.2594	45.6206	0.0000
Abs E. Mean	34.0573	39.9776	28.1239	27.9945	0.0000
S.D. Ratio	0.7102	0.7981	0.5120	0.7083	0.0000
Correlation	0.7178	0.6240	0.8647	0.7208	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	51.5974	32.0000	48.2632	0.0000
Data S.D.	83.0502	95.1557	53.3745	79.4351	0.0000
Error Mean	2.0154	-6.1381	5.5078	15.0447	0.0000
Error S.D.	56.4062	66.5526	37.6781	45.8150	0.0000
Abs E. Mean	33.1885	37.7116	23.4948	33.7172	0.0000
S.D. Ratio	0.6792	0.6994	0.7059	0.5768	0.0000
Correlation	0.7364	0.7423	0.7372	0.8320	0.0000

Biochemical Oxygen Demand (BOD)

	Overall	Training	Selection	Test	Ignored
Data Mean	45.9020	43.3247	51.8947	45.1316	0.0000
Data S.D.	83.0502	79.5060	101.6309	67.6999	0.0000
Error Mean	2.2160	1.0711	-5.3046	12.0566	0.0000
Error S.D.	40.2139	21.5552	31.4811	66.5027	0.0000
Abs E. Mean	25.6230	15.5791	23.2964	48.3017	0.0000
S.D. Ratio	0.4842	0.2711	0.3098	0.9823	0.0000
Correlation	0.8912	0.9626	0.9530	0.7099	0.0000

Table 1.9. Station 100 Chlorophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	41.1500	67.1795	36.9231	0.0000
Data S.D.	82.4392	67.6378	121.2928	53.4700	0.0000
Error Mean	-8.7895	0.5712	-8.9728	-27.8075	0.0000
Error S.D.	56.6133	13.4527	89.8839	63.1887	0.0000
Abs E. Mean	30.9084	10.4011	55.8732	48.0100	0.0000
S.D. Ratio	0.6867	0.1989	0.7410	1.1818	0.0000
Correlation	0.7462	0.9800	0.6731	0.5283	0.0000

Wind Direction

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	40.7000	71.4872	33.5385	0.0000
Data S.D.	82.4392	74.7389	115.7971	42.4831	0.0000
Error Mean	5.3256	1.7613	-10.2473	28.2099	0.0000
Error S.D.	61.3742	35.1371	100.4058	43.0603	0.0000
Abs E. Mean	37.7223	24.8113	62.8493	39.0795	0.0000
S.D. Ratio	0.7445	0.4701	0.8671	1.0136	0.0000
Correlation	0.6787	0.8826	0.5096	0.6397	0.0000

Total Suspended Solids (TSS)

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	48.4500	47.7949	41.3333	0.0000
Data S.D.	82.4392	77.5990	101.9399	68.9457	0.0000
Error Mean	-1.3748	-3.5517	-0.7491	2.4649	0.0000
Error S.D.	65.6307	39.2906	70.9066	96.0790	0.0000
Abs E. Mean	33.7199	25.5495	32.2481	51.9514	0.0000
S.D. Ratio	0.7961	0.5063	0.6956	1.3935	0.0000
Correlation	0.6329	0.8624	0.7185	-0.0549	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	49.1000	48.7179	39.0769	0.0000
Data S.D.	82.4392	80.7365	106.5328	52.3378	0.0000
Error Mean	3.9224	0.2371	-0.2330	15.6371	0.0000
Error S.D.	57.0259	10.1903	69.4658	89.1834	0.0000
Abs E. Mean	28.7936	7.5027	44.9353	56.3255	0.0000
S.D. Ratio	0.6917	0.1262	0.6521	1.7040	0.0000
Correlation	0.7513	0.9920	0.7660	0.2006	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	44.6000	32.6154	64.4103	0.0000
Data S.D.	82.4392	81.6042	63.5532	96.5063	0.0000
Error Mean	-5.1557	-2.4615	0.9267	-16.7648	0.0000
Error S.D.	62.6334	44.5341	51.2768	94.9143	0.0000
Abs E. Mean	36.8891	29.9828	31.7448	56.2001	0.0000
S.D. Ratio	0.7598	0.5457	0.8068	0.9835	0.0000
Correlation	0.6529	0.8433	0.5921	0.3742	0.0000

Biochemical Oxygen Demand (BOD)

	Overall	Training	Selection	Test	Ignored
Data Mean	46.5316	45.8000	44.6154	49.9487	0.0000
Data S.D.	82.4392	79.6666	102.8279	62.6451	0.0000
Error Mean	-3.0327	-0.7194	-3.5625	-7.2483	0.0000
Error S.D.	59.6539	34.1662	86.2682	67.4619	0.0000
Abs E. Mean	34.6102	21.9496	50.5499	44.6407	0.0000
S.D. Ratio	0.7236	0.4289	0.8390	1.0769	0.0000
Correlation	0.7011	0.9042	0.5445	0.4377	0.0000

Table 2.1. Station 101 Cyanohyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6949	7.8710	3.1429	3.4286	0.0000
Data S.D.	23.7753	31.8623	6.2662	8.5332	0.0000
Error Mean	0.7229	-0.0168	0.6998	2.3842	0.0000
Error S.D.	5.5045	5.3695	1.7088	7.5472	0.0000
Abs E. Mean	2.8229	2.6899	1.6467	4.2936	0.0000
S.D. Ratio	0.2315	0.1685	0.2727	0.8845	0.0000
Correlation	0.9736	0.9857	0.9664	0.9178	0.0000

Heating Degree Days

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	9.0667	2.1333	2.1333	0.0000
Data S.D.	23.5876	32.7566	3.5377	4.3492	0.0000
Error Mean	1.7698	-0.1816	-0.0530	7.4956	0.0000
Error S.D.	14.1826	6.8513	3.3161	25.6122	0.0000
Abs E. Mean	5.0361	3.5180	2.4431	10.6653	0.0000
S.D. Ratio	0.6013	0.2092	0.9374	5.8889	0.0000
Correlation	0.8414	0.9779	0.3504	-0.1409	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	8.5333	3.2000	2.1333	0.0000
Data S.D.	23.5876	32.4918	7.3321	5.0315	0.0000
Error Mean	-0.2081	-0.8011	0.5516	0.2181	0.0000
Error S.D.	6.3007	6.2365	6.9007	5.6502	0.0000
Abs E. Mean	3.8119	3.3002	4.8783	3.7688	0.0000
S.D. Ratio	0.2671	0.1919	0.9412	1.1230	0.0000
Correlation	0.9637	0.9815	0.3584	-0.0592	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	10.2667	0.2667	1.6000	0.0000
Data S.D.	23.5876	32.6384	0.9978	2.4440	0.0000
Error Mean	0.1030	-0.0698	0.0104	0.5412	0.0000
Error S.D.	2.9226	1.5875	0.9207	5.2933	0.0000
Abs E. Mean	1.6250	1.1038	0.7587	3.5339	0.0000
S.D. Ratio	0.1239	0.0486	0.9228	2.1658	0.0000
Correlation	0.9924	0.9988	0.6701	0.0093	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	9.0667	1.8667	2.4000	0.0000
Data S.D.	23.5876	32.4129	5.0315	7.1255	0.0000
Error Mean	0.1192	-0.3094	1.3562	-0.2605	0.0000
Error S.D.	5.9361	6.5926	1.6066	7.0286	0.0000
Abs E. Mean	3.4455	3.8929	2.0749	3.9213	0.0000
S.D. Ratio	0.2517	0.2034	0.3193	0.9864	0.0000
Correlation	0.9688	0.9804	0.9720	0.8519	0.0000

Ammonia

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	7.2000	5.3333	2.6667	0.0000
Data S.D.	23.5876	32.2060	10.4987	5.1983	0.0000
Error Mean	0.2694	-0.0049	0.1142	0.9731	0.0000
Error S.D.	6.4075	2.9951	6.0561	10.4373	0.0000
Abs E. Mean	3.5788	2.1111	3.8960	6.1969	0.0000
S.D. Ratio	0.2716	0.0930	0.5768	2.0078	0.0000
Correlation	0.9640	0.9957	0.8255	0.1787	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	5.6000	6.9333	4.2667	4.2667	0.0000
Data S.D.	23.5876	32.2975	8.9403	7.2246	0.0000
Error Mean	-1.2628	-0.0241	-1.6410	-3.3618	0.0000
Error S.D.	4.7703	2.0052	4.4529	7.4522	0.0000
Abs E. Mean	2.1317	1.1527	2.1898	4.0313	0.0000
S.D. Ratio	0.2022	0.0621	0.4981	1.0315	0.0000
Correlation	0.9794	0.9981	0.8672	-0.0947	0.0000

Initial Cyanobacteria Level

Data Mean	5.6000	6.9333	6.1333	2.4000	0.0000
Data S.D.	23.5876	32.2148	9.3371	6.9742	0.0000
Error Mean	-0.4077	0.1620	-1.7850	-0.1699	0.0000
Error S.D.	5.3542	2.2499	3.6025	9.4323	0.0000
Abs E. Mean	2.8863	1.8097	3.0322	4.8938	0.0000
S.D. Ratio	0.2270	0.0698	0.3858	1.3524	0.0000
Correlation	0.9741	0.9976	0.9235	-0.3449	0.0000

Table 2.2. Station 101 Cyanophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	7.4000	3.2000	0.4000	0.0000
Data S.D.	12.3467	16.6505	4.3081	1.2000	0.0000
Error Mean	0.8754	-0.0406	-0.1330	3.7156	0.0000
Error S.D.	3.8320	2.1636	2.5642	5.6603	0.0000
Abs E. Mean	2.2526	1.6323	2.0302	3.7156	0.0000
S.D. Ratio	0.3104	0.1299	0.5952	4.7169	0.0000
Correlation	0.9511	0.9916	0.8145	0.1703	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	6.6000	3.6000	1.6000	0.0000
Data S.D.	12.3467	16.8416	4.1761	2.6533	0.0000
Error Mean	-0.0827	-0.0354	-0.1286	-0.1315	0.0000
Error S.D.	2.9395	2.5417	2.9686	3.5806	0.0000
Abs E. Mean	2.1210	1.9635	2.2352	2.3216	0.0000
S.D. Ratio	0.2381	0.1509	0.7108	1.3495	0.0000
Correlation	0.9721	0.9891	0.7048	0.0351	0.0000

current week's Precipitation

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	7.6000	1.2000	2.0000	0.0000
Data S.D.	12.3467	16.6325	1.8330	4.0988	0.0000
Error Mean	-0.4733	-0.6800	0.1051	-0.6384	0.0000
Error S.D.	7.8381	10.6116	1.8408	4.0859	0.0000
Abs E. Mean	4.1577	6.0549	1.7287	2.7925	0.0000
S.D. Ratio	0.6348	0.6380	1.0042	0.9969	0.0000
Correlation	0.7746	0.7720	-0.1789	0.0994	0.0000

Wind Direction

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	7.4000	1.6000	2.0000	0.0000
Data S.D.	12.3467	16.7940	2.6533	2.6833	0.0000
Error Mean	-0.2130	-0.1759	-0.0707	-0.4298	0.0000
Error S.D.	3.0020	3.4154	2.4626	2.5659	0.0000
Abs E. Mean	2.0733	2.2478	1.7960	2.0014	0.0000
S.D. Ratio	0.2431	0.2034	0.9281	0.9562	0.0000
Correlation	0.9702	0.9793	0.4106	0.3035	0.0000

Wind Speed

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	6.4000	4.0000	1.6000	0.0000
Data S.D.	12.3467	15.7683	9.4657	2.6533	0.0000
Error Mean	0.0219	0.0418	0.1849	-0.1808	0.0000
Error S.D.	2.9445	2.9819	1.3823	3.8623	0.0000
Abs E. Mean	1.7832	1.7379	0.9321	2.7250	0.0000
S.D. Ratio	0.2385	0.1891	0.1460	1.4557	0.0000
Correlation	0.9712	0.9820	0.9893	-0.1520	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	4.6000	6.8000	2.8000	2.0000	0.0000
Data S.D.	12.3467	16.6421	5.0754	3.2249	0.0000
Error Mean	1.5817	0.9191	-0.6097	5.0983	0.0000
Error S.D.	9.5991	8.7045	3.0135	13.7807	0.0000
Abs E. Mean	4.8655	4.6058	2.0471	8.2035	0.0000
S.D. Ratio	0.7775	0.5230	0.5937	4.2732	0.0000
Correlation	0.7058	0.8531	0.8106	-0.2294	0.0000

Table 2.3. Station 101 Cyanophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	13.6000	1.6000	4.0000	0.0000
Data S.D.	25.1865	34.0447	3.2000	9.4657	0.0000
Error Mean	-1.5208	-0.5573	-0.3971	-4.5716	0.0000
Error S.D.	8.3668	9.6357	0.8230	9.0121	0.0000
Abs E. Mean	4.5658	6.4065	0.8391	4.6111	0.0000
S.D. Ratio	0.3322	0.2830	0.2572	0.9521	0.0000
Correlation	0.9445	0.9614	0.9937	0.7948	0.0000

Total Phosphorous/Orthophosphate

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	13.4000	4.4000	1.6000	0.0000
Data S.D.	25.1865	34.0652	9.5415	3.6661	0.0000
Error Mean	1.4140	-0.2422	1.0125	5.1280	0.0000
Error S.D.	7.1374	2.3957	4.2418	12.4442	0.0000
Abs E. Mean	4.1806	1.8833	3.5710	9.3849	0.0000
S.D. Ratio	0.2834	0.0703	0.4446	3.3944	0.0000
Correlation	0.9605	0.9976	0.9019	-0.3428	0.0000

Point View Reservoir extractions

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	14.2000	1.2000	3.2000	0.0000
Data S.D.	25.1865	33.8579	2.5612	9.6000	0.0000
Error Mean	0.1704	-0.1941	2.4480	-1.3781	0.0000
Error S.D.	5.9736	3.6445	3.6626	9.7420	0.0000
Abs E. Mean	3.4800	2.9081	3.3915	4.7124	0.0000
S.D. Ratio	0.2372	0.1076	1.4300	1.0148	0.0000
Correlation	0.9715	0.9942	0.3548	-0.0744	0.0000

Turbidity

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	13.2727	2.6667	1.3333	0.0000
Data S.D.	25.1865	32.9051	5.3333	1.8856	0.0000
Error Mean	-0.2399	-1.6317	0.5301	2.3924	0.0000
Error S.D.	4.6443	4.4469	2.3567	5.4509	0.0000
Abs E. Mean	2.9372	2.8054	1.8404	4.3564	0.0000
S.D. Ratio	0.1844	0.1351	0.4419	2.8908	0.0000
Correlation	0.9829	0.9909	0.8972	-0.0732	0.0000

Sulfate

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	12.4000	4.4000	3.6000	0.0000
Data S.D.	25.1865	34.2672	9.5415	5.2000	0.0000
Error Mean	-5.4544	-8.8949	-0.8187	-3.2091	0.0000
Error S.D.	24.2680	32.9221	8.6068	7.9823	0.0000
Abs E. Mean	9.5915	13.5522	4.4597	6.8019	0.0000
S.D. Ratio	0.9635	0.9607	0.9020	1.5351	0.0000
Correlation	0.2812	0.3580	0.4358	-0.0205	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	8.2000	7.4000	16.8000	1.2000	0.0000
Data S.D.	25.1865	21.6619	38.2330	3.6000	0.0000
Error Mean	0.2445	0.1069	0.5525	0.2118	0.0000
Error S.D.	15.4857	11.4557	25.5038	6.7959	0.0000
Abs E. Mean	9.7747	7.5713	19.0145	4.9417	0.0000
S.D. Ratio	0.6148	0.5288	0.6671	1.8877	0.0000
Correlation	0.7888	0.8594	0.7814	-0.2087	0.0000

Table 2.4. Station 101 Chrysophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	64.8000	63.2000	67.2000	65.6000	0.0000
Data S.D.	50.3841	52.4229	42.5131	53.2826	0.0000
Error Mean	3.6557	4.9346	-4.8659	9.6195	0.0000
Error S.D.	46.7237	45.1607	35.3006	57.4095	0.0000
Abs E. Mean	37.9294	35.9151	31.7894	48.0979	0.0000
S.D. Ratio	0.9274	0.8615	0.8303	1.0775	0.0000
Correlation	0.3895	0.5085	0.5577	-0.1214	0.0000

Total Hardness

	Overall	Training	Selection	Test	Ignored
Data Mean	65.1148	62.0645	57.3333	79.2000	0.0000
Data S.D.	50.0289	48.3948	54.8776	45.2595	0.0000
Error Mean	-4.5113	-5.7449	1.7005	-8.1735	0.0000
Error S.D.	42.0202	27.4280	37.9699	64.2566	0.0000
Abs E. Mean	32.3079	20.3698	29.3889	59.8990	0.0000
S.D. Ratio	0.8399	0.5668	0.6919	1.4197	0.0000
Correlation	0.6096	0.8241	0.7392	-0.0245	0.0000

Initial Chrysophyta level

	Overall	Training	Selection	Test	Ignored
Data Mean	65.1148	70.0645	59.2000	60.8000	0.0000
Data S.D.	50.0289	56.7768	41.7280	40.8757	0.0000
Error Mean	-0.0289	-9.8078	0.6521	19.5000	0.0000
Error S.D.	36.5532	20.1248	26.3320	57.6521	0.0000
Abs E. Mean	25.4176	16.7660	19.7815	48.9338	0.0000
S.D. Ratio	0.7306	0.3545	0.6310	1.4104	0.0000
Correlation	0.7323	0.9360	0.7909	0.2879	0.0000

Nitrite/Nitrate

	Overall	Training	Selection	Test	Ignored
Data Mean	64.8000	70.0000	50.4000	68.8000	0.0000
Data S.D.	50.3841	50.3190	50.4021	47.6700	0.0000
Error Mean	5.8804	3.9776	4.2128	11.3536	0.0000
Error S.D.	47.3924	25.6178	46.8696	73.7215	0.0000
Abs E. Mean	34.9030	20.8512	38.8955	59.0140	0.0000
S.D. Ratio	0.9406	0.5091	0.9299	1.5465	0.0000
Correlation	0.4753	0.8641	0.4422	-0.2981	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	64.8000	69.8667	50.6667	68.8000	0.0000
Data S.D.	50.3841	51.0031	38.1063	56.8544	0.0000
Error Mean	-3.5385	-7.6505	8.0487	-6.9016	0.0000
Error S.D.	46.7331	32.2720	39.3492	70.1798	0.0000
Abs E. Mean	35.8692	25.9508	36.4225	55.1527	0.0000
S.D. Ratio	0.9275	0.6327	1.0326	1.2344	0.0000
Correlation	0.4119	0.7861	0.2051	-0.2532	0.0000

extraction from Jackson Ave Pumping Station

	Overall	Training	Selection	Test	Ignored
Data Mean	64.8000	73.4667	66.4000	45.8667	0.0000
Data S.D.	50.3841	56.4976	45.3208	34.7138	0.0000
Error Mean	2.4564	-4.9594	-0.8803	20.6248	0.0000
Error S.D.	37.7578	25.3921	30.7232	54.9359	0.0000
Abs E. Mean	28.3943	19.4124	24.4657	50.2867	0.0000
S.D. Ratio	0.7494	0.4494	0.6779	1.5825	0.0000
Correlation	0.6937	0.8976	0.7510	0.1622	0.0000

Pompton streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	64.8000	68.2667	53.8667	68.8000	0.0000
Data S.D.	50.3841	45.9789	59.3811	47.3331	0.0000
Error Mean	15.7180	5.1207	8.7155	43.9151	0.0000
Error S.D.	55.4648	16.8947	43.3941	93.7163	0.0000
Abs E. Mean	35.9094	14.1654	36.9337	78.3730	0.0000
S.D. Ratio	1.1008	0.3674	0.7308	1.9799	0.0000
Correlation	0.5016	0.9303	0.7241	-0.0803	0.0000

Table 2.5. Station 101 Chrysophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	90.0952	61.7778	50.6667	0.0000
Data S.D.	51.1819	54.2111	48.2995	29.3939	0.0000
Error Mean	12.7109	3.1038	-7.2473	55.0854	0.0000
Error S.D.	48.8585	14.2100	33.0195	79.8349	0.0000
Abs E. Mean	26.5241	10.8726	29.4580	60.1103	0.0000
S.D. Ratio	0.9546	0.2621	0.6836	2.7160	0.0000
Correlation	0.5912	0.9656	0.7534	-0.3213	0.0000

Temperature

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	71.4286	77.3333	78.6667	0.0000
Data S.D.	51.1819	43.9790	58.5757	57.9655	0.0000
Error Mean	3.6096	-0.8083	9.0851	8.4425	0.0000
Error S.D.	28.5842	10.6342	36.0317	43.3536	0.0000
Abs E. Mean	20.7630	8.9703	31.1462	37.8960	0.0000
S.D. Ratio	0.5585	0.2418	0.6151	0.7479	0.0000
Correlation	0.8296	0.9708	0.8292	0.6752	0.0000

current week's Precipitation

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	76.1905	56.4444	88.4444	0.0000
Data S.D.	51.1819	53.8566	36.6337	52.1006	0.0000
Error Mean	-10.3657	-9.8348	-2.9216	-19.0483	0.0000
Error S.D.	40.9091	41.1755	19.1334	52.9012	0.0000
Abs E. Mean	32.4069	35.1226	15.9341	42.5433	0.0000
S.D. Ratio	0.7993	0.7645	0.5223	1.0154	0.0000
Correlation	0.6153	0.6780	0.8897	0.1720	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	82.4762	64.0000	66.2222	0.0000
Data S.D.	51.1819	51.3954	63.5820	28.6037	0.0000
Error Mean	-1.9381	-0.3492	2.8702	-10.4540	0.0000
Error S.D.	25.3772	5.4350	26.3980	43.8562	0.0000
Abs E. Mean	15.9340	3.6760	21.6962	38.7736	0.0000
S.D. Ratio	0.4958	0.1057	0.4152	1.5332	0.0000
Correlation	0.8886	0.9945	0.9143	0.5142	0.0000

Initial Chrysophyta levels

	Overall	Training	Selection	Test	Ignored
Data Mean	74.7000	72.8000	62.8000	90.4000	0.0000
Data S.D.	50.5600	53.3906	49.5758	40.8784	0.0000
Error Mean	2.1006	-1.9517	14.0264	-1.7204	0.0000
Error S.D.	52.6282	24.4032	26.0846	94.9621	0.0000
Abs E. Mean	31.4933	18.6719	24.3936	64.2356	0.0000
S.D. Ratio	1.0409	0.4571	0.5262	2.3230	0.0000
Correlation	0.5673	0.8896	0.8586	0.0768	0.0000

extraction from Jackson Ave Pumping Station

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	75.2381	58.6667	88.4444	0.0000
Data S.D.	51.1819	53.9434	44.5421	46.1666	0.0000
Error Mean	2.7354	3.8167	11.2130	-8.2651	0.0000
Error S.D.	43.5319	33.5634	12.9572	72.2480	0.0000
Abs E. Mean	33.1244	29.1780	15.3616	60.0955	0.0000
S.D. Ratio	0.8505	0.6222	0.2909	1.5649	0.0000
Correlation	0.6421	0.7906	0.9773	0.5224	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4615	76.3810	80.8889	63.5556	0.0000
Data S.D.	51.1819	55.2315	53.9886	33.9120	0.0000
Error Mean	-1.4658	3.1318	-2.9412	-10.7181	0.0000
Error S.D.	48.8837	20.1150	37.3018	88.7827	0.0000
Abs E. Mean	30.3799	17.2709	32.6255	58.7218	0.0000
S.D. Ratio	0.9551	0.3642	0.6909	2.6180	0.0000
Correlation	0.6666	0.9328	0.7247	0.5716	0.0000

Table 2.6. Station 101 Chrysophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	79.0000	70.8000	68.8000	0.0000
Data S.D.	62.1340	73.7550	51.8783	42.2488	0.0000
Error Mean	-3.4471	1.4908	-5.5755	-11.1947	0.0000
Error S.D.	41.2784	35.6343	30.0706	57.0829	0.0000
Abs E. Mean	31.1093	30.0679	24.1550	40.1464	0.0000
S.D. Ratio	0.6643	0.4831	0.5796	1.3511	0.0000
Correlation	0.7542	0.9041	0.8450	0.2997	0.0000

Alkalinity

	Overall	Training	Selection	Test	Ignored
Data Mean	74.1463	76.5714	40.0000	103.2000	0.0000
Data S.D.	61.3926	50.7811	31.3943	83.8437	0.0000
Error Mean	0.5855	-0.1997	1.2813	1.5387	0.0000
Error S.D.	49.9817	4.5217	22.0499	98.5428	0.0000
Abs E. Mean	21.9495	2.7632	19.1661	65.0242	0.0000
S.D. Ratio	0.8141	0.0890	0.7024	1.1753	0.0000
Correlation	0.6120	0.9961	0.7629	-0.1938	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	79.6000	74.4000	64.0000	0.0000
Data S.D.	62.1340	70.3011	55.3158	48.3322	0.0000
Error Mean	-3.4229	-4.3308	10.6054	-15.6354	0.0000
Error S.D.	53.4775	55.1156	27.2202	65.3865	0.0000
Abs E. Mean	38.6894	38.2192	23.0493	55.2699	0.0000
S.D. Ratio	0.8607	0.7840	0.4921	1.3529	0.0000
Correlation	0.5758	0.6322	0.8816	0.3938	0.0000

Ammonia

	Overall	Training	Selection	Test	Ignored
Data Mean	74.1463	75.4286	71.2000	74.4000	0.0000
Data S.D.	61.3926	70.0942	58.2903	41.5384	0.0000
Error Mean	-0.1140	-0.7159	11.9722	-10.9362	0.0000
Error S.D.	33.0675	30.6407	27.1543	38.8622	0.0000
Abs E. Mean	27.8059	26.4591	23.9752	34.4650	0.0000
S.D. Ratio	0.5386	0.4371	0.4658	0.9356	0.0000
Correlation	0.8475	0.8995	0.9057	0.4901	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	68.0000	113.6000	48.0000	0.0000
Data S.D.	62.1340	36.5294	95.5690	36.3978	0.0000
Error Mean	10.4003	0.3440	-16.9244	57.8374	0.0000
Error S.D.	51.7230	10.3756	68.3909	51.0809	0.0000
Abs E. Mean	33.9951	8.7715	52.3674	66.0700	0.0000
S.D. Ratio	0.8324	0.2840	0.7156	1.4034	0.0000
Correlation	0.5660	0.9590	0.7595	0.1494	0.0000

Passaic streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	84.0000	59.2000	70.4000	0.0000
Data S.D.	62.1340	74.0702	48.2593	41.3454	0.0000
Error Mean	7.8430	4.8919	-6.5429	28.1310	0.0000
Error S.D.	48.7105	37.1985	41.2095	66.2510	0.0000
Abs E. Mean	34.8914	25.7237	34.3473	53.7710	0.0000
S.D. Ratio	0.7840	0.5022	0.8539	1.6024	0.0000
Correlation	0.6545	0.8655	0.5603	-0.4517	0.0000

current week's Precipitation

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	99.4000	43.2000	55.6000	0.0000
Data S.D.	62.1340	68.0855	30.4000	51.6744	0.0000
Error Mean	-1.3740	-12.8988	0.9896	19.3120	0.0000
Error S.D.	49.5978	52.7062	25.8190	54.0197	0.0000
Abs E. Mean	35.1657	37.6831	20.7880	44.5087	0.0000
S.D. Ratio	0.7982	0.7741	0.8493	1.0454	0.0000
Correlation	0.6092	0.6332	0.5331	0.4499	0.0000

Heating Degree Days

	Overall	Training	Selection	Test	Ignored
Data Mean	74.4000	66.0000	59.2000	106.4000	0.0000
Data S.D.	62.1340	46.6219	49.2114	85.3079	0.0000
Error Mean	-3.0605	3.8078	-3.3308	-16.5267	0.0000
Error S.D.	56.9545	10.9491	27.1291	108.2764	0.0000
Abs E. Mean	31.4389	9.4401	22.2497	84.6258	0.0000
S.D. Ratio	0.9166	0.2348	0.5513	1.2692	0.0000
Correlation	0.4804	0.9742	0.8344	-0.1936	0.0000

Table 2.7 Station 101 Chlorophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	46.1290	7.2000	58.1333	0.0000
Data S.D.	69.5189	61.4091	8.0266	101.5597	0.0000
Error Mean	-5.9704	-0.2083	3.4046	-27.2538	0.0000
Error S.D.	32.2355	7.5045	10.0716	58.2963	0.0000
Abs E. Mean	14.2799	4.8753	9.2158	38.7801	0.0000
S.D. Ratio	0.4637	0.1222	1.2548	0.5740	0.0000
Correlation	0.8948	0.9925	-0.1294	0.8883	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	43.1613	22.1333	49.3333	0.0000
Data S.D.	69.5189	79.9448	27.2026	72.6587	0.0000
Error Mean	8.0151	-0.7292	1.1917	32.9102	0.0000
Error S.D.	41.1243	28.7152	18.1462	63.4022	0.0000
Abs E. Mean	24.6371	18.3297	13.4612	48.8483	0.0000
S.D. Ratio	0.5916	0.3592	0.6671	0.8726	0.0000
Correlation	0.8779	0.9335	0.7666	0.9112	0.0000

Initial Chlorophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	37.3548	74.1333	9.3333	0.0000
Data S.D.	69.5189	61.8414	97.6728	9.5406	0.0000
Error Mean	-1.3885	1.1288	-13.1684	5.1888	0.0000
Error S.D.	28.9698	21.5878	46.6313	8.9566	0.0000
Abs E. Mean	17.7971	16.0754	30.1588	8.9935	0.0000
S.D. Ratio	0.4167	0.3491	0.4774	0.9388	0.0000
Correlation	0.9106	0.9373	0.8886	0.4937	0.0000

Sulfate

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	28.4516	48.8000	53.0667	0.0000
Data S.D.	69.5189	61.6666	74.6790	75.4643	0.0000
Error Mean	0.5849	0.9950	2.2045	-1.8821	0.0000
Error S.D.	38.4473	23.4370	60.4385	34.8463	0.0000
Abs E. Mean	21.9931	13.3260	35.9326	25.9656	0.0000
S.D. Ratio	0.5530	0.3801	0.8093	0.4618	0.0000
Correlation	0.8341	0.9261	0.5944	0.8870	0.0000

Heating Degree Days

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	49.5484	35.7333	22.5333	0.0000
Data S.D.	69.5189	87.5453	42.2934	38.9219	0.0000
Error Mean	2.5833	-7.8950	9.7553	17.0664	0.0000
Error S.D.	43.9635	54.3013	20.6034	29.2158	0.0000
Abs E. Mean	29.6496	35.4153	20.8173	26.5660	0.0000
S.D. Ratio	0.6324	0.6203	0.4872	0.7506	0.0000
Correlation	0.7751	0.7916	0.8773	0.8051	0.0000

Conductivity

	Overall	Training	Selection	Test	Ignored
Data Mean	39.5082	53.4839	30.9333	19.2000	0.0000
Data S.D.	69.5189	82.1014	64.8192	25.1375	0.0000
Error Mean	2.0291	-0.6146	3.5909	5.9308	0.0000
Error S.D.	29.5091	33.0461	21.8083	27.8673	0.0000
Abs E. Mean	20.0452	20.0084	18.0149	22.1514	0.0000
S.D. Ratio	0.4245	0.4025	0.3364	1.1086	0.0000
Correlation	0.9055	0.9154	0.9431	0.0806	0.0000

Table 2.8. Station 101 Chlorophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	64.9524	55.2000	22.8000	0.0000
Data S.D.	76.1584	84.4108	83.2308	25.9877	0.0000
Error Mean	2.1605	-1.7917	9.6096	3.0113	0.0000
Error S.D.	45.1901	59.7418	15.2376	23.5905	0.0000
Abs E. Mean	25.5274	35.5499	12.5009	17.5066	0.0000
S.D. Ratio	0.5934	0.7078	0.1831	0.9078	0.0000
Correlation	0.8085	0.7108	0.9858	0.5051	0.0000

Wind Speed

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	60.9524	26.8000	59.6000	0.0000
Data S.D.	76.1584	81.1902	50.2490	80.9434	0.0000
Error Mean	-6.9679	-0.2660	2.9924	-31.0023	0.0000
Error S.D.	41.7143	4.2374	7.9569	79.1337	0.0000
Abs E. Mean	14.1931	3.2795	7.0008	44.3041	0.0000
S.D. Ratio	0.5477	0.0522	0.1583	0.9776	0.0000
Correlation	0.8380	0.9986	0.9886	0.2665	0.0000

Initial Chlorophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	52.9524	37.2000	66.0000	0.0000
Data S.D.	76.1584	84.8430	51.6620	74.6887	0.0000
Error Mean	-10.3163	-0.2961	3.5703	-45.2454	0.0000
Error S.D.	42.6633	6.3702	11.5640	74.9665	0.0000
Abs E. Mean	17.0565	4.3282	9.7764	51.0663	0.0000
S.D. Ratio	0.5602	0.0751	0.2238	1.0037	0.0000
Correlation	0.8304	0.9972	0.9766	0.0663	0.0000

Chloride

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	57.5238	55.6000	38.0000	0.0000
Data S.D.	76.1584	93.7228	54.6245	45.5807	0.0000
Error Mean	-3.1397	-0.6273	-0.6224	-10.9329	0.0000
Error S.D.	19.8697	9.5897	22.7663	28.7568	0.0000
Abs E. Mean	13.6936	7.2527	18.3961	22.5170	0.0000
S.D. Ratio	0.2609	0.1023	0.4168	0.6309	0.0000
Correlation	0.9654	0.9948	0.9142	0.8505	0.0000

Initial Cyanophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	48.3810	72.8000	40.0000	0.0000
Data S.D.	76.1584	82.7886	77.2073	53.1263	0.0000
Error Mean	4.6472	0.7738	-6.2964	23.7250	0.0000
Error S.D.	41.3731	22.5632	66.4366	31.9364	0.0000
Abs E. Mean	26.5663	16.7325	43.9314	29.8523	0.0000
S.D. Ratio	0.5432	0.2725	0.8605	0.6011	0.0000
Correlation	0.8446	0.9630	0.5222	0.9445	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	38.8571	83.2000	49.6000	0.0000
Data S.D.	76.1584	62.4837	93.0686	74.6876	0.0000
Error Mean	-7.1437	1.4411	-9.2576	-23.0576	0.0000
Error S.D.	44.3338	7.6390	32.7639	80.3118	0.0000
Abs E. Mean	21.3876	6.1608	24.1121	50.6394	0.0000
S.D. Ratio	0.5821	0.1223	0.3520	1.0753	0.0000
Correlation	0.8131	0.9928	0.9516	-0.0658	0.0000

pH

	Overall	Training	Selection	Test	Ignored
Data Mean	52.2927	60.0000	52.8000	35.6000	0.0000
Data S.D.	76.1584	85.9324	80.8515	36.5053	0.0000
Error Mean	0.3654	-0.4401	2.2339	0.1884	0.0000
Error S.D.	44.8187	53.4955	19.4836	42.9132	0.0000
Abs E. Mean	27.1660	30.7232	14.9307	31.9312	0.0000
S.D. Ratio	0.5885	0.6225	0.2410	1.1755	0.0000
Correlation	0.8097	0.7840	0.9716	0.4010	0.0000

Table 2.9. Station 101 Chlorophyta two-week prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	47.2000	49.0000	29.6000	61.2000	0.0000
Data S.D.	69.0229	79.0025	51.4805	58.4068	0.0000
Error Mean	3.4848	-1.3695	1.4297	15.2483	0.0000
Error S.D.	23.2298	8.4670	20.9365	37.2430	0.0000
Abs E. Mean	14.9488	7.1205	16.7078	28.8464	0.0000
S.D. Ratio	0.3366	0.1072	0.4067	0.6376	0.0000
Correlation	0.9437	0.9955	0.9201	0.8602	0.0000

Conductivity

	Overall	Training	Selection	Test	Ignored
Data Mean	47.2000	48.0000	59.2000	33.6000	0.0000
Data S.D.	69.0229	63.6113	94.2983	41.7306	0.0000
Error Mean	-3.8641	0.2458	-6.4839	-9.4639	0.0000
Error S.D.	26.6604	7.6816	40.9492	31.2449	0.0000
Abs E. Mean	17.5693	6.1131	31.3041	26.7467	0.0000
S.D. Ratio	0.3863	0.1208	0.4343	0.7487	0.0000
Correlation	0.9228	0.9930	0.9028	0.6651	0.0000

Point View Reservoir extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	47.2000	60.2000	47.6000	20.8000	0.0000
Data S.D.	69.0229	80.6818	55.0331	44.4270	0.0000
Error Mean	6.9036	0.0752	0.8163	26.6476	0.0000
Error S.D.	40.2043	46.3976	23.3724	33.0708	0.0000
Abs E. Mean	32.0039	34.9701	19.2325	38.8428	0.0000
S.D. Ratio	0.5825	0.5751	0.4247	0.7444	0.0000
Correlation	0.8175	0.8239	0.9148	0.7615	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	48.0976	41.5238	58.4000	51.6000	0.0000
Data S.D.	68.4119	52.1021	70.3409	91.2745	0.0000
Error Mean	-2.3203	-0.1808	6.4557	-15.5892	0.0000
Error S.D.	29.9248	15.2907	39.0349	37.3378	0.0000
Abs E. Mean	19.4975	12.5999	26.1160	27.3637	0.0000
S.D. Ratio	0.4374	0.2935	0.5549	0.4091	0.0000
Correlation	0.8993	0.9561	0.8356	0.9192	0.0000

Initial Chlorophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	48.0976	48.5714	71.2000	24.0000	0.0000
Data S.D.	68.4119	72.6981	73.0545	40.4772	0.0000
Error Mean	6.9443	0.1005	-8.1355	36.3962	0.0000
Error S.D.	43.5721	2.2774	30.3192	75.2373	0.0000
Abs E. Mean	18.7310	1.8951	27.4413	45.3762	0.0000
S.D. Ratio	0.6369	0.0313	0.4150	1.8588	0.0000
Correlation	0.8011	0.9995	0.9199	0.2150	0.0000

Total Hardness

	Overall	Training	Selection	Test	Ignored
Data Mean	47.2000	63.0000	17.6000	45.2000	0.0000
Data S.D.	69.0229	81.3376	23.8126	62.2781	0.0000
Error Mean	-5.6438	-6.7384	-4.9580	-4.1402	0.0000
Error S.D.	38.5653	36.1132	11.3719	56.6246	0.0000
Abs E. Mean	23.4124	24.4337	8.9943	35.7881	0.0000
S.D. Ratio	0.5587	0.4440	0.4776	0.9092	0.0000
Correlation	0.8446	0.9120	0.8859	0.4736	0.0000

Table 3.1. Station 612 Cyanophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	72.9744	33.6667	2.4444	0.0000
Data S.D.	149.4134	182.4988	131.1255	6.1303	0.0000
Error Mean	2.1039	-2.6672	-1.4942	16.0393	0.0000
Error S.D.	54.8670	30.8736	88.7730	48.3836	0.0000
Abs E. Mean	32.9398	22.5193	55.3181	33.1392	0.0000
S.D. Ratio	0.3672	0.1692	0.6770	7.8926	0.0000
Correlation	0.9313	0.9865	0.7399	0.2530	0.0000

Initial Cyanophyta level

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	84.0000	4.0000	8.2222	0.0000
Data S.D.	149.4134	199.5549	13.7275	15.1714	0.0000
Error Mean	5.6224	0.4057	-1.0427	23.5904	0.0000
Error S.D.	53.1228	9.9826	18.4341	103.8098	0.0000
Abs E. Mean	12.8630	5.8452	9.2611	31.6701	0.0000
S.D. Ratio	0.3555	0.0500	1.3429	6.8424	0.0000
Correlation	0.9414	0.9988	-0.1223	0.7997	0.0000

Ammonia

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	35.5385	81.1111	36.1111	0.0000
Data S.D.	149.4134	142.2223	174.6809	130.8170	0.0000
Error Mean	-14.8589	-0.9962	-27.8129	-31.9408	0.0000
Error S.D.	68.9132	17.1544	69.4617	115.9703	0.0000
Abs E. Mean	28.6050	13.6993	42.7216	46.7841	0.0000
S.D. Ratio	0.4612	0.1206	0.3976	0.8865	0.0000
Correlation	0.8885	0.9928	0.9271	0.5380	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	59.1795	60.4444	5.5556	0.0000
Data S.D.	149.4134	170.7262	165.6389	14.4922	0.0000
Error Mean	5.3933	5.6177	-3.3134	13.6139	0.0000
Error S.D.	58.4394	68.0245	29.0264	56.7268	0.0000
Abs E. Mean	22.0962	27.8432	16.1207	15.6198	0.0000
S.D. Ratio	0.3911	0.3984	0.1752	3.9143	0.0000
Correlation	0.9219	0.9178	0.9850	0.9326	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	51.7949	78.6667	3.3333	0.0000
Data S.D.	149.4134	163.3846	179.3878	6.4291	0.0000
Error Mean	-1.6527	-0.6033	-1.1573	-4.4216	0.0000
Error S.D.	70.8245	41.0935	127.4436	31.4565	0.0000
Abs E. Mean	34.5983	27.4025	57.8315	26.9560	0.0000
S.D. Ratio	0.4740	0.2515	0.7104	4.8928	0.0000
Correlation	0.8805	0.9719	0.7161	0.1134	0.0000

Total Organic Carbon (TOC)

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	40.1026	102.6667	4.6667	0.0000
Data S.D.	149.4134	135.4604	219.4751	9.9107	0.0000
Error Mean	3.3324	1.2862	-7.3737	18.4721	0.0000
Error S.D.	53.6998	21.6796	91.1084	48.4074	0.0000
Abs E. Mean	28.8333	16.2059	50.3322	34.6936	0.0000
S.D. Ratio	0.3594	0.1600	0.4151	4.8844	0.0000
Correlation	0.9338	0.9875	0.9207	-0.1613	0.0000

Temperature

	Overall	Training	Selection	Test	Ignored
Data Mean	46.6133	47.8462	42.6667	47.8889	0.0000
Data S.D.	149.4134	153.3612	155.6920	133.4108	0.0000
Error Mean	12.9053	-0.1683	0.6737	53.4631	0.0000
Error S.D.	71.0913	11.8015	10.8813	135.9160	0.0000
Abs E. Mean	18.4026	6.7044	6.7039	55.4475	0.0000
S.D. Ratio	0.4758	0.0770	0.0699	1.0188	0.0000
Correlation	0.9371	0.9970	0.9976	0.9888	0.0000

Table 3.2. Station 612 Cyanophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	27.8462	86.7692	3.3846	0.0000
Data S.D.	134.9203	126.5761	192.2779	5.1670	0.0000
Error Mean	2.6056	-0.0552	4.5856	5.9472	0.0000
Error S.D.	21.2947	3.7739	35.6892	21.9638	0.0000
Abs E. Mean	11.3872	3.2145	25.3985	13.7214	0.0000
S.D. Ratio	0.1578	0.0298	0.1856	4.2508	0.0000
Correlation	0.9875	0.9996	0.9834	-0.2725	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	31.2308	3.3846	80.0000	0.0000
Data S.D.	134.9203	126.4815	6.9894	194.2306	0.0000
Error Mean	-7.7870	-0.5113	-0.0660	-30.0595	0.0000
Error S.D.	40.8070	12.3116	6.9882	75.1485	0.0000
Abs E. Mean	13.5518	7.1921	5.1712	34.6516	0.0000
S.D. Ratio	0.3025	0.0973	0.9998	0.3869	0.0000
Correlation	0.9586	0.9953	0.3666	0.9451	0.0000

Initial Cyanophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	57.2308	4.9231	26.4615	0.0000
Data S.D.	134.9203	178.0260	8.8965	85.9701	0.0000
Error Mean	-2.0128	-0.5159	0.0915	-7.1110	0.0000
Error S.D.	27.1343	6.4036	5.0409	52.9410	0.0000
Abs E. Mean	9.2025	5.0464	3.4464	23.2709	0.0000
S.D. Ratio	0.2011	0.0360	0.5666	0.6158	0.0000
Correlation	0.9798	0.9994	0.8242	0.9671	0.0000

Total Organic Carbon (TOC)

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	40.9231	61.5385	2.4615	0.0000
Data S.D.	134.9203	138.4232	180.6419	5.9822	0.0000
Error Mean	0.4675	0.0924	0.9653	0.7201	0.0000
Error S.D.	7.2100	6.8286	8.4628	6.5165	0.0000
Abs E. Mean	5.1864	4.6207	6.9307	4.5734	0.0000
S.D. Ratio	0.0534	0.0493	0.0468	1.0893	0.0000
Correlation	0.9986	0.9988	0.9990	0.0071	0.0000

Turbidity

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	29.8462	29.5385	56.6154	0.0000
Data S.D.	134.9203	126.7498	85.1647	181.3511	0.0000
Error Mean	-2.2821	0.1567	-7.0428	-2.3989	0.0000
Error S.D.	9.6332	3.6561	9.2607	14.9709	0.0000
Abs E. Mean	6.1284	2.5379	8.0738	11.3642	0.0000
S.D. Ratio	0.0714	0.0288	0.1087	0.0826	0.0000
Correlation	0.9976	0.9996	0.9952	0.9969	0.0000

Initial Chrysophyta Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	26.9231	60.9231	31.0769	0.0000
Data S.D.	134.9203	126.6931	180.7346	85.0723	0.0000
Error Mean	-4.6034	0.1864	-0.6752	-18.1113	0.0000
Error S.D.	28.3091	4.4896	8.0064	53.4549	0.0000
Abs E. Mean	8.5063	2.9199	6.3743	21.8108	0.0000
S.D. Ratio	0.2098	0.0354	0.0443	0.6283	0.0000
Correlation	0.9778	0.9994	0.9993	0.9918	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	36.4615	40.1538	63.0769	2.4615	0.0000
Data S.D.	134.9203	138.6417	180.1617	4.5845	0.0000
Error Mean	0.5331	-0.0514	2.0581	0.1770	0.0000
Error S.D.	18.9033	6.1713	36.4236	4.8326	0.0000
Abs E. Mean	7.4394	3.7627	18.1785	4.0535	0.0000
S.D. Ratio	0.1401	0.0445	0.2022	1.0541	0.0000
Correlation	0.9902	0.9990	0.9797	-0.2565	0.0000

Table 3.3. Station 612 Cyanophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	90.4286	5.2308	16.0000	0.0000
Data S.D.	174.8345	234.2730	18.1199	42.0403	0.0000
Error Mean	-0.5241	-2.8803	6.1653	-2.1384	0.0000
Error S.D.	58.6287	74.7004	7.5090	46.2991	0.0000
Abs E. Mean	22.3903	28.1473	8.0155	24.3652	0.0000
S.D. Ratio	0.3353	0.3189	0.4144	1.1013	0.0000
Correlation	0.9442	0.9501	0.9390	0.0248	0.0000

pH

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	84.8571	30.1538	3.0769	0.0000
Data S.D.	174.8345	230.4340	85.7849	6.8664	0.0000
Error Mean	3.0282	2.6387	1.6539	5.2412	0.0000
Error S.D.	32.1900	43.1307	7.8491	15.1255	0.0000
Abs E. Mean	12.6718	18.8605	5.1221	6.8919	0.0000
S.D. Ratio	0.1841	0.1872	0.0915	2.2028	0.0000
Correlation	0.9830	0.9825	0.9958	0.2383	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	83.2857	6.7692	29.8462	0.0000
Data S.D.	174.8345	227.3325	18.0519	103.3901	0.0000
Error Mean	-1.2940	-1.2810	8.6520	-11.2682	0.0000
Error S.D.	58.7092	33.7564	9.8457	107.5533	0.0000
Abs E. Mean	23.8148	19.4290	10.7419	46.3338	0.0000
S.D. Ratio	0.3358	0.1485	0.5454	1.0403	0.0000
Correlation	0.9421	0.9890	0.8842	-0.0598	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	97.0000	6.7692	0.3077	0.0000
Data S.D.	174.8345	233.6313	18.0519	1.0659	0.0000
Error Mean	1.0999	-2.2271	4.5710	4.7947	0.0000
Error S.D.	23.7415	32.4327	4.9741	1.2163	0.0000
Abs E. Mean	10.6844	15.6022	5.9819	4.7947	0.0000
S.D. Ratio	0.1358	0.1388	0.2755	1.1411	0.0000
Correlation	0.9908	0.9904	0.9793	-0.1059	0.0000

Initial Cyanophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	81.5714	6.1538	34.1538	0.0000
Data S.D.	174.8345	227.8905	17.9993	102.3973	0.0000
Error Mean	-6.3198	-0.2837	0.7773	-26.4176	0.0000
Error S.D.	52.2492	8.1368	2.5557	103.2377	0.0000
Abs E. Mean	11.3704	5.0528	2.1755	34.1724	0.0000
S.D. Ratio	0.2988	0.0357	0.1420	1.0082	0.0000
Correlation	0.9544	0.9994	0.9901	-0.0244	0.0000

Passaic streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	90.2857	7.0769	14.4615	0.0000
Data S.D.	174.8345	234.4073	18.1042	41.3775	0.0000
Error Mean	-1.9173	-1.5461	10.6880	-15.3222	0.0000
Error S.D.	34.0447	12.5785	12.5530	63.0653	0.0000
Abs E. Mean	15.9107	8.1929	12.8323	35.6122	0.0000
S.D. Ratio	0.1947	0.0537	0.6934	1.5241	0.0000
Correlation	0.9809	0.9987	0.8372	0.1032	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	52.0000	68.4286	66.7692	1.8462	0.0000
Data S.D.	174.8345	191.1240	212.0516	3.7179	0.0000
Error Mean	4.4525	0.2894	-0.8607	18.7323	0.0000
Error S.D.	33.3906	33.0600	10.3516	43.5952	0.0000
Abs E. Mean	14.2891	15.4230	6.6952	19.4409	0.0000
S.D. Ratio	0.1910	0.1730	0.0488	11.7259	0.0000
Correlation	0.9816	0.9850	0.9988	0.8022	0.0000

Table 3.4. Station 612 Chrysophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	92.2051	84.0000	59.7778	0.0000
Data S.D.	93.8643	109.2434	85.4894	53.1241	0.0000
Error Mean	5.3886	-0.6240	10.3782	13.4263	0.0000
Error S.D.	51.9193	45.3996	61.6526	52.8875	0.0000
Abs E. Mean	42.1518	35.8372	49.1962	48.7891	0.0000
S.D. Ratio	0.5531	0.4156	0.7212	0.9955	0.0000
Correlation	0.8393	0.9134	0.6994	0.4125	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	94.8718	63.5556	74.4444	0.0000
Data S.D.	93.8643	116.4067	64.1788	49.7664	0.0000
Error Mean	-1.9911	-1.5163	-1.2394	-3.7713	0.0000
Error S.D.	60.4220	66.2151	57.0161	49.5686	0.0000
Abs E. Mean	47.3459	51.1806	43.3998	42.9833	0.0000
S.D. Ratio	0.6437	0.5688	0.8884	0.9960	0.0000
Correlation	0.7660	0.8244	0.4668	0.3221	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	94.1538	62.0000	77.5556	0.0000
Data S.D.	93.8643	113.3240	72.2619	54.0804	0.0000
Error Mean	-1.3187	-4.7996	6.5697	-1.6652	0.0000
Error S.D.	57.3981	54.9185	39.9850	74.1963	0.0000
Abs E. Mean	40.7641	38.3085	34.7098	52.1386	0.0000
S.D. Ratio	0.6115	0.4846	0.5533	1.3720	0.0000
Correlation	0.7927	0.8748	0.8792	-0.0940	0.0000

Initial Chrysophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	94.8718	63.5556	74.4444	0.0000
Data S.D.	93.8643	116.4067	64.1788	49.7664	0.0000
Error Mean	-1.9911	-1.5163	-1.2394	-3.7713	0.0000
Error S.D.	60.4220	66.2151	57.0161	49.5686	0.0000
Abs E. Mean	47.3459	51.1806	43.3998	42.9833	0.0000
S.D. Ratio	0.6437	0.5688	0.8884	0.9960	0.0000
Correlation	0.7660	0.8244	0.4668	0.3221	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	90.3077	83.0000	64.8889	0.0000
Data S.D.	93.8643	113.4002	78.2879	47.7131	0.0000
Error Mean	-2.5430	-0.1001	-17.6098	7.2309	0.0000
Error S.D.	51.8959	59.2997	32.8774	46.7571	0.0000
Abs E. Mean	38.5880	44.7330	27.7262	36.1358	0.0000
S.D. Ratio	0.5529	0.5229	0.4200	0.9800	0.0000
Correlation	0.8394	0.8577	0.9505	0.6710	0.0000

Initial Chlorophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	89.0769	77.7778	72.7778	0.0000
Data S.D.	93.8643	117.8150	53.3204	59.8559	0.0000
Error Mean	-2.6262	-3.4141	8.1796	-11.7251	0.0000
Error S.D.	48.0040	38.7253	34.5486	70.4120	0.0000
Abs E. Mean	36.2413	28.8033	31.2067	57.3914	0.0000
S.D. Ratio	0.5114	0.3287	0.6479	1.1764	0.0000
Correlation	0.8603	0.9528	0.7804	-0.0669	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	81.7436	60.4444	106.0000	0.0000
Data S.D.	93.8643	105.3231	53.8457	93.4689	0.0000
Error Mean	8.8344	-5.8051	-0.0344	49.4221	0.0000
Error S.D.	82.7555	50.6932	36.1689	139.5308	0.0000
Abs E. Mean	50.7052	37.6623	30.6999	98.9700	0.0000
S.D. Ratio	0.8816	0.4813	0.6717	1.4928	0.0000
Correlation	0.6617	0.8811	0.7419	0.4689	0.0000

Initial Cyanophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	82.4533	90.3590	52.0000	95.7778	0.0000
Data S.D.	93.8643	105.2303	62.9038	86.7228	0.0000
Error Mean	9.4930	-0.4495	4.2401	36.2881	0.0000
Error S.D.	80.8553	17.2881	39.6693	155.1095	0.0000
Abs E. Mean	42.5441	13.6988	32.7707	114.8157	0.0000
S.D. Ratio	0.8614	0.1643	0.6306	1.7886	0.0000
Correlation	0.6590	0.9864	0.7792	-0.1256	0.0000

Table 3.5. Station 612 Chrysophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	58.1538	57.5385	81.2308	0.0000
Data S.D.	55.0324	45.7986	40.3535	76.7074	0.0000
Error Mean	-3.6228	-1.5388	1.0042	-12.4177	0.0000
Error S.D.	37.4465	15.9067	27.5314	65.0959	0.0000
Abs E. Mean	20.8285	13.2252	18.9483	37.9153	0.0000
S.D. Ratio	0.6804	0.3473	0.6823	0.8486	0.0000
Correlation	0.7340	0.9416	0.7693	0.5471	0.0000

Passaic streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	58.0000	80.3077	58.7692	0.0000
Data S.D.	55.0324	43.1277	79.8685	40.6224	0.0000
Error Mean	-6.3363	0.6985	-17.6759	-9.0666	0.0000
Error S.D.	27.3186	11.8595	27.9206	41.1016	0.0000
Abs E. Mean	19.2228	9.5748	23.3834	34.3584	0.0000
S.D. Ratio	0.4964	0.2750	0.3496	1.0118	0.0000
Correlation	0.8684	0.9615	0.9499	0.3885	0.0000

Initial Chrysophyt Levels

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	61.3846	66.4615	65.8462	0.0000
Data S.D.	55.0324	61.2580	41.5556	53.4730	0.0000
Error Mean	-3.3572	-0.3235	-7.9981	-4.7838	0.0000
Error S.D.	34.8296	32.3070	29.8897	42.7731	0.0000
Abs E. Mean	26.7437	24.4337	24.9528	33.1546	0.0000
S.D. Ratio	0.6329	0.5274	0.7193	0.7999	0.0000
Correlation	0.7753	0.8864	0.7549	0.6159	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	73.8462	50.7692	56.6154	0.0000
Data S.D.	55.0324	66.3532	42.8919	32.3384	0.0000
Error Mean	4.7751	3.0008	0.0949	13.0037	0.0000
Error S.D.	31.1679	32.9151	23.2941	32.8697	0.0000
Abs E. Mean	25.5671	26.0487	18.1361	32.0351	0.0000
S.D. Ratio	0.5664	0.4961	0.5431	1.0164	0.0000
Correlation	0.8242	0.8712	0.8401	0.4168	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	64.1538	62.7692	64.0000	0.0000
Data S.D.	55.0324	65.1576	35.5141	48.5862	0.0000
Error Mean	2.1687	2.7277	3.0706	0.1487	0.0000
Error S.D.	35.4093	30.9131	24.0220	50.2142	0.0000
Abs E. Mean	28.2554	26.0828	18.8833	41.9727	0.0000
S.D. Ratio	0.6434	0.4744	0.6764	1.0335	0.0000
Correlation	0.7661	0.8848	0.7434	0.3972	0.0000

Ammonia

	Overall	Training	Selection	Test	Ignored
Data Mean	63.7692	62.7692	72.3077	57.2308	0.0000
Data S.D.	55.0324	64.0170	46.1826	40.8339	0.0000
Error Mean	-3.5057	0.0282	0.3932	-14.4726	0.0000
Error S.D.	28.6472	12.6997	27.5463	45.1757	0.0000
Abs E. Mean	21.2630	9.5956	22.8585	43.0023	0.0000
S.D. Ratio	0.5206	0.1984	0.5965	1.1063	0.0000
Correlation	0.8624	0.9802	0.8026	0.4673	0.0000

Table 3.6. Station 612 Chrysophyta two-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	112.0714	61.2308	46.4615	0.0000
Data S.D.	110.2768	141.3046	53.2370	32.4028	0.0000
Error Mean	12.5830	-1.6977	11.7972	44.1270	0.0000
Error S.D.	73.8329	84.8177	42.0034	62.8477	0.0000
Abs E. Mean	50.5494	58.5165	34.1303	49.8086	0.0000
S.D. Ratio	0.6695	0.6002	0.7890	1.9396	0.0000
Correlation	0.7482	0.8019	0.6348	-0.2779	0.0000

Ammonia

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	73.7857	127.0769	63.0769	0.0000
Data S.D.	110.2768	83.6410	173.6639	52.6271	0.0000
Error Mean	2.3748	1.5868	-4.2545	10.7014	0.0000
Error S.D.	56.0624	14.6823	44.5424	102.4331	0.0000
Abs E. Mean	32.2738	11.1379	37.4576	72.6136	0.0000
S.D. Ratio	0.5084	0.1755	0.2565	1.9464	0.0000
Correlation	0.8701	0.9845	0.9671	-0.0254	0.0000

Pompton river extractions

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	95.6429	92.9231	50.1538	0.0000
Data S.D.	110.2768	96.5313	167.2375	30.9686	0.0000
Error Mean	2.4002	-0.5206	-0.9949	12.0862	0.0000
Error S.D.	56.0328	64.5468	53.9078	32.2244	0.0000
Abs E. Mean	43.8035	50.7065	43.7794	28.9597	0.0000
S.D. Ratio	0.5081	0.6687	0.3223	1.0406	0.0000
Correlation	0.8617	0.7479	0.9521	0.2633	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	85.0714	100.6154	65.2308	0.0000
Data S.D.	110.2768	127.5712	110.6273	50.9210	0.0000
Error Mean	10.1577	2.5392	-13.0643	49.7889	0.0000
Error S.D.	62.5316	23.7446	51.8744	100.5096	0.0000
Abs E. Mean	38.9658	18.7563	38.9346	82.5251	0.0000
S.D. Ratio	0.5670	0.1861	0.4689	1.9738	0.0000
Correlation	0.8466	0.9826	0.8848	0.1427	0.0000

Turbidity

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	73.3571	132.9231	58.1538	0.0000
Data S.D.	110.2768	67.7813	185.9108	52.4505	0.0000
Error Mean	-4.5864	0.3778	-19.0021	-0.8630	0.0000
Error S.D.	45.1208	13.4675	66.5997	57.9297	0.0000
Abs E. Mean	27.7596	9.8219	51.5087	42.6455	0.0000
S.D. Ratio	0.4092	0.1987	0.3582	1.1045	0.0000
Correlation	0.9159	0.9821	0.9459	0.1210	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	80.9286	68.6154	106.1538	0.0000
Data S.D.	110.2768	83.7368	90.5076	162.7049	0.0000
Error Mean	-3.5121	3.0925	-3.4597	-17.7899	0.0000
Error S.D.	47.6026	29.1413	64.1017	56.3624	0.0000
Abs E. Mean	32.3922	22.7082	45.6654	39.9769	0.0000
S.D. Ratio	0.4317	0.3480	0.7082	0.3464	0.0000
Correlation	0.9141	0.9375	0.7160	0.9784	0.0000

Sulfate

	Overall	Training	Selection	Test	Ignored
Data Mean	84.0370	87.4286	99.8462	60.9231	0.0000
Data S.D.	110.2768	130.4441	102.9905	49.4935	0.0000
Error Mean	2.5344	1.0419	-5.0044	13.2878	0.0000
Error S.D.	44.9885	8.6022	52.7284	72.7346	0.0000
Abs E. Mean	28.4957	6.8671	44.2293	59.3467	0.0000
S.D. Ratio	0.4080	0.0659	0.5120	1.4696	0.0000
Correlation	0.9161	0.9979	0.8595	0.1401	0.0000

Table 3.7 Station 612 Chlorophyta real-time prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	42.3846	57.9444	52.0000	0.0000
Data S.D.	69.1854	55.7621	99.8858	55.2047	0.0000
Error Mean	-8.7006	1.3255	-13.8199	-25.3045	0.0000
Error S.D.	45.2187	23.3804	49.9184	65.7556	0.0000
Abs E. Mean	27.7548	17.0565	26.3669	52.3226	0.0000
S.D. Ratio	0.6536	0.4193	0.4998	1.1911	0.0000
Correlation	0.7586	0.9108	0.9366	0.2802	0.0000

Sky Cover

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	38.4103	45.7778	72.7778	0.0000
Data S.D.	69.1854	43.9334	97.7454	73.4216	0.0000
Error Mean	-5.2404	0.0633	-11.4410	-10.5311	0.0000
Error S.D.	74.1886	2.1759	59.0739	138.9451	0.0000
Abs E. Mean	28.8939	1.4201	35.8873	81.4272	0.0000
S.D. Ratio	1.0723	0.0495	0.6044	1.8924	0.0000
Correlation	0.5862	0.9988	0.7973	0.4025	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	53.3077	27.3889	58.8889	0.0000
Data S.D.	69.1854	78.3219	26.7688	73.0273	0.0000
Error Mean	-0.9849	1.2997	-1.7038	-5.2159	0.0000
Error S.D.	43.6931	29.1980	15.5996	76.3828	0.0000
Abs E. Mean	28.0267	20.5462	13.3195	58.9415	0.0000
S.D. Ratio	0.6315	0.3728	0.5828	1.0459	0.0000
Correlation	0.7754	0.9330	0.8206	0.2037	0.0000

Pompton streamflow

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	53.3846	52.0556	34.0556	0.0000
Data S.D.	69.1854	82.1158	54.7321	45.4514	0.0000
Error Mean	9.0568	9.4707	-9.6942	26.9112	0.0000
Error S.D.	47.8647	44.4765	33.1035	59.1045	0.0000
Abs E. Mean	36.2295	36.3700	29.4657	42.6887	0.0000
S.D. Ratio	0.6918	0.5416	0.6048	1.3004	0.0000
Correlation	0.7469	0.8406	0.8005	0.5250	0.0000

Chloride

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	56.8974	44.0556	34.4444	0.0000
Data S.D.	69.1854	64.0356	93.6331	43.8460	0.0000
Error Mean	4.4487	0.0403	1.0225	17.4266	0.0000
Error S.D.	49.2385	10.0717	48.6509	85.3981	0.0000
Abs E. Mean	22.3790	6.2856	29.2004	50.4268	0.0000
S.D. Ratio	0.7117	0.1573	0.5196	1.9477	0.0000
Correlation	0.7394	0.9876	0.8751	0.0758	0.0000

Heating Degree Days

	Overall	Training	Selection	Test	Ignored
Data Mean	48.4267	45.8974	53.3333	49.0000	0.0000
Data S.D.	69.1854	72.9326	54.8655	73.2863	0.0000
Error Mean	1.4915	1.0172	-17.3670	21.3777	0.0000
Error S.D.	97.9475	11.7274	36.6883	193.8510	0.0000
Abs E. Mean	33.2390	9.7828	29.9000	87.3996	0.0000
S.D. Ratio	1.4157	0.1608	0.6687	2.6451	0.0000
Correlation	0.3993	0.9870	0.7437	-0.0794	0.0000

Table 3.8. Station 612 Chlorophyta one-week ahead prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	54.6154	48.9231	24.5385	0.0000
Data S.D.	72.7233	95.9419	29.5256	35.4414	0.0000
Error Mean	2.5785	-0.7814	4.5201	7.3569	0.0000
Error S.D.	21.2259	15.0809	16.6214	31.9660	0.0000
Abs E. Mean	15.3043	10.7396	14.7994	24.9387	0.0000
S.D. Ratio	0.2919	0.1572	0.5629	0.9019	0.0000
Correlation	0.9580	0.9878	0.8926	0.5898	0.0000

Initial Chrysophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	37.4231	74.4615	33.3846	0.0000
Data S.D.	72.7233	43.0940	121.7163	38.8558	0.0000
Error Mean	0.6889	1.3829	-28.5413	28.5313	0.0000
Error S.D.	73.2113	11.5963	89.1064	107.7037	0.0000
Abs E. Mean	38.0081	10.0437	57.0093	74.9355	0.0000
S.D. Ratio	1.0067	0.2691	0.7321	2.7719	0.0000
Correlation	0.5545	0.9633	0.6900	0.7538	0.0000

Total Count

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	57.0385	38.1538	30.4615	0.0000
Data S.D.	72.7233	94.3123	38.2257	36.8461	0.0000
Error Mean	17.3008	0.3241	-4.3695	72.9248	0.0000
Error S.D.	91.6739	7.5616	25.2887	169.4771	0.0000
Abs E. Mean	26.2386	5.6481	16.4029	77.2553	0.0000
S.D. Ratio	1.2606	0.0802	0.6616	4.5996	0.0000
Correlation	0.6710	0.9968	0.7518	0.8306	0.0000

Total Phosphorous/Orthophosphate

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	72.0000	12.4615	26.2308	0.0000
Data S.D.	72.7233	92.4138	10.2928	33.1805	0.0000
Error Mean	5.3511	-0.4713	-0.0907	22.4377	0.0000
Error S.D.	27.5958	16.2678	8.9063	45.2565	0.0000
Abs E. Mean	15.6509	10.9230	7.2012	33.5563	0.0000
S.D. Ratio	0.3795	0.1760	0.8653	1.3639	0.0000
Correlation	0.9349	0.9844	0.5555	0.8932	0.0000

Initial Chlorophyta Level

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	47.9615	28.0000	58.7692	0.0000
Data S.D.	72.7233	91.4425	24.5075	57.7610	0.0000
Error Mean	-3.9743	-0.2591	1.5452	-16.9242	0.0000
Error S.D.	37.3478	15.1723	12.7552	68.7792	0.0000
Abs E. Mean	20.9285	9.7806	10.0609	54.0920	0.0000
S.D. Ratio	0.5136	0.1659	0.5205	1.1908	0.0000
Correlation	0.8603	0.9862	0.8540	-0.0213	0.0000

Pompton river extraction

	Overall	Training	Selection	Test	Ignored
Data Mean	45.6731	59.2308	32.1538	32.0769	0.0000
Data S.D.	72.7233	95.6469	27.8508	36.7035	0.0000
Error Mean	6.9174	0.0573	4.2781	23.2771	0.0000
Error S.D.	43.9091	21.5311	19.1966	77.7665	0.0000
Abs E. Mean	21.8449	15.0025	17.3043	40.0702	0.0000
S.D. Ratio	0.6038	0.2251	0.6893	2.1188	0.0000
Correlation	0.8213	0.9749	0.7310	0.0390	0.0000

Table 3.9. Station 612 Chlorophyta two-week prediction models
DESCRIPTIVE STATISTICS

All Inputs

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	55.8519	33.0000	28.5385	0.0000
Data S.D.	59.7010	73.7522	42.8055	27.3963	0.0000
Error Mean	1.2390	-0.2371	-2.8845	8.4282	0.0000
Error S.D.	25.0725	20.0515	27.6132	29.8683	0.0000
Abs E. Mean	19.8913	15.7009	23.5160	24.9695	0.0000
S.D. Ratio	0.4200	0.2719	0.6451	1.0902	0.0000
Correlation	0.9080	0.9624	0.8352	0.5270	0.0000

Odor

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	46.8519	44.6154	35.6154	0.0000
Data S.D.	59.7010	69.4117	46.7753	47.4318	0.0000
Error Mean	-3.3029	1.0636	-0.1139	-15.5610	0.0000
Error S.D.	42.3058	38.6567	25.4825	57.8255	0.0000
Abs E. Mean	28.3540	30.3160	18.3443	34.2886	0.0000
S.D. Ratio	0.7086	0.5569	0.5448	1.2191	0.0000
Correlation	0.7117	0.8314	0.8397	-0.0923	0.0000

UV254

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	53.6296	23.0769	43.0769	0.0000
Data S.D.	59.7010	72.7879	23.2262	48.5536	0.0000
Error Mean	-0.5471	-0.3963	9.8035	-11.2110	0.0000
Error S.D.	30.4567	20.9233	12.6999	49.9035	0.0000
Abs E. Mean	20.5617	15.0227	15.3561	37.2714	0.0000
S.D. Ratio	0.5102	0.2875	0.5468	1.0278	0.0000
Correlation	0.8608	0.9578	0.8460	0.1314	0.0000

Total Amorphous Materials

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	47.8148	33.6154	44.6154	0.0000
Data S.D.	59.7010	50.2645	39.9914	86.8717	0.0000
Error Mean	-2.6532	-0.7351	3.5713	-12.8615	0.0000
Error S.D.	49.8569	24.3309	22.6146	90.7883	0.0000
Abs E. Mean	24.4821	17.7615	17.2677	45.6547	0.0000
S.D. Ratio	0.8351	0.4841	0.5655	1.0451	0.0000
Correlation	0.5571	0.8764	0.8388	0.0043	0.0000

current week's Precipitation

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	45.3333	44.9231	38.4615	0.0000
Data S.D.	59.7010	72.4477	45.0136	39.6147	0.0000
Error Mean	2.2159	0.5699	-5.8772	13.7275	0.0000
Error S.D.	46.9430	26.8120	23.9884	81.9264	0.0000
Abs E. Mean	26.2009	16.5712	17.9095	54.4926	0.0000
S.D. Ratio	0.7863	0.3701	0.5329	2.0681	0.0000
Correlation	0.7206	0.9300	0.8470	0.0342	0.0000

Color

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	47.8889	51.0769	27.0000	0.0000
Data S.D.	59.7010	72.1133	52.8138	23.9037	0.0000
Error Mean	2.0440	0.0577	-5.5223	13.7357	0.0000
Error S.D.	31.2042	2.3699	41.5662	45.0351	0.0000
Abs E. Mean	16.6262	1.7873	33.4700	30.6015	0.0000
S.D. Ratio	0.5227	0.0329	0.7870	1.8840	0.0000
Correlation	0.8641	0.9995	0.6431	0.2980	0.0000

Wind Direction

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	47.5556	61.5385	17.2308	0.0000
Data S.D.	59.7010	45.9221	93.2702	20.0544	0.0000
Error Mean	9.2885	0.3379	-12.0916	49.2582	0.0000
Error S.D.	54.2250	14.0806	60.0921	75.7870	0.0000
Abs E. Mean	28.1217	9.3451	38.8377	56.4035	0.0000
S.D. Ratio	0.9083	0.3066	0.6443	3.7791	0.0000
Correlation	0.6082	0.9519	0.7696	0.0473	0.0000

Total Organic Carbon (TOC)

	Overall	Training	Selection	Test	Ignored
Data Mean	43.5472	35.2593	43.3077	61.0000	0.0000
Data S.D.	59.7010	63.8149	42.5882	61.7414	0.0000
Error Mean	-6.4757	4.4567	-9.5890	-26.0682	0.0000
Error S.D.	41.1985	22.5787	26.1839	67.3321	0.0000
Abs E. Mean	27.3926	19.5379	19.4076	51.6911	0.0000
S.D. Ratio	0.6901	0.3538	0.6148	1.0906	0.0000
Correlation	0.7251	0.9386	0.7987	0.0063	0.0000

Table 3.10. Comparison of ANN and LM models for Algae predictions at the three stations

CYANOBACTERIA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	15.01	41.25	2.82	10.37	32.93	93.2
Real-Time Correlation Coefficient	0.96	0.46	0.97	0.0039	0.93	0.5
One-Week Mean Absolute Error	22.55	50.08	2.25	5.85	11.38	24.19
One-Week Correlation Coefficient	0.94	0.13	0.95	0.35	0.99	0.5
Two-Week Mean Absolute Error	15.48	42.86	4.56	16.8	22.39	43.57
Two-Week Correlation Coefficient	0.96	0.49	0.94	0.42	0.94	0.5

CHRYSOPHYTA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	35.97	66.0471	37.93	38.72	42.15	106.25
Real-Time Correlation Coefficient	0.86	0.2310	0.39	0.65	0.84	0.18
One-Week Mean Absolute Error	42.88	89.9135	31.11	29.40	50.55	44.39
One-Week Correlation Coefficient	0.85	0.1818	0.75	0.48	0.75	0.78
Two-Week Mean Absolute Error	28.64	78.1125	26.52	23.56	20.83	23.33
Two-Week Correlation Coefficient	0.89	0.4744	0.59	0.62	0.73	0.54

CHLOROPHYTA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	37.47	71.7835	14.28	30.99	27.75	94.34
Real-Time Correlation Coefficient	0.75	0.5899	0.89	0.65	0.76	0.24
One-Week Mean Absolute Error	30.57	40.5150	14.95	33.43	19.89	29.03
One-Week Correlation Coefficient	0.73	0.6825	0.94	0.65	0.91	0.32
Two-Week Mean Absolute Error	30.91	53.5609	25.53	30.02	15.30	20.12
Two-Week Correlation Coefficient	0.75	0.5038	0.81	0.57	0.96	0.61

APPENDIX A-3C

PVWC (INITIAL) ORIGINAL MODELING
Sensitivity Analyses

Table 4.1. Station 100 Cyanobacteria real-time predictions: Sensitivity Analysis

All Input		
TSS, mg/L	2.656298	1
DO, mg/L	2.531148	2
WindDir	2.177556	3
Pompton extraction	2.150194	4
HeatingDays	1.857288	5
Passaic extractions	1.662716	6
Temp (0C)	1.659592	7
Total Count, cells/ml	1.613225	8
Ammonia, mg/L	1.565445	9
PrevPrecip	1.45653	10
Alkalinity mg/L as CaCO3	1.42249	11
WindSpeed	1.31262	12
Odor	1.19008	13
T.Phosphorus/Orthophosph	1.11931	14
Initial Chrysophyta	1.10090	15
Pompton streamflow	1.09488	16
Turbidity NTU	1.06669	17
SkyCover	1.05816	18
TOC, mg/L	1.05700	19
JAPS extractions	1.05149	20
Initial Chlorophyta	1.04423	21
WkPrecip	1.04376	22
Chloride, mg/L	1.04222	23
Nitrite/Nitrate	1.02735	24
Initial Cyanophyta	1.01336	25
PointRes extractions	1.01169	26
BOD, mg/L	1.00751	27
Sulfate, mg/L	1.00323	28
UV-254, cm-1	1.00300	29
Hardness, Total mg/L as Ca	1.00247	30
Conductivity, umhos/cm	1.00068	31
pH	0.99373	32

Dissolved Oxygen (DO)		
Alkalinity mg/L as CaCO3	2.271221	1
Pompton extraction	1.905625	2
TSS, mg/L	1.890795	3
Nitrite/Nitrate	1.685554	4
WindDir	1.672311	5
T.Phosphorus/Orthophosph	1.529044	6
HeatingDays	1.502498	7
Temp (0C)	1.367439	8
PrevPrecip	1.303646	9
WindSpeed	1.26361	10
Pompton streamflow	1.25286	11
Sulfate, mg/L	1.23154	12
Turbidity NTU	1.20110	13
Odor	1.18870	14
Total Count, cells/ml	1.09498	15
BOD, mg/L	1.09298	16
Ammonia, mg/L	1.06932	17
Initial Cyanophyta	1.05924	18
TOC, mg/L	1.01558	19
UV-254, cm-1	1.01375	20
PointRes extractions	1.00810	21
Initial Chlorophyta	1.00137	22
JAPS extractions	1.00017	23
Initial Chrysophyta	0.99960	24
Chloride, mg/L	0.99819	25
WkPrecip	0.99658	26
Conductivity, umhos/cm	0.99614	27
Passaic extractions	0.99562	28
Hardness, Total mg/L as Ca	0.99286	29
pH	0.97963	30
SkyCover	0.97055	31

Total Suspended Solids		
Odor	1.633813	1
Pompton extraction	1.353477	2
WindDir	1.153735	3
DO, mg/L	1.150629	4
Alkalinity mg/L as CaCO3	1.144782	5
HeatingDays	1.062784	6
PrevPrecip	1.056823	7
Ammonia, mg/L	1.040613	8
Nitrite/Nitrate	1.035340	9
Pompton streamflow	1.03004	10
Initial Chrysophyta	1.02993	11
Sulfate, mg/L	1.02940	12
Total Count, cells/ml	1.02460	13
Turbidity NTU	1.02429	14
WindSpeed	1.01630	15
T.Phosphorus/Orthophosph	1.01625	16
UV-254, cm-1	1.01067	17
Initial Cyanophyta	1.00708	18
SkyCover	1.00660	19
pH	1.00272	20
WkPrecip	1.00182	21
PointRes extractions	0.99953	22
Conductivity, umhos/cm	0.99851	23
JAPS extractions	0.99511	24
Passaic extractions	0.99480	25
BOD, mg/L	0.99404	26
Initial Chlorophyta	0.99366	27
TOC, mg/L	0.99327	28
Chloride, mg/L	0.99009	29
Temp (0C)	0.98765	30
Hardness, Total mg/L as Ca	0.97632	31

Table 4.1. Station 100 Cyanobacteria real-time predictions: Sensitivity Analysis (continued)

Pompton extraction (WSPS)		
TSS, mg/L	2.571796	1
DO, mg/L	2.502710	2
Alkalinity mg/L as CaCO3	2.147737	3
WindDir	2.056945	4
Passaic extractions	1.791554	5
Nitrite/Nitrate	1.570824	6
BOD, mg/L	1.532795	7
T.Phosphorus/Orthophosph	1.466004	8
Turbidity NTU	1.210338	9
Ammonia, mg/L	1.20745	10
TOC, mg/L	1.15166	11
Odor	1.10933	12
pH	1.10843	13
Sulfate, mg/L	1.04362	14
Total Count, cells/ml	1.03863	15
Temp (0C)	1.03275	16
PrevPrecip	1.02587	17
HeatingDays	1.02205	18
PointRes extractions	1.02177	19
Pompton streamflow	1.01994	20
Conductivity, umhos/cm	1.01416	21
UV-254, cm-1	1.01317	22
SkyCover	1.01230	23
Chloride, mg/L	1.01009	24
WkPrecip	1.00982	25
Initial Chrysophyta	1.00729	26
Initial Cyanophyta	1.00624	27
Initial Chlorophyta	1.00019	28
JAPS extractions	0.99921	29
Hardness, Total mg/L as Ca	0.99860	30
WindSpeed	0.98458	31

Conductivity		
Odor	1.615528	1
TSS, mg/L	1.501171	2
T.Phosphorus/Orthophosph	1.446625	3
DO, mg/L	1.361237	4
Nitrite/Nitrate	1.285877	5
Turbidity NTU	1.277718	6
PointRes extractions	1.238084	7
Passaic extractions	1.237371	8
BOD, mg/L	1.226334	9
Pompton extraction	1.21641	10
SkyCover	1.19001	11
Alkalinity mg/L as CaCO3	1.18491	12
Hardness, Total mg/L as Ca	1.17061	13
Ammonia, mg/L	1.12903	14
UV-254, cm-1	1.11373	15
WindDir	1.09515	16
Initial Chrysophyta	1.07692	17
WindSpeed	1.07194	18
TOC, mg/L	1.03493	19
Pompton streamflow	1.03491	20
pH	1.03309	21
WkPrecip	1.01302	22
Temp (0C)	1.01142	23
Initial Cyanophyta	1.01061	24
Total Count, cells/ml	1.00110	25
Sulfate, mg/L	1.00094	26
JAPS extractions	1.00043	27
Chloride, mg/L	1.00008	28
PrevPrecip	0.99991	29
HeatingDays	0.99984	30
Initial Chlorophyta	0.99011	31

pH Level		
PrevPrecip	3.342597	1
Odor	3.328447	2
TSS, mg/L	2.815842	3
WindDir	2.593109	4
Pompton extraction	2.551475	5
DO, mg/L	2.532642	6
Alkalinity mg/L as CaCO3	2.402860	7
Nitrite/Nitrate	2.156453	8
Turbidity NTU	2.031704	9
BOD, mg/L	1.53327	10
WindSpeed	1.47502	11
Pompton streamflow	1.37965	12
Ammonia, mg/L	1.36459	13
T.Phosphorus/Orthophosph	1.31943	14
WkPrecip	1.24671	15
SkyCover	1.24124	16
Initial Cyanophyta	1.13316	17
Temp (0C)	1.11528	18
TOC, mg/L	1.07296	19
UV-254, cm-1	1.06425	20
Sulfate, mg/L	1.05733	21
Passaic extractions	1.04727	22
HeatingDays	1.03853	23
Conductivity, umhos/cm	1.03390	24
Initial Chrysophyta	1.03080	25
PointRes extractions	1.02311	26
Chloride, mg/L	1.00838	27
Total Count, cells/ml	1.00757	28
Hardness, Total mg/L as Ca	1.00607	29
JAPS extractions	1.00224	30
Initial Chlorophyta	0.99002	31

Table 4.2. Station 100 Cyanobacteria one-week ahead predictions: Sensitivity Analysis

All Input		
TSS, mg/L	1.707758	1
WindDir	1.690551	2
Alkalinity mg/L as CaCO3	1.643495	3
Pompton extraction	1.526106	4
HeatingDays	1.479285	5
PrevPrecip	1.406209	6
Ammonia, mg/L	1.309682	7
Odor	1.309053	8
Nitrite/Nitrate	1.243477	9
T.Phosphorus/Orthophosph	1.15696	10
SkyCover	1.13916	11
Chloride, mg/L	1.11992	12
DO, mg/L	1.09915	13
Turbidity NTU	1.09622	14
BOD, mg/L	1.05614	15
TOC, mg/L	1.04318	16
Temp (0C)	1.03837	17
Sulfate, mg/L	1.02625	18
Initial Chlorophyta	1.01692	19
Hardness, Total mg/L as Ca	1.01442	20
WindSpeed	1.00976	21
Initial Cyanophyta	1.00941	22
pH	1.00678	23
JAPS extractions	1.00189	24
Initial Chrysophyta	1.00042	25
Pompton streamflow	0.99999	26
Passaic extractions	0.99692	27
WkPrecip	0.99277	28
Total Count, cells/ml	0.99152	29
UV-254, cm-1	0.99026	30
Conductivity, umhos/cm	0.97659	31
PointRes extractions	0.83975	32

Total Suspended Solids		
Pompton extraction	2.254715	1
DO, mg/L	2.251864	2
WindDir	2.038830	3
Alkalinity mg/L as CaCO3	1.963103	4
Odor	1.838503	5
Sulfate, mg/L	1.791942	6
Turbidity NTU	1.749568	7
BOD, mg/L	1.547533	8
Nitrite/Nitrate	1.401355	9
PrevPrecip	1.37288	10
WindSpeed	1.23402	11
HeatingDays	1.23389	12
TOC, mg/L	1.23114	13
Temp (0C)	1.19181	14
Ammonia, mg/L	1.10404	15
pH	1.06383	16
Passaic extractions	1.05934	17
SkyCover	1.05533	18
UV-254, cm-1	1.04918	19
Pompton streamflow	1.02741	20
Initial Chlorophyta	1.01804	21
WkPrecip	1.01144	22
Chloride, mg/L	1.00459	23
PointRes extractions	1.00366	24
JAPS extractions	1.00187	25
Hardness, Total mg/L as Ca	1.00160	26
Initial Cyanophyta	1.00135	27
T.Phosphorus/Orthophosph	1.00000	28
Conductivity, umhos/cm	0.99879	29
Total Count, cells/ml	0.97919	30
Initial Chrysophyta	0.93464	31

Wind Direction		
DO, mg/L	2.317179	1
Alkalinity mg/L as CaCO3	2.128899	2
Odor	1.646587	3
Pompton extraction	1.567837	4
Nitrite/Nitrate	1.343262	5
Passaic extractions	1.256501	6
T.Phosphorus/Orthophosph	1.246215	7
Sulfate, mg/L	1.180967	8
Turbidity NTU	1.120314	9
Initial Cyanophyta	1.11786	10
SkyCover	1.10700	11
BOD, mg/L	1.08772	12
Ammonia, mg/L	1.08605	13
Hardness, Total mg/L as Ca	1.08300	14
UV-254, cm-1	1.07650	15
Temp (0C)	1.07343	16
TSS, mg/L	1.06632	17
PointRes extractions	1.05095	18
HeatingDays	1.04489	19
Total Count, cells/ml	1.04362	20
WindSpeed	1.04214	21
pH	1.03939	22
Pompton streamflow	1.03515	23
Conductivity, umhos/cm	1.02834	24
Initial Chlorophyta	1.01948	25
Chloride, mg/L	1.00715	26
JAPS extractions	1.00521	27
TOC, mg/L	1.00332	28
WkPrecip	1.00000	29
Initial Chrysophyta	0.99652	30
PrevPrecip	0.99627	31

Table 4.2. Station 100 Cyanobacteria one-week ahead predictions: Sensitivity Analysis (cont.)

Pompton extraction (WSPS)		
Odor	2.283424	1
TSS, mg/L	1.891304	2
Nitrite/Nitrate	1.782804	3
BOD, mg/L	1.780079	4
DO, mg/L	1.754019	5
Total Count, cells/ml	1.548822	6
Hardness, Total mg/L as Ca	1.515699	7
Alkalinity mg/L as CaCO3	1.455126	8
Ammonia, mg/L	1.305248	9
Passaic extractions	1.21241	10
WindSpeed	1.20784	11
SkyCover	1.18787	12
UV-254, cm-1	1.10238	13
Pompton streamflow	1.08972	14
Sulfate, mg/L	1.07251	15
PrevPrecip	1.06823	16
HeatingDays	1.06311	17
TOC, mg/L	1.02841	18
Turbidity NTU	1.02518	19
Initial Chrysophyta	1.02411	20
Initial Chlorophyta	1.02102	21
T.Phosphorus/Orthophosph	1.01757	22
Temp (0C)	1.01742	23
Chloride, mg/L	1.01250	24
Conductivity, umhos/cm	1.01166	25
Initial Cyanophyta	1.00898	26
JAPS extractions	1.00683	27
pH	1.00408	28
PointRes extractions	0.99005	29
WindDir	0.98984	30
WkPrecip	0.96749	31

Conductivity		
DO, mg/L	1.688212	1
PointRes extractions	1.521401	2
Alkalinity mg/L as CaCO3	1.413659	3
Odor	1.293821	4
TSS, mg/L	1.278063	5
Initial Chrysophyta	1.198936	6
WindDir	1.153704	7
UV-254, cm-1	1.144870	8
Sulfate, mg/L	1.135760	9
Turbidity NTU	1.11763	10
Temp (0C)	1.08504	11
T.Phosphorus/Orthophosph	1.07946	12
Initial Cyanophyta	1.07057	13
Hardness, Total mg/L as Ca	1.06958	14
Ammonia, mg/L	1.05255	15
Pompton extraction	1.04746	16
HeatingDays	1.04713	17
PrevPrecip	1.04619	18
WkPrecip	1.04423	19
Initial Chlorophyta	1.01484	20
BOD, mg/L	1.00158	21
Total Count, cells/ml	0.99997	22
JAPS extractions	0.99795	23
WindSpeed	0.99617	24
Chloride, mg/L	0.99381	25
TOC, mg/L	0.98928	26
Passaic extractions	0.98893	27
SkyCover	0.97829	28
Pompton streamflow	0.96198	29
Nitrite/Nitrate	0.95208	30
pH	0.94638	31

PointRes extractions		
TSS, mg/L	2.149711	1
WindDir	2.082613	2
DO, mg/L	1.934959	3
Pompton extraction	1.852019	4
Alkalinity mg/L as CaCO3	1.629735	5
T.Phosphorus/Orthophosph	1.625930	6
WindSpeed	1.387102	7
Total Count, cells/ml	1.323525	8
Ammonia, mg/L	1.314639	9
PrevPrecip	1.28950	10
Nitrite/Nitrate	1.28567	11
Turbidity NTU	1.24208	12
Passaic extractions	1.20299	13
Odor	1.17777	14
Hardness, Total mg/L as Ca	1.13402	15
Temp (0C)	1.12013	16
Pompton streamflow	1.11915	17
Chloride, mg/L	1.08301	18
Conductivity, umhos/cm	1.07291	19
UV-254, cm-1	1.06867	20
Initial Chlorophyta	1.03825	21
WkPrecip	1.02894	22
HeatingDays	1.02862	23
TOC, mg/L	1.02757	24
SkyCover	1.02193	25
pH	1.01753	26
Sulfate, mg/L	1.00743	27
Initial Cyanophyta	1.00418	28
JAPS extractions	0.99491	29
BOD, mg/L	0.96485	30
Initial Chrysophyta	0.93967	31

Table 4.3. Station 100 Cyanobacteria two-week ahead predictions: Sensitivity Analysis

All Input		
Sulfate, mg/L	2.467837	1
Nitrite/Nitrate	2.458814	2
Hardness, Total mg/L as Ca	2.425212	3
pH	2.112513	4
Turbidity NTU	2.033659	5
TSS, mg/L	1.868083	6
DO, mg/L	1.794440	7
WindDir	1.676114	8
Conductivity, umhos/cm	1.627026	9
Initial Chrysophyta	1.53643	10
Odor	1.49187	11
HeatingDays	1.42294	12
Passaic extractions	1.40099	13
Alkalinity mg/L as CaCO3	1.36501	14
PointRes extractions	1.34289	15
Total Count, cells/ml	1.34184	16
Initial Cyanophyta	1.29873	17
SkyCover	1.20175	18
Temp (0C)	1.16366	19
Ammonia, mg/L	1.14068	20
Initial Chlorophyta	1.10231	21
TOC, mg/L	1.08969	22
WindSpeed	1.04890	23
Pompton extraction	1.04214	24
WkPrecip	1.02692	25
PrevPrecip	1.01865	26
T.Phosphorus/Orthophosph	1.00837	27
BOD, mg/L	1.00568	28
Chloride, mg/L	1.00321	29
JAPS extractions	0.99109	30
UV-254, cm-1	0.98593	31
Pompton streamflow	0.97335	32

Sulfate		
Initial Chrysophyta	1.435304	1
Nitrite/Nitrate	1.372073	2
Pompton extraction	1.314645	3
HeatingDays	1.298006	4
WkPrecip	1.280172	5
Passaic extractions	1.259798	6
UV-254, cm-1	1.190626	7
Odor	1.176839	8
DO, mg/L	1.116307	9
BOD, mg/L	1.10848	10
Chloride, mg/L	1.09739	11
Pompton streamflow	1.09217	12
Initial Chlorophyta	1.08900	13
Turbidity NTU	1.08539	14
Conductivity, umhos/cm	1.08091	15
TOC, mg/L	1.07212	16
T.Phosphorus/Orthophosph	1.07148	17
WindSpeed	1.06785	18
pH	1.04388	19
TSS, mg/L	1.03644	20
Alkalinity mg/L as CaCO3	1.03015	21
SkyCover	1.02792	22
PrevPrecip	1.02508	23
Initial Cyanophyta	1.02332	24
JAPS extractions	1.01597	25
PointRes extractions	1.01523	26
Total Count, cells/ml	1.00696	27
Hardness, Total mg/L as Ca	1.00334	28
Temp (0C)	1.00261	29
Ammonia, mg/L	0.99856	30
WindDir	0.97620	31

Total Hardness		
Passaic extractions	2.375180	1
Nitrite/Nitrate	2.259148	2
Sulfate, mg/L	2.090625	3
HeatingDays	1.992810	4
pH	1.909499	5
TOC, mg/L	1.517145	6
DO, mg/L	1.363047	7
SkyCover	1.306976	8
WkPrecip	1.267681	9
TSS, mg/L	1.16976	10
Ammonia, mg/L	1.16056	11
WindDir	1.15831	12
Initial Chrysophyta	1.13532	13
Alkalinity mg/L as CaCO3	1.10189	14
WindSpeed	1.09558	15
Turbidity NTU	1.06967	16
PrevPrecip	1.06899	17
Temp (0C)	1.03088	18
BOD, mg/L	1.03071	19
Pompton streamflow	1.02348	20
T.Phosphorus/Orthophosph	1.01298	21
Chloride, mg/L	1.00470	22
PointRes extractions	1.00202	23
JAPS extractions	1.00106	24
Initial Cyanophyta	1.00026	25
Odor	0.99706	26
Conductivity, umhos/cm	0.99665	27
TOTAL COUNT, CELLS/M	0.99499	28
Pompton extraction	0.97942	29
UV-254, cm-1	0.97366	30
Initial Chlorophyta	0.96373	31

Table 4.3. Station 100 Cyanobacteria two-week ahead predictions: Sensitivity Analysis (cont.)

Nitrite/Nitrate		
Sulfate, mg/L	1.754537	1
pH	1.666891	2
HeatingDays	1.463843	3
Turbidity NTU	1.375960	4
Ammonia, mg/L	1.354598	5
TOC, mg/L	1.353729	6
SkyCover	1.309883	7
Initial Chlorophyta	1.281707	8
DO, mg/L	1.269960	9
Odor	1.24403	10
Conductivity, umhos/cm	1.23939	11
Alkalinity mg/L as CaCO3	1.16924	12
Pompton extraction	1.16420	13
Pompton streamflow	1.12859	14
T.Phosphorus/Orthophosph	1.08165	15
Chloride, mg/L	1.07889	16
Initial Chrysophyta	1.06902	17
TSS, mg/L	1.06265	18
Temp (0C)	1.05556	19
WkPrecip	1.05297	20
Total Count, cells/ml	1.02312	21
JAPS extractions	1.02057	22
WindSpeed	1.01499	23
WindDir	1.01145	24
Initial Cyanophyta	1.00796	25
UV-254, cm-1	0.99703	26
PointRes extractions	0.98522	27
BOD, mg/L	0.96936	28
PrevPrecip	0.95153	29
Passaic extractions	0.85179	30
Hardness, Total mg/L as Ca	0.70173	31

UV254		
Nitrite/Nitrate	2.786798	1
Sulfate, mg/L	2.536960	2
DO, mg/L	2.119257	3
TSS, mg/L	2.115843	4
pH	1.950561	5
HeatingDays	1.854371	6
TOC, mg/L	1.788475	7
Passaic extractions	1.780163	8
Ammonia, mg/L	1.717885	9
Turbidity NTU	1.67844	10
Hardness, Total mg/L as Ca	1.58301	11
SkyCover	1.57636	12
BOD, mg/L	1.49211	13
Alkalinity mg/L as CaCO3	1.29809	14
Initial Chrysophyta	1.27375	15
Temp (0C)	1.25017	16
Pompton extraction	1.24518	17
WindDir	1.23821	18
WkPrecip	1.16848	19
WindSpeed	1.10688	20
Total Count, cells/ml	1.10647	21
Odor	1.07352	22
Pompton streamflow	1.05822	23
Chloride, mg/L	1.05711	24
Conductivity, umhos/cm	1.04951	25
Initial Chlorophyta	1.04234	26
Initial Cyanophyta	1.00252	27
JAPS extractions	1.00177	28
PrevPrecip	0.99670	29
PointRes extractions	0.99440	30
T.Phosphorus/Orthophosph	0.99323	31

Pompton streamflow (Pompton streamflow		
Nitrite/Nitrate	2.435652	1
HeatingDays	1.973367	2
Sulfate, mg/L	1.827476	3
Passaic extractions	1.818289	4
DO, mg/L	1.625066	5
pH	1.589752	6
TOC, mg/L	1.405555	7
SkyCover	1.384630	8
Hardness, Total mg/L as Ca	1.275761	9
TSS, mg/L	1.27477	10
WindDir	1.19291	11
Pompton extraction	1.14213	12
Chloride, mg/L	1.11867	13
WkPrecip	1.08584	14
Total Count, cells/ml	1.07858	15
PrevPrecip	1.07495	16
Ammonia, mg/L	1.05828	17
Initial Chlorophyta	1.05270	18
Turbidity NTU	1.04719	19
WindSpeed	1.03026	20
Odor	1.02746	21
BOD, mg/L	1.02208	22
Alkalinity mg/L as CaCO3	1.01438	23
JAPS extractions	1.00848	24
Conductivity, umhos/cm	1.00254	25
PointRes extractions	1.00111	26
T.Phosphorus/Orthophosph	0.99965	27
Temp (0C)	0.99383	28
Initial Cyanophyta	0.97123	29
Initial Chrysophyta	0.95342	30
UV-254, cm-1	0.94331	31

Table 4.4. Station 101 Cyanobacteria real-time predictions: Sensitivity Analysis

All Input		
Odor	2.463794	1
UV254	2.019682	2
Total Amorphous Material	1.811064	3
Color	1.781754	4
HeatingDays	1.781167	5
Chloride	1.653677	6
TOC	1.568962	7
pH	1.488918	8
PointRes extractions	1.467453	9
Conductivity	1.45049	10
Sulfate	1.43051	11
Alkalinity	1.29447	12
Passaic extractions	1.22610	13
Hardness Total	1.22256	14
Turbidity NTU	1.21444	15
PrevPrecip	1.11760	16
DO	1.07286	17
Total Count, cells/ml	1.06482	18
Initial Chrysophyta	1.05096	19
T.Phosphorus/Orthophosph	1.03715	20
BOD	1.01793	21
WindDir	1.01292	22
Nitrite/Nitrate	1.00816	23
JAPS extractions	1.00684	24
Temp 0C	1.00627	25
WkPrecip	1.00132	26
Pompton extractions	0.99110	27
Pompton streamflow	0.98975	28
SkyCover	0.95157	29
Initial Chlorophyta	0.95129	30
Initial Cyanophyta	0.94782	31
WindSpeed	0.93696	32
Ammonia	0.93072	33

UV254		
Total Amorphous Material	3.884360	1
DO, mg/L	1.102475	2
BOD, mg/L	1.078928	3
HeatingDays	1.044452	4
Odor	1.035457	5
WkPrecip	1.027327	6
Passaic extractions	1.023281	7
Temp 0C	1.022480	8
PointRes extractions	1.020897	9
WindDir	1.01640	10
Pompton extractions	1.01532	11
WindSpeed	1.01289	12
PrevPrecip	1.01235	13
T.Phosphorus/Orthophosph	1.01201	14
pH	1.01081	15
Sulfate mg/L	1.01070	16
Ammonia mg/L	1.00854	17
Initial Chlorophyta	1.00773	18
Total Count, cells/ml	1.00331	19
Color, Cu	1.00189	20
JAPS extractions	1.00115	21
Initial Cyanophyta	1.00089	22
Nitrite/Nitrate	0.99952	23
SkyCover	0.99625	24
Turbidity NTU	0.99574	25
Hardness Total, mg/L as Ca	0.99344	26
Initial Chrysophyta	0.99164	27
Pompton streamflow	0.98971	28
Alkalinity mg/L as CaCO3	0.98924	29
Conductivity umhos/cm	0.98583	30
Chloride mg/L	0.98247	31
TOC, mg/L	0.97770	32

Color		
PointRes extractions	5.885022	1
Total Amorphous Material	3.521186	2
UV254 cm-1	1.900803	3
Sulfate mg/L	1.458726	4
Initial Cyanophyta	1.360434	5
HeatingDays	1.357852	6
Conductivity umhos/cm	1.335931	7
Chloride mg/L	1.239934	8
Alkalinity mg/L as CaCO3	1.127773	9
TOC, mg/L	1.12305	10
PrevPrecip	1.07738	11
SkyCover	1.06920	12
T.Phosphorus/Orthophosph	1.05978	13
Temp 0C	1.04736	14
Odor	1.04458	15
Turbidity NTU	1.04298	16
Hardness Total, mg/L as Ca	1.03770	17
BOD, mg/L	1.03360	18
WkPrecip	1.02669	19
WindSpeed	1.02405	20
pH	1.01516	21
Initial Chrysophyta	1.01112	22
Total Count, cells/ml	1.00994	23
Nitrite/Nitrate	1.00798	24
Passaic extractions	1.00235	25
Initial Chlorophyta	1.00189	26
Pompton streamflow	1.00094	27
Ammonia mg/L	1.00084	28
WindDir	0.99999	29
DO, mg/L	0.99987	30
JAPS extractions	0.99919	31
Pompton extractions	0.99755	32

Table 4.4. Station 101 Cyanobacteria real-time predictions: Sensitivity Analysis (continued)

Heating Degree Days		
Conductivity umhos/cm	1.614678	1
Sulfate mg/L	1.463761	2
Initial Chlorophyta	1.394282	3
Nitrite/Nitrate	1.268965	4
WkPrecip	1.208284	5
T.Phosphorus/Orthophosphate	1.152879	6
TOC, mg/L	1.140386	7
BOD, mg/L	1.139256	8
SkyCover	1.129202	9
Total Count, cells/ml	1.09568	10
Ammonia mg/L	1.05664	11
Initial Chrysophyta	1.04313	12
WindDir	1.03854	13
Temp 0C	1.03709	14
Pompton streamflow	1.03090	15
Chloride mg/L	1.02962	16
PrevPrecip	1.02502	17
Color, Cu	1.02501	18
Passaic extractions	1.00712	19
WindSpeed	1.00328	20
Alkalinity mg/L as CaCO3	1.00167	21
pH	1.00163	22
UV254 cm-1	1.00032	23
Total Amorphous Material	0.99995	24
JAPS extractions	0.99963	25
Turbidity NTU	0.99795	26
Initial Cyanophyta	0.99470	27
Pompton extractions	0.99340	28
Hardness Total, mg/L as CaC	0.99153	29
Odor	0.99031	30
PointRes extractions	0.98696	31
DO, mg/L	0.83349	32

Ammonia		
PointRes extractions	2.293876	1
Conductivity umhos/cm	1.664685	2
T.Phosphorus/Orthophosphate	1.622270	3
Chloride mg/L	1.502857	4
WkPrecip	1.425608	5
Alkalinity mg/L as CaCO3	1.362363	6
Initial Chlorophyta	1.352123	7
Color, Cu	1.329516	8
Temp 0C	1.323101	9
HeatingDays	1.32122	10
SkyCover	1.28260	11
BOD, mg/L	1.27984	12
Passaic extractions	1.09611	13
Total Count, cells/ml	1.05390	14
Nitrite/Nitrate	1.05123	15
UV254 cm-1	1.04700	16
pH	1.04435	17
Initial Chrysophyta	1.03773	18
Sulfate mg/L	1.02092	19
Total Amorphous Material	1.02060	20
Odor	1.01562	21
Hardness Total, mg/L as CaC	1.01357	22
Turbidity NTU	1.01007	23
WindDir	1.00629	24
JAPS extractions	1.00629	25
Pompton streamflow	1.00593	26
DO, mg/L	1.00470	27
WindSpeed	1.00020	28
PrevPrecip	0.99987	29
Initial Cyanophyta	0.99908	30
TOC, mg/L	0.98924	31
Pompton extractions	0.98524	32

Initial Cyanobacteria level		
PointRes extractions	4.936578	1
UV254 cm-1	3.199476	2
HeatingDays	1.835109	3
PrevPrecip	1.758042	4
Sulfate mg/L	1.587518	5
TOC, mg/L	1.508543	6
Color, Cu	1.404736	7
Initial Chlorophyta	1.221644	8
Conductivity umhos/cm	1.214580	9
Chloride mg/L	1.17402	10
pH	1.16796	11
Hardness Total, mg/L as CaC	1.10958	12
Total Count, cells/ml	1.09571	13
Odor	1.06810	14
Alkalinity mg/L as CaCO3	1.04209	15
Pompton streamflow	1.02591	16
Pompton extractions	1.02277	17
WindDir	1.01753	18
Total Amorphous Material	1.01626	19
Ammonia mg/L	1.01322	20
Nitrite/Nitrate	1.01039	21
T.Phosphorus/Orthophosphate	1.00848	22
Initial Chrysophyta	1.00394	23
DO, mg/L	1.00181	24
JAPS extractions	1.00021	25
BOD, mg/L	1.00002	26
SkyCover	0.99967	27
Temp 0C	0.99853	28
Turbidity NTU	0.99779	29
Passaic extractions	0.99403	30
WindSpeed	0.99051	31
WkPrecip	0.98059	32

Table 4.5. Station 101 Cyanobacteria one-week ahead predictions: Sensitivity Analysis

All Input		
WkPrecip	2.375960	1
Odor		
WindSpeed	1.497471	3
BOD, mg/L	1.475692	4
Total Amorphous Material	1.433807	5
Hardness Total, mg/L as Ca	1.302327	6
Temp 0C	1.289236	7
Alkalinity mg/L as CaCO3	1.284141	8
T.Phosphorus/Orthophosph	1.180530	9
Pompton streamflow	1.11581	10
Initial Chlorophyta	1.10272	11
TOC, mg/L	1.09565	12
PointRes extractions	1.02963	13
Conductivity umhos/cm	1.02829	14
Nitrite/Nitrate	1.02528	15
Chloride mg/L	1.01134	16
Color, Cu	1.00867	17
Turbidity NTU	1.00586	18
pH	1.00338	19
Initial Cyanophyta	1.00106	20
HeatingDays	0.99575	21
Sulfate mg/L	0.99532	22
JAPS extractions	0.99337	23
UV254 cm-1	0.99271	24
DO, mg/L	0.98928	25
Ammonia mg/L	0.98680	26
Total Count, cells/ml	0.98352	27
Passaic extractions	0.98289	28
Pompton extractions	0.97628	29
PrevPrecip	0.97003	30
SkyCover	0.96602	31
WindDir	0.94659	32
Initial Chrysophyta	0.86828	33

current week Precipitation		
Odor	1.440140	1
BOD, mg/L		
Total Amorphous Material	1.164254	3
HeatingDays	1.161231	4
T.Phosphorus/Orthophosph	1.157781	5
WindSpeed	1.148149	6
Temp 0C	1.107819	7
Initial Chrysophyta	1.092060	8
Pompton streamflow	1.069130	9
Pompton extractions	1.04872	10
Conductivity umhos/cm	1.03976	11
WindDir	1.03519	12
Passaic extractions	1.02533	13
DO, mg/L	1.01978	14
Initial Chlorophyta	1.01780	15
Chloride mg/L	1.01497	16
PrevPrecip	1.01386	17
Nitrite/Nitrate	1.00750	18
Turbidity NTU	1.00696	19
Color, Cu	1.00584	20
Alkalinity mg/L as CaCO3	1.00578	21
Sulfate mg/L	1.00428	22
pH	1.00217	23
UV254 cm-1	1.00074	24
TOC, mg/L	0.99738	25
Initial Cyanophyta	0.99437	26
PointRes extractions	0.99339	27
JAPS extractions	0.99320	28
Hardness Total, mg/L as Ca	0.99280	29
Total Count, cells/ml	0.99010	30
Ammonia mg/L	0.97122	31
SkyCover	0.91778	32

Wind Speed		
Initial Cyanophyta	5.428742	1
WkPrecip		
T.Phosphorus/Orthophosph	2.438786	3
UV254 cm-1	2.406714	4
Alkalinity mg/L as CaCO3	1.827316	5
TOC, mg/L	1.810535	6
Total Amorphous Material	1.744769	7
BOD, mg/L	1.679110	8
Temp 0C	1.666047	9
Total Count, cells/ml	1.55283	10
Odor	1.40823	11
pH	1.39239	12
PointRes extractions	1.38450	13
Initial Chlorophyta	1.31863	14
Pompton extractions	1.27620	15
Ammonia mg/L	1.23577	16
Sulfate mg/L	1.22533	17
SkyCover	1.21528	18
Hardness Total, mg/L as Ca	1.15503	19
Initial Chrysophyta	1.15217	20
Passaic extractions	1.11694	21
HeatingDays	1.09776	22
PrevPrecip	1.08995	23
Turbidity NTU	1.08854	24
DO, mg/L	1.06809	25
Chloride mg/L	1.03864	26
Nitrite/Nitrate	1.03790	27
WindDir	1.03534	28
Conductivity umhos/cm	1.02918	29
Color, Cu	0.99069	30
Pompton streamflow	0.98792	31
JAPS extractions	0.98762	32

Table 4.5. Station 101 Cyanobacteria one-week ahead predictions: Sensitivity Analysis (cont.)

Wind Direction		
Total Amorphous Material	3.807815	1
BOD, mg/L		
WindSpeed	3.135347	3
HeatingDays	2.573351	4
WkPrecip	2.397991	5
PrevPrecip	2.295884	6
TOC, mg/L	2.286281	7
JAPS extractions	2.017245	8
Hardness Total, mg/L as Ca	1.910305	9
Temp 0C	1.76076	10
Initial Cyanophyta	1.67988	11
T.Phosphorus/Orthophosph	1.58544	12
PointRes extractions	1.55781	13
Ammonia mg/L	1.45289	14
Passaic extractions	1.38528	15
Initial Chlorophyta	1.25641	16
pH	1.23157	17
Alkalinity mg/L as CaCO3	1.21313	18
Chloride mg/L	1.17908	19
SkyCover	1.16891	20
Color, Cu	1.10757	21
Total Count, cells/ml	1.06327	22
Initial Chrysophyta	1.04604	23
DO, mg/L	1.04157	24
Turbidity NTU	1.03405	25
Pompton extractions	1.03229	26
Pompton streamflow	1.02620	27
Conductivity umhos/cm	1.02102	28
UV254 cm-1	1.02032	29
Sulfate mg/L	1.01527	30
Nitrite/Nitrate	1.01116	31
Odor	0.99999	32

Pompton extractions		
WkPrecip	1.169728	1
WindSpeed		
Alkalinity mg/L as CaCO3	1.024587	3
HeatingDays	1.024209	4
TOC, mg/L	1.018587	5
T.Phosphorus/Orthophosph	1.017614	6
JAPS extractions	1.013135	7
Sulfate mg/L	1.008506	8
PointRes extractions	1.005035	9
Initial Chrysophyta	1.00385	10
Conductivity umhos/cm	1.00290	11
Hardness Total, mg/L as Ca	1.00255	12
Initial Cyanophyta	1.00241	13
DO, mg/L	1.00236	14
Color, Cu	0.99503	15
Chloride mg/L	0.99421	16
Turbidity NTU	0.99340	17
Nitrite/Nitrate	0.99287	18
pH	0.99002	19
Temp 0C	0.98847	20
PrevPrecip	0.98827	21
Pompton streamflow	0.98739	22
Total Count, cells/ml	0.98036	23
WindDir	0.97894	24
Initial Chlorophyta	0.97679	25
UV254 cm-1	0.97339	26
Ammonia mg/L	0.97116	27
BOD, mg/L	0.96792	28
Total Amorphous Material	0.96336	29
SkyCover	0.96264	30
Passaic extractions	0.94645	31
Odor	0.91253	32

Table 4.6. Station 101 Cyanobacteria two-week ahead predictions: Sensitivity Analysis

All Input		
PointRes extractions	1.668657	1
BOD, mg/L	1.472355	2
Sulfate mg/L	1.416568	3
PrevPrecip	1.350115	4
Initial Chlorophyta	1.331149	5
SkyCover	1.281632	6
Chloride mg/L	1.261790	7
T.Phosphorus/Orthophosph	1.259234	8
HeatingDays	1.253517	9
Conductivity umhos/cm	1.21105	10
Initial Cyanophyta	1.17616	11
WindDir	1.16712	12
Temp 0C	1.15920	13
Odor	1.15858	14
pH	1.15706	15
WkPrecip	1.12722	16
Hardness Total, mg/L as Ca	1.09142	17
WindSpeed	1.07881	18
DO, mg/L	1.07102	19
Alkalinity mg/L as CaCO3	1.06728	20
TOC, mg/L	1.06260	21
Initial Chrysophyta	1.05258	22
JAPS extractions	1.04868	23
Color, Cu	1.03327	24
Pompton extractions	1.02942	25
Pompton streamflow	1.01960	26
Nitrite/Nitrate	1.01946	27
UV254 cm-1	1.00870	28
Passaic extractions	0.99663	29
Ammonia mg/L	0.99438	30
Total Amorphous Material	0.98634	31
Total Count, cells/ml	0.98385	32
Turbidity NTU	0.93853	33

PointRes extractions		
Conductivity umhos/cm	2.422956	1
WkPrecip	2.150426	2
Chloride mg/L	2.040962	3
Odor	1.940527	4
Sulfate mg/L	1.938236	5
Total Amorphous Material	1.906110	6
BOD, mg/L	1.889180	7
WindDir	1.870918	8
Color, Cu	1.510106	9
Temp 0C	1.45593	10
PrevPrecip	1.44181	11
HeatingDays	1.39202	12
Total Count, cells/ml	1.35574	13
Nitrite/Nitrate	1.30784	14
Pompton streamflow	1.28680	15
UV254 cm-1	1.22528	16
Hardness Total, mg/L as Ca	1.21456	17
Initial Chlorophyta	1.18026	18
DO, mg/L	1.16929	19
Alkalinity mg/L as CaCO3	1.15713	20
TOC, mg/L	1.09360	21
Pompton extractions	1.08937	22
WindSpeed	1.08244	23
Initial Chrysophyta	1.08011	24
SkyCover	1.05705	25
JAPS extractions	1.05011	26
Passaic extractions	1.04527	27
T.Phosphorus/Orthophosph	1.02601	28
Turbidity NTU	1.02431	29
Initial Cyanophyta	1.01138	30
Ammonia mg/L	0.99896	31
pH	0.99692	32

Sulfate		
Temp 0C	1.019789	1
Color, Cu	1.011617	2
Nitrite/Nitrate	1.010873	3
DO, mg/L	1.009484	4
Initial Chlorophyta	1.009322	5
PrevPrecip	1.009317	6
T.Phosphorus/Orthophosph	1.008753	7
Pompton extractions	1.005605	8
Passaic extractions	1.004587	9
Pompton streamflow	1.00401	10
Initial Cyanophyta	1.00363	11
Total Amorphous Material	1.00275	12
JAPS extractions	1.00271	13
Odor	1.00258	14
SkyCover	1.00241	15
Alkalinity mg/L as CaCO3	1.00218	16
Hardness Total, mg/L as Ca	1.00158	17
Ammonia mg/L	1.00153	18
WindSpeed	1.00081	19
BOD, mg/L	0.99923	20
Total Count, cells/ml	0.99894	21
pH	0.99880	22
Turbidity NTU	0.99858	23
Initial Chrysophyta	0.99747	24
WkPrecip	0.99663	25
PointRes extractions	0.99534	26
Conductivity umhos/cm	0.99360	27
HeatingDays	0.99240	28
WindDir	0.98879	29
Chloride mg/L	0.98758	30
TOC, mg/L	0.98104	31
UV254 cm-1	0.97505	32

Table 4.6. Station 101 Cyanobacteria two-week ahead predictions: Sensitivity Analysis (cont.)

Total Phosphorous		
Sulfate mg/L	1.648329	1
Total Amorphous Material	1.557007	2
PrevPrecip	1.506649	3
Temp 0C	1.440068	4
SkyCover	1.432059	5
WkPrecip	1.368913	6
DO, mg/L	1.307842	7
Hardness Total, mg/L as Ca	1.297457	8
Chloride mg/L	1.251756	9
Odor	1.24755	10
Ammonia mg/L	1.17488	11
Pompton extractions	1.11711	12
Initial Cyanophyta	1.09301	13
pH	1.08407	14
TOC, mg/L	1.08266	15
Passaic extractions	1.07418	16
WindSpeed	1.04623	17
Nitrite/Nitrate	1.03422	18
PointRes extractions	1.02807	19
Alkalinity mg/L as CaCO3	1.01790	20
Conductivity umhos/cm	1.01689	21
Pompton streamflow	1.01592	22
Turbidity NTU	1.01009	23
UV254 cm-1	1.00695	24
Color, Cu	1.00280	25
JAPS extractions	0.99352	26
Initial Chlorophyta	0.98571	27
HeatingDays	0.95645	28
BOD, mg/L	0.89297	29
WindDir	0.86668	30
Total Count, cells/ml	0.83309	31
Initial Chrysophyta	0.75459	32

Turbidity		
T.Phosphorus/Orthophosph	3.038790	1
WkPrecip	2.321076	2
Sulfate mg/L	2.242010	3
HeatingDays	2.157462	4
UV254 cm-1	1.938595	5
Hardness Total, mg/L as Ca	1.934710	6
Color, Cu	1.894899	7
PointRes extractions	1.782926	8
Total Amorphous Material	1.695734	9
Nitrite/Nitrate	1.47101	10
SkyCover	1.38487	11
PrevPrecip	1.38410	12
WindSpeed	1.31122	13
Initial Chlorophyta	1.30379	14
BOD, mg/L	1.29707	15
Pompton extractions	1.26088	16
DO, mg/L	1.25993	17
Conductivity umhos/cm	1.22793	18
Alkalinity mg/L as CaCO3	1.21274	19
Temp 0C	1.18598	20
pH	1.16607	21
TOC, mg/L	1.15333	22
Pompton streamflow	1.13759	23
Odor	1.12243	24
Chloride mg/L	1.10070	25
WindDir	1.08138	26
Initial Cyanophyta	1.05796	27
Ammonia mg/L	1.02589	28
Total Count, cells/ml	1.00415	29
JAPS extractions	0.99372	30
Initial Chrysophyta	0.98544	31
Passaic extractions	0.97849	32

Total Count		
WkPrecip	1.221294	1
Initial Chlorophyta	1.218456	2
HeatingDays	1.185675	3
Odor	1.151959	4
TOC, mg/L	1.109734	5
PointRes extractions	1.079715	6
Nitrite/Nitrate	1.078581	7
Alkalinity mg/L as CaCO3	1.074844	8
Sulfate mg/L	1.072327	9
DO, mg/L	1.06014	10
WindDir	1.05952	11
Pompton streamflow	1.05703	12
Initial Chrysophyta	1.05580	13
Ammonia mg/L	1.02895	14
Conductivity umhos/cm	1.02482	15
SkyCover	1.02283	16
UV254 cm-1	1.02262	17
PrevPrecip	1.01931	18
Hardness Total, mg/L as Ca	1.01354	19
T.Phosphorus/Orthophosph	1.00945	20
Passaic extractions	1.00553	21
Turbidity NTU	1.00200	22
JAPS extractions	1.00151	23
BOD, mg/L	1.00150	24
Initial Cyanophyta	0.99951	25
WindSpeed	0.99814	26
Chloride mg/L	0.98361	27
Color, Cu	0.98215	28
Total Amorphous Material	0.97058	29
pH	0.96766	30
Pompton extractions	0.94250	31
Temp 0C	0.92099	32

Table 4.7. 612 Cyanobacteria real-time predictions: Sensitivity Analysis

All Input		
Ammonia mg/L	1.534490	1
Odor	1.300776	2
Color, Cu	1.293387	3
Temp 0C	1.232146	4
WkPrecip	1.214887	5
Total Amorphous Material	1.208770	6
Sulfate mg/L	1.160632	7
Passaic extractions	1.153723	8
BOD, mg/L	1.130447	9
DO, mg/L	1.13043	10
Turbidity NTU	1.10166	11
Initial Chlorophyta	1.08693	12
Total Count, cells/ml	1.08506	13
Hardness Total, mg/L as Ca	1.07094	14
WindDir	1.06319	15
SkyCover	1.06167	16
Initial Cyanophyta	1.04892	17
PrevPrecip	1.03929	18
WindSpeed	1.03849	19
UV254 cm-1	1.03118	20
Conductivity umhos/cm	1.02264	21
PointRes extractions	1.01968	22
Chloride mg/L	1.01552	23
TotalPhosphorus/Orthophos	1.00632	24
Alkalinity mg/L as CaCO3	1.00498	25
Pompton streamflow	1.00495	26
HeatingDays	1.00310	27
Initial Chrysophyta	1.00288	28
pH	1.00243	29
Nitrite/Nitrate	0.99984	30
TOC, mg/L	0.98792	31
Pompton extractions	0.98720	32
JAPS extractions	0.98222	33

Temperature		
Odor	1.835449	1
DO, mg/L	1.735790	2
WkPrecip	1.717052	3
Color, Cu	1.562639	4
HeatingDays	1.512905	5
TotalPhosphorus/Orthophos	1.398574	6
Total Amorphous Material	1.368873	7
BOD, mg/L	1.309531	8
Sulfate mg/L	1.165397	9
Conductivity umhos/cm	1.13546	10
SkyCover	1.11824	11
Turbidity NTU	1.11593	12
pH	1.10849	13
Alkalinity mg/L as CaCO3	1.10130	14
TOC, mg/L	1.04163	15
Initial Chrysophyta	1.02356	16
Passaic extractions	1.02181	17
Hardness Total, mg/L as Ca	1.00217	18
WindSpeed	0.99646	19
Nitrite/Nitrate	0.98486	20
JAPS extractions	0.96486	21
Chloride mg/L	0.95892	22
WindDir	0.95837	23
Pompton extractions	0.93345	24
PointRes extractions	0.93062	25
Initial Chlorophyta	0.92230	26
UV254 cm-1	0.89540	27
PrevPrecip	0.89321	28
Initial Cyanophyta	0.89252	29
Pompton streamflow	0.80490	30
Total Count, cells/ml	0.80331	31
Ammonia mg/L	0.73609	32

Ammonia		
Initial Cyanophyta	1.910801	1
Color, Cu	1.725183	2
Total Amorphous Material	1.463307	3
BOD, mg/L	1.229598	4
PointRes extractions	1.219697	5
pH	1.167427	6
Alkalinity mg/L as CaCO3	1.160631	7
Total Count, cells/ml	1.143973	8
HeatingDays	1.112484	9
Temp 0C	1.10921	10
Odor	1.09886	11
Initial Chrysophyta	1.09403	12
DO, mg/L	1.09296	13
Turbidity NTU	1.07715	14
SkyCover	1.06047	15
Conductivity umhos/cm	1.05730	16
Sulfate mg/L	1.05311	17
WindDir	1.05088	18
UV254 cm-1	1.04473	19
TotalPhosphorus/Orthophos	1.03019	20
WkPrecip	1.02779	21
PrevPrecip	1.02751	22
Hardness Total, mg/L as Ca	1.02659	23
WindSpeed	1.02279	24
Initial Chlorophyta	1.01793	25
Chloride mg/L	0.99695	26
TOC, mg/L	0.99630	27
Passaic extractions	0.99606	28
Nitrite/Nitrate	0.99553	29
Pompton extractions	0.99325	30
JAPS extractions	0.98095	31
Pompton streamflow	0.97866	32

Table 4.7. 612 Cyanobacteria real-time predictions: Sensitivity Analysis (cont.)

Color		
Total Count, cells/ml	1.286662	1
BOD, mg/L	1.177008	2
Initial Cyanophyta	1.176869	3
HeatingDays	1.118468	4
Odor	1.117975	5
Ammonia mg/L	1.077856	6
PrevPrecip	1.077556	7
Turbidity NTU	1.054768	8
Nitrite/Nitrate	1.050339	9
TotalPhosphorus/Orthophosph	1.03889	10
WkPrecip	1.03812	11
WindDir	1.02865	12
Pompton extractions	1.02836	13
pH	1.02674	14
PointRes extractions	1.02063	15
Alkalinity mg/L as CaCO3	1.01796	16
Total Amorphous Material	1.01681	17
SkyCover	1.01235	18
Chloride mg/L	1.00660	19
Initial Chrysophyta	1.00333	20
Sulfate mg/L	1.00332	21
UV254 cm-1	1.00273	22
Temp 0C	1.00191	23
DO, mg/L	1.00110	24
Pompton streamflow	1.00097	25
Hardness Total, mg/L as CaC	1.00055	26
WindSpeed	0.99855	27
JAPS extractions	0.99840	28
TOC, mg/L	0.99819	29
Initial Chlorophyta	0.99730	30
Conductivity umhos/cm	0.99670	31
Passaic extractions	0.99580	32

Pompton extractions		
Odor	1.648928	1
PrevPrecip	1.362462	2
DO, mg/L	1.197961	3
Turbidity NTU	1.181921	4
SkyCover	1.165362	5
Color, Cu	1.156353	6
Ammonia mg/L	1.144237	7
Sulfate mg/L	1.144204	8
WindDir	1.068663	9
Total Amorphous Material	1.05239	10
Nitrite/Nitrate	1.04057	11
Conductivity umhos/cm	1.03553	12
BOD, mg/L	1.03345	13
Initial Chrysophyta	1.02758	14
TOC, mg/L	1.02353	15
WkPrecip	1.01704	16
TotalPhosphorus/Orthophosph	1.01650	17
Temp 0C	1.01555	18
Alkalinity mg/L as CaCO3	1.00512	19
Hardness Total, mg/L as CaC	1.00217	20
Passaic extractions	0.99987	21
Chloride mg/L	0.99486	22
UV254 cm-1	0.99276	23
Pompton streamflow	0.98927	24
JAPS extractions	0.98746	25
HeatingDays	0.98530	26
WindSpeed	0.98215	27
pH	0.98110	28
Initial Chlorophyta	0.95135	29
Initial Cyanophyta	0.91764	30
PointRes extractions	0.84164	31
Total Count, cells/ml	0.82607	32

Total Organic Carbon (TOC)		
Color, Cu	1.594600	1
Turbidity NTU	1.487938	2
Odor	1.400429	3
Total Count, cells/ml	1.214893	4
Total Amorphous Material	1.182006	5
Ammonia mg/L	1.161017	6
SkyCover	1.143709	7
Temp 0C	1.134768	8
Sulfate mg/L	1.089343	9
Passaic extractions	1.08842	10
PrevPrecip	1.08468	11
Alkalinity mg/L as CaCO3	1.08074	12
Pompton extractions	1.07141	13
WkPrecip	1.05742	14
pH	1.05147	15
Nitrite/Nitrate	1.05096	16
UV254 cm-1	1.03415	17
Initial Chlorophyta	1.03278	18
BOD, mg/L	1.02794	19
WindDir	1.02684	20
TotalPhosphorus/Orthophosph	1.02280	21
Initial Cyanophyta	1.01998	22
DO, mg/L	1.01109	23
WindSpeed	1.00372	24
HeatingDays	1.00294	25
PointRes extractions	1.00228	26
Conductivity umhos/cm	1.00185	27
Initial Chrysophyta	0.99896	28
Pompton streamflow	0.99705	29
Chloride mg/L	0.99430	30
JAPS extractions	0.99318	31
Hardness Total, mg/L as CaC	0.97370	32

Table 4.8. Station 612 Cyanobacteria one-week ahead predictions: Sensitivity Analysis

All Input		
Initial Cyanophyta	3.429483	1
Turbidity NTU	2.667634	2
Total Amorphous Material	2.516674	3
Color, Cu	2.086754	4
Total Count, cells/ml	1.820608	5
pH	1.345663	6
Odor	1.175509	7
Alkalinity mg/L as CaCO3	1.161541	8
HeatingDays	1.096879	9
DO, mg/L	1.05219	10
BOD, mg/L	1.03766	11
Temp 0C	1.03483	12
Pompton streamflow	1.01949	13
WkPrecip	1.01817	14
WindDir	1.01221	15
UV254 cm-1	1.01201	16
TotalPhosphorus/Orthophos	1.01043	17
Sulfate mg/L	1.01003	18
WindSpeed	1.00926	19
Chloride mg/L	1.00796	20
Initial Chlorophyta	1.00683	21
PrevPrecip	1.00525	22
PointRes extractions	1.00458	23
Ammonia mg/L	0.99998	24
Passaic extractions	0.99908	25
SkyCover	0.99804	26
JAPS extractions	0.99591	27
Pompton extractions	0.99456	28
Conductivity umhos/cm	0.99434	29
Nitrite/Nitrate	0.99419	30
Hardness Total, mg/L as Ca	0.99034	31
Initial Chrysophyta	0.98404	32
TOC, mg/L	0.92386	33

Initial Cyanobacteria level		
Color, Cu	2.715833	1
Total Count, cells/ml	2.409606	2
Turbidity NTU	2.073950	3
TotalPhosphorus/Orthophos	1.658668	4
HeatingDays	1.631856	5
Total Amorphous Material	1.572717	6
Ammonia mg/L	1.539952	7
pH	1.335608	8
DO, mg/L	1.197333	9
Pompton extractions	1.13755	10
Sulfate mg/L	1.11259	11
PrevPrecip	1.11183	12
Alkalinity mg/L as CaCO3	1.06901	13
Hardness Total, mg/L as Ca	1.04632	14
SkyCover	1.04532	15
Initial Chrysophyta	1.02998	16
WindSpeed	1.02767	17
UV254 cm-1	1.02358	18
Odor	1.02213	19
Chloride mg/L	1.02067	20
BOD, mg/L	1.02039	21
Pompton streamflow	1.01585	22
Nitrite/Nitrate	1.01100	23
Initial Chlorophyta	1.00008	24
JAPS extractions	0.99431	25
Conductivity umhos/cm	0.99361	26
TOC, mg/L	0.98686	27
WindDir	0.97775	28
Passaic extractions	0.96994	29
Temp 0C	0.96182	30
PointRes extractions	0.96041	31
WkPrecip	0.92449	32

Turbidity		
Initial Cyanophyta	10.899936	1
Color, Cu	9.069299	2
Total Count, cells/ml	4.933325	3
PointRes extractions	4.450310	4
pH	4.248417	5
HeatingDays	1.960222	6
Initial Chrysophyta	1.644684	7
PrevPrecip	1.640934	8
WkPrecip	1.635183	9
Alkalinity mg/L as CaCO3	1.59066	10
Odor	1.51352	11
Ammonia mg/L	1.46059	12
SkyCover	1.22644	13
Sulfate mg/L	1.20190	14
Conductivity umhos/cm	1.17904	15
WindSpeed	1.17629	16
TotalPhosphorus/Orthophos	1.14228	17
Total Amorphous Material	1.13564	18
Pompton extractions	1.08915	19
BOD, mg/L	1.08115	20
Hardness Total, mg/L as Ca	1.07664	21
Initial Chlorophyta	1.07095	22
DO, mg/L	1.05064	23
WindDir	1.02233	24
JAPS extractions	1.01394	25
Passaic extractions	1.01224	26
Pompton streamflow	0.98833	27
Temp 0C	0.97424	28
UV254 cm-1	0.96665	29
TOC, mg/L	0.96224	30
Chloride mg/L	0.95751	31
Nitrite/Nitrate	0.94710	32

Table 4.8. Station 612 Cyanobacteria one-week ahead predictions: Sensitivity Analysis (cont.)

Color		
Turbidity NTU	5.889727	1
Initial Cyanophyta	4.429869	2
PointRes extractions	3.913289	3
Total Count, cells/ml	3.251304	4
Total Amorphous Material	2.601089	5
Ammonia mg/L	2.246021	6
DO, mg/L	2.234065	7
BOD, mg/L	2.144503	8
Alkalinity mg/L as CaCO3	1.722991	9
Temp 0C	1.57910	10
Hardness Total, mg/L as CaC	1.54426	11
PrevPrecip	1.44583	12
WkPrecip	1.33562	13
Passaic extractions	1.29419	14
Conductivity umhos/cm	1.27029	15
Pompton extractions	1.26096	16
Initial Chlorophyta	1.20291	17
pH	1.14380	18
Sulfate mg/L	1.13444	19
WindSpeed	1.10203	20
Nitrite/Nitrate	1.07060	21
UV254 cm-1	1.03451	22
TotalPhosphorus/Orthophosph	1.01624	23
WindDir	0.99939	24
TOC, mg/L	0.99205	25
Chloride mg/L	0.99042	26
Pompton streamflow	0.98632	27
HeatingDays	0.98523	28
JAPS extractions	0.97382	29
Odor	0.95481	30
SkyCover	0.88333	31
Initial Chrysophyta	0.86872	32

TOC		
Turbidity NTU	12.081841	1
Color, Cu	9.935443	2
Initial Cyanophyta	5.720426	3
DO, mg/L	2.941575	4
BOD, mg/L	2.845495	5
Ammonia mg/L	2.352102	6
Total Count, cells/ml	2.144256	7
UV254 cm-1	1.877955	8
WindSpeed	1.648907	9
WkPrecip	1.55626	10
Passaic extractions	1.44135	11
Sulfate mg/L	1.38076	12
SkyCover	1.33215	13
pH	1.28997	14
PointRes extractions	1.25619	15
PrevPrecip	1.24266	16
Pompton streamflow	1.22645	17
HeatingDays	1.18481	18
Total Amorphous Material	1.17660	19
Nitrite/Nitrate	1.17613	20
Initial Chrysophyta	1.17469	21
WindDir	1.15780	22
Conductivity umhos/cm	1.15733	23
Temp 0C	1.14358	24
Pompton extractions	1.09282	25
JAPS extractions	1.06157	26
Chloride mg/L	1.05874	27
Odor	1.02945	28
Alkalinity mg/L as CaCO3	1.01719	29
Hardness Total, mg/L as CaC	0.99209	30
Initial Chlorophyta	0.96305	31
TotalPhosphorus/Orthophosph	0.94915	32

Initial Chrysophyta level		
Color, Cu	3.292300	1
Turbidity NTU	2.590321	2
Initial Cyanophyta	2.135257	3
PointRes extractions	1.719382	4
pH	1.464313	5
Total Amorphous Material	1.377234	6
WindDir	1.234439	7
UV254 cm-1	1.219319	8
TotalPhosphorus/Orthophosph	1.100046	9
BOD, mg/L	1.09715	10
Temp 0C	1.09481	11
WkPrecip	1.05196	12
Ammonia mg/L	1.05088	13
Odor	1.05079	14
Pompton streamflow	1.03034	15
TOC, mg/L	1.02732	16
Conductivity umhos/cm	1.02665	17
Alkalinity mg/L as CaCO3	1.01820	18
Sulfate mg/L	1.00910	19
Chloride mg/L	1.00849	20
HeatingDays	1.00399	21
JAPS extractions	1.00029	22
Nitrite/Nitrate	0.99640	23
Initial Chlorophyta	0.98990	24
Hardness Total, mg/L as CaC	0.98986	25
Pompton extractions	0.98577	26
PrevPrecip	0.98531	27
Passaic extractions	0.98356	28
DO, mg/L	0.98276	29
WindSpeed	0.96983	30
Total Count, cells/ml	0.96536	31
SkyCover	0.95562	32

Table 4.9. Station 612 Cyanobacteria two-week ahead predictions: Sensitivity Analysis

All Input		
Total Amorphous Material	1.849556	1
Total Count, cells/ml	1.130197	2
Initial Cyanophyta	1.118654	3
Odor	1.106885	4
pH	1.102334	5
HeatingDays	1.098789	6
BOD, mg/L	1.046581	7
Alkalinity mg/L as CaCO3	1.046181	8
PrevPrecip	1.030285	9
WindDir	1.02449	10
Turbidity NTU	1.02161	11
Initial Chlorophyta	1.02126	12
PointRes extractions	1.01731	13
Temp 0C	1.00647	14
Hardness Total, mg/L as Ca	1.00555	15
Initial Chrysophyta	1.00472	16
Nitrite/Nitrate	1.00462	17
SkyCover	1.00335	18
Ammonia mg/L	1.00199	19
Color, Cu	1.00090	20
TOC, mg/L	1.00043	21
TotalPhosphorus/Orthophos	0.99991	22
JAPS extractions	0.99951	23
Chloride mg/L	0.99764	24
DO, mg/L	0.99724	25
Pompton streamflow	0.99660	26
Conductivity umhos/cm	0.99649	27
Sulfate mg/L	0.99562	28
WkPrecip	0.99551	29
Pompton extractions	0.99384	30
WindSpeed	0.99285	31
Passaic extractions	0.98825	32
UV254 cm-1	0.98472	33

Initial Cyanophyta level		
Odor	2.115679	1
Total Amorphous Material	2.011052	2
pH	1.862064	3
Turbidity NTU	1.834786	4
HeatingDays	1.815682	5
Temp 0C	1.591622	6
WindDir	1.556734	7
DO, mg/L	1.365383	8
TotalPhosphorus/Orthophos	1.327688	9
Total Count, cells/ml	1.25532	10
PrevPrecip	1.22520	11
BOD, mg/L	1.21869	12
Ammonia mg/L	1.18048	13
Alkalinity mg/L as CaCO3	1.14728	14
Color, Cu	1.14634	15
Pompton extractions	1.12510	16
Initial Chlorophyta	1.08038	17
Sulfate mg/L	1.05676	18
Passaic extractions	1.04663	19
UV254 cm-1	1.03739	20
PointRes extractions	1.03639	21
SkyCover	1.02889	22
Conductivity umhos/cm	1.02673	23
Nitrite/Nitrate	1.02123	24
Chloride mg/L	1.01987	25
Pompton streamflow	1.01103	26
WindSpeed	1.00730	27
TOC, mg/L	1.00303	28
Initial Chrysophyta	1.00191	29
WkPrecip	1.00147	30
Hardness Total, mg/L as Ca	1.00009	31
JAPS extractions	1.00003	32

Total Count		
Total Amorphous Material	1.892747	1
Turbidity NTU	1.475623	2
Color, Cu	1.470421	3
WkPrecip	1.410272	4
Ammonia mg/L	1.169351	5
Pompton extractions	1.166250	6
BOD, mg/L	1.144955	7
SkyCover	1.117559	8
WindDir	1.105014	9
Initial Cyanophyta	1.08628	10
Initial Chlorophyta	1.07013	11
Alkalinity mg/L as CaCO3	1.06628	12
Sulfate mg/L	1.04391	13
HeatingDays	1.03795	14
DO, mg/L	1.01736	15
PointRes extractions	1.01574	16
Hardness Total, mg/L as Ca	1.01286	17
Nitrite/Nitrate	1.01012	18
pH	1.00291	19
JAPS extractions	1.00183	20
TOC, mg/L	1.00053	21
Chloride mg/L	0.99778	22
Passaic extractions	0.99767	23
Odor	0.99733	24
Conductivity umhos/cm	0.99064	25
PrevPrecip	0.99024	26
Temp 0C	0.98686	27
Initial Chrysophyta	0.97478	28
UV254 cm-1	0.96757	29
WindSpeed	0.95428	30
Pompton streamflow	0.95408	31
TotalPhosphorus/Orthophos	0.92726	32

Table 4.9. Station 612 Cyanobacteria two-week ahead predictions: Sensitivity Analysis (cont.)

pH		
Total Amorphous Material	2.574277	1
Turbidity NTU	1.856367	2
PointRes extractions	1.545818	3
Sulfate mg/L	1.436625	4
WkPrecip	1.415024	5
PrevPrecip	1.297332	6
WindDir	1.278549	7
BOD, mg/L	1.269651	8
Conductivity umhos/cm	1.254139	9
Initial Cyanophyta	1.20948	10
Color, Cu	1.17962	11
Temp 0C	1.16985	12
Odor	1.16079	13
Ammonia mg/L	1.10880	14
HeatingDays	1.08641	15
DO, mg/L	1.06578	16
Alkalinity mg/L as CaCO3	1.02942	17
Pompton extractions	1.02630	18
SkyCover	1.01734	19
Initial Chlorophyta	1.01430	20
Initial Chrysophyta	1.01018	21
Total Count, cells/ml	1.00766	22
Hardness Total, mg/L as Ca	0.99961	23
TOC, mg/L	0.99922	24
UV254 cm-1	0.99897	25
Nitrite/Nitrate	0.99815	26
Pompton streamflow	0.98562	27
JAPS extractions	0.98396	28
WindSpeed	0.98370	29
Chloride mg/L	0.98213	30
Passaic extractions	0.98204	31
TotalPhosphorus/Orthophos	0.90639	32

UV254		
Total Amorphous Material	4.216232	1
WkPrecip	3.102156	2
WindDir	3.076739	3
Total Count, cells/ml	2.809666	4
Turbidity NTU	2.724043	5
DO, mg/L	2.631624	6
Temp 0C	2.360474	7
Ammonia mg/L	2.309327	8
Initial Cyanophyta	2.077078	9
SkyCover	1.96285	10
Passaic extractions	1.90373	11
PrevPrecip	1.87055	12
HeatingDays	1.86446	13
Sulfate mg/L	1.74673	14
PointRes extractions	1.70783	15
Color, Cu	1.67784	16
Alkalinity mg/L as CaCO3	1.58365	17
Odor	1.38638	18
Initial Chlorophyta	1.38120	19
WindSpeed	1.17542	20
pH	1.13632	21
TotalPhosphorus/Orthophos	1.11209	22
Chloride mg/L	1.09043	23
Conductivity umhos/cm	1.04128	24
JAPS extractions	1.02200	25
Hardness Total, mg/L as Ca	1.00909	26
TOC, mg/L	1.00466	27
Pompton extractions	0.99618	28
Initial Chrysophyta	0.99399	29
BOD, mg/L	0.99392	30
Pompton streamflow	0.99046	31
Nitrite/Nitrate	0.98848	32

Passaic extractions		
Total Amorphous Material	2.430170	1
Sulfate mg/L	2.284002	2
Odor	1.966158	3
Initial Cyanophyta	1.936658	4
Turbidity NTU	1.374403	5
Total Count, cells/ml	1.313313	6
WindDir	1.253490	7
Color, Cu	1.217354	8
pH	1.151814	9
TotalPhosphorus/Orthophos	1.14181	10
DO, mg/L	1.13721	11
HeatingDays	1.10457	12
PrevPrecip	1.08252	13
SkyCover	1.07713	14
Ammonia mg/L	1.06066	15
Alkalinity mg/L as CaCO3	1.05775	16
PointRes extractions	1.05624	17
BOD, mg/L	1.02513	18
WkPrecip	1.02193	19
Pompton streamflow	1.02098	20
UV254 cm-1	1.01678	21
Pompton extractions	1.01639	22
Initial Chrysophyta	1.00784	23
Temp 0C	1.00737	24
Initial Chlorophyta	1.00151	25
WindSpeed	0.99676	26
Chloride mg/L	0.99380	27
TOC, mg/L	0.98500	28
Conductivity umhos/cm	0.98358	29
Hardness Total, mg/L as Ca	0.97473	30
Nitrite/Nitrate	0.94845	31
JAPS extractions	0.79664	32

Table 5.1. Station 100 Chrysophyta real-time predictions: Sensitivity Analysis

All Input		
Odor	1.439141	1
HeatingDays	1.270610	2
Initial Chrysophyta	1.246146	3
pH	1.146152	4
Pompton extraction	1.145812	5
Temp (0C)	1.119222	6
WindSpeed	1.114208	7
TOC, mg/L	1.109885	8
Nitrite/Nitrate	1.105814	9
Initial Chlorophyta	1.09386	10
Turbidity NTU	1.09186	11
DO, mg/L	1.08959	12
Sulfate, mg/L	1.06262	13
BOD, mg/L	1.05409	14
Hardness, Total mg/L as Ca	1.04852	15
SkyCover	1.03024	16
Passaic Streamflow	1.02417	17
Alkalinity mg/L as CaCO3	1.02310	18
Conductivity, umhos/cm	1.02019	19
TOTAL COUNT, CELLS/M	1.00599	20
UV-254, cm-1	1.00514	21
Initial Cyanophyta	1.00430	22
Chloride, mg/L	1.00133	23
PointRes extractions	0.99909	24
T.Phosphorus/Orthophosph	0.99813	25
Pompton streamflow	0.99598	26
PrevPrecip	0.99572	27
Passaic extractions	0.99453	28
WindDir	0.99375	29
Ammonia, mg/L	0.99076	30
WkPrecip	0.97987	31
TSS, mg/L	0.95963	32

Heating Days		
Initial Chrysophyta	1.309694	1
Odor	1.205482	2
Hardness, Total mg/L as Ca	1.145899	3
Passaic Streamflow	1.083866	4
Initial Chlorophyta	1.078649	5
SkyCover	1.069544	6
Pompton extraction	1.058765	7
Conductivity, umhos/cm	1.044685	8
pH	1.044134	9
Turbidity NTU	1.04408	10
Sulfate, mg/L	1.04131	11
TOTAL COUNT, CELLS/M	1.03772	12
Ammonia, mg/L	1.03597	13
TOC, mg/L	1.03163	14
WindSpeed	1.03070	15
Nitrite/Nitrate	1.03035	16
BOD, mg/L	1.02801	17
Alkalinity mg/L as CaCO3	1.01969	18
DO, mg/L	1.01721	19
Passaic extractions	1.01714	20
Pompton streamflow	1.01348	21
PointRes extractions	1.00841	22
T.Phosphorus/Orthophosph	1.00671	23
WkPrecip	1.00552	24
Initial Cyanophyta	1.00472	25
WindDir	1.00394	26
UV-254, cm-1	1.00105	27
Temp (0C)	1.00028	28
PrevPrecip	1.00015	29
TSS, mg/L	1.00015	30
Chloride, mg/L	0.99025	31

initial Chrysophyta level		
HeatingDays	1.510352	1
TOTAL COUNT, CELLS/M	1.368042	2
Hardness, Total mg/L as Ca	1.260132	3
Odor	1.134722	4
Turbidity NTU	1.061965	5
Initial Chlorophyta	1.056379	6
pH	1.054054	7
WkPrecip	1.036440	8
BOD, mg/L	1.034954	9
WindSpeed	1.03390	10
Sulfate, mg/L	1.02963	11
UV-254, cm-1	1.02624	12
Temp (0C)	1.02459	13
TOC, mg/L	1.02321	14
Passaic Streamflow	1.02124	15
Alkalinity mg/L as CaCO3	1.02046	16
SkyCover	1.01132	17
PointRes extractions	1.00998	18
DO, mg/L	1.00738	19
PrevPrecip	1.00580	20
T.Phosphorus/Orthophosph	1.00576	21
Nitrite/Nitrate	1.00575	22
Ammonia, mg/L	1.00415	23
Conductivity, umhos/cm	1.00344	24
WindDir	1.00071	25
TSS, mg/L	0.99991	26
Passaic extractions	0.99888	27
Pompton streamflow	0.99872	28
Chloride, mg/L	0.99863	29
Initial Cyanophyta	0.98077	30
Pompton extraction	0.98008	31

Table 5.1. Station 100 Chrysophyta real-time predictions: Sensitivity Analysis(cont.)

pH		
Odor	1.140756	1
Initial Chrysophyta	1.055469	2
T.Phosphorus/Orthophosph	1.049894	3
Hardness, Total mg/L as Ca	1.031690	4
Initial Chlorophyta	1.031313	5
WindSpeed	1.021259	6
Alkalinity mg/L as CaCO3	1.016709	7
PointRes extractions	1.013623	8
TOC, mg/L	1.002882	9
Pompton extraction	1.00172	10
Chloride, mg/L	1.00143	11
TOTAL COUNT, CELLS/M	1.00129	12
Passaic extractions	1.00121	13
Conductivity, umhos/cm	1.00048	14
WkPrecip	0.99932	15
Passaic Streamflow	0.99919	16
Turbidity NTU	0.99891	17
SkyCover	0.99871	18
WindDir	0.99853	19
Pompton streamflow	0.99820	20
PrevPrecip	0.99795	21
Temp (0C)	0.99764	22
BOD, mg/L	0.99751	23
UV-254, cm-1	0.99511	24
TSS, mg/L	0.99396	25
DO, mg/L	0.99236	26
Initial Cyanophyta	0.98987	27
Nitrite/Nitrate	0.98857	28
Ammonia, mg/L	0.98754	29
HeatingDays	0.98716	30
Sulfate, mg/L	0.98226	31

TSS		
Initial Chrysophyta	1.175846	1
Nitrite/Nitrate	1.117533	2
Sulfate, mg/L	1.108814	3
Hardness, Total mg/L as Ca	1.101210	4
Pompton extraction	1.085457	5
Turbidity NTU	1.067302	6
HeatingDays	1.054893	7
Ammonia, mg/L	1.052390	8
Odor	1.052268	9
Passaic Streamflow	1.05072	10
TOC, mg/L	1.04781	11
TOTAL COUNT, CELLS/M	1.04724	12
Alkalinity mg/L as CaCO3	1.04629	13
BOD, mg/L	1.04272	14
SkyCover	1.03973	15
pH	1.03226	16
Initial Cyanophyta	1.01536	17
Initial Chlorophyta	1.01440	18
DO, mg/L	1.01439	19
WindDir	1.01407	20
T.Phosphorus/Orthophosph	1.01387	21
Chloride, mg/L	1.01358	22
Pompton streamflow	1.01186	23
Passaic extractions	1.00910	24
Temp (0C)	1.00631	25
UV-254, cm-1	0.99907	26
PrevPrecip	0.99676	27
WindSpeed	0.99667	28
PointRes extractions	0.98873	29
WkPrecip	0.98511	30
Conductivity, umhos/cm	0.97903	31

Weekly Precip		
Initial Chrysophyta	1.155736	1
Odor	1.144995	2
Initial Chlorophyta	1.064076	3
TOTAL COUNT, CELLS/M	1.022826	4
HeatingDays	1.020930	5
PrevPrecip	1.019179	6
Turbidity NTU	1.013917	7
Sulfate, mg/L	1.011784	8
PointRes extractions	1.009233	9
T.Phosphorus/Orthophosph	1.00870	10
Alkalinity mg/L as CaCO3	1.00650	11
Pompton extraction	1.00530	12
Passaic Streamflow	1.00305	13
Initial Cyanophyta	1.00303	14
TOC, mg/L	1.00297	15
DO, mg/L	1.00241	16
Passaic extractions	1.00216	17
Pompton streamflow	1.00142	18
UV-254, cm-1	1.00132	19
SkyCover	1.00096	20
WindSpeed	1.00093	21
TSS, mg/L	1.00045	22
Nitrite/Nitrate	1.00001	23
WindDir	0.99979	24
Ammonia, mg/L	0.99911	25
Chloride, mg/L	0.99863	26
Hardness, Total mg/L as Ca	0.99686	27
Conductivity, umhos/cm	0.99525	28
Temp (0C)	0.99360	29
BOD, mg/L	0.99210	30
pH	0.98775	31

Table 5.2. Station 100 Chrysophyta one-week ahead predictions: Sensitivity Analysis

All Inputs		
Odor	1.521446	1
Initial Chrysophyta	1.360829	2
Hardness, Total mg/L as Ca	1.294863	3
WindSpeed	1.286118	4
TOTAL COUNT, CELLS/M	1.224270	5
HeatingDays	1.194645	6
Turbidity NTU	1.171724	7
Pompton extraction	1.149709	8
Alkalinity mg/L as CaCO3	1.146786	9
Sulfate, mg/L	1.14351	10
Conductivity, umhos/cm	1.14095	11
Initial Cyanophyta	1.13048	12
pH	1.10245	13
PrevPrecip	1.09297	14
BOD, mg/L	1.09179	15
TOC, mg/L	1.09174	16
TSS, mg/L	1.09056	17
Passaic Streamflow	1.08779	18
Nitrite/Nitrate	1.08300	19
Chloride, mg/L	1.07045	20
Temp (0C)	1.06524	21
Ammonia, mg/L	1.04878	22
Initial Chlorophyta	1.04733	23
UV-254, cm-1	1.04686	24
PointRes extractions	1.04620	25
WindDir	1.02197	26
DO, mg/L	1.01103	27
Pompton streamflow	1.00795	28
T.Phosphorus/Orthophosph	1.00781	29
Passaic extractions	1.00402	30
WkPrecip	1.00373	31
SkyCover	0.99898	32

initChrysop		
TOTAL COUNT, CELLS/M	1.132248	1
Odor	1.077437	2
HeatingDays	1.073765	3
Initial Cyanophyta	1.042965	4
Initial Chlorophyta	1.029886	5
TOC, mg/L	1.029012	6
WkPrecip	1.025820	7
T.Phosphorus/Orthophosph	1.017465	8
PrevPrecip	1.015716	9
PointRes extractions	1.01408	10
Temp (0C)	1.01324	11
Turbidity NTU	1.01317	12
BOD, mg/L	1.01301	13
UV-254, cm-1	1.00825	14
Passaic Streamflow	1.00702	15
WindSpeed	1.00550	16
Passaic extractions	1.00294	17
Conductivity, umhos/cm	1.00152	18
pH	1.00077	19
Pompton streamflow	1.00071	20
DO, mg/L	1.00036	21
Ammonia, mg/L	1.00021	22
Pompton extraction	1.00006	23
Chloride, mg/L	0.99939	24
Alkalinity mg/L as CaCO3	0.99933	25
Sulfate, mg/L	0.99923	26
Hardness, Total mg/L as Ca	0.99914	27
WindDir	0.99710	28
Nitrite/Nitrate	0.99483	29
TSS, mg/L	0.99408	30
SkyCover	0.99269	31

Hardness		
Odor	1.202124	1
Initial Chrysophyta	1.141478	2
Temp (0C)	1.074029	3
HeatingDays	1.053165	4
WindSpeed	1.037704	5
Conductivity, umhos/cm	1.035255	6
Chloride, mg/L	1.030076	7
TOTAL COUNT, CELLS/M	1.029534	8
Pompton streamflow	1.026190	9
BOD, mg/L	1.02165	10
T.Phosphorus/Orthophosph	1.02063	11
TSS, mg/L	1.01937	12
Turbidity NTU	1.01928	13
TOC, mg/L	1.01910	14
Passaic Streamflow	1.01408	15
Sulfate, mg/L	1.01379	16
DO, mg/L	1.00903	17
PrevPrecip	1.00901	18
Pompton extraction	1.00830	19
Ammonia, mg/L	1.00314	20
Alkalinity mg/L as CaCO3	1.00262	21
Initial Chlorophyta	1.00057	22
PointRes extractions	0.99965	23
Initial Cyanophyta	0.99515	24
Passaic extractions	0.99514	25
pH	0.99441	26
Nitrite/Nitrate	0.98731	27
UV-254, cm-1	0.98360	28
WkPrecip	0.98337	29
SkyCover	0.97615	30
WindDir	0.96864	31

Table 5.2. Station 100 Chrysophyta one-week ahead predictions: Sensitivity Analysis (cont.)

WindSpeed		
TOTAL COUNT, CELLS/M	1.279477	1
Passaic Streamflow	1.251466	2
BOD, mg/L	1.129827	3
Hardness, Total mg/L as Ca	1.118425	4
Pompton extraction	1.104410	5
Nitrite/Nitrate	1.067198	6
Turbidity NTU	1.057599	7
Pompton streamflow	1.051405	8
Temp (0C)	1.049346	9
Initial Chlorophyta	1.04311	10
WkPrecip	1.03481	11
SkyCover	1.03441	12
Initial Chrysophyta	1.02954	13
T.Phosphorus/Orthophosph	1.01916	14
Ammonia, mg/L	1.01063	15
PrevPrecip	1.00956	16
Initial Cyanophyta	1.00937	17
DO, mg/L	1.00745	18
Chloride, mg/L	1.00586	19
WindDir	1.00542	20
Passaic extractions	1.00500	21
HeatingDays	1.00461	22
TOC, mg/L	1.00375	23
PointRes extractions	1.00158	24
UV-254, cm-1	0.99489	25
Alkalinity mg/L as CaCO3	0.99383	26
Sulfate, mg/L	0.99319	27
Conductivity, umhos/cm	0.99296	28
TSS, mg/L	0.98954	29
Odor	0.97792	30
pH	0.97649	31

SkyCover		
Odor	1.104889	1
Initial Chrysophyta	1.102143	2
Passaic Streamflow	1.027748	3
Hardness, Total mg/L as Ca	1.019397	4
PointRes extractions	1.017602	5
Initial Chlorophyta	1.014602	6
Pompton extraction	1.011959	7
WindSpeed	1.011038	8
Turbidity NTU	1.010418	9
Nitrite/Nitrate	1.00753	10
BOD, mg/L	1.00705	11
WkPrecip	1.00699	12
TOTAL COUNT, CELLS/M	1.00612	13
TOC, mg/L	1.00604	14
Temp (0C)	1.00552	15
Pompton streamflow	1.00352	16
HeatingDays	1.00253	17
Passaic extractions	1.00205	18
Conductivity, umhos/cm	1.00182	19
T.Phosphorus/Orthophosph	1.00143	20
UV-254, cm-1	1.00130	21
Chloride, mg/L	1.00098	22
Initial Cyanophyta	0.99950	23
WindDir	0.99910	24
Ammonia, mg/L	0.99870	25
TSS, mg/L	0.99859	26
DO, mg/L	0.99767	27
pH	0.99659	28
Sulfate, mg/L	0.99644	29
Alkalinity mg/L as CaCO3	0.99348	30
PrevPrecip	0.99279	31

WkPrecip		
HeatingDays	1.160695	1
Odor	1.136484	2
Initial Chrysophyta	1.128300	3
BOD, mg/L	1.097827	4
Temp (0C)	1.063753	5
Initial Chlorophyta	1.054119	6
Nitrite/Nitrate	1.045015	7
WindSpeed	1.033937	8
UV-254, cm-1	1.032817	9
Chloride, mg/L	1.03001	10
Sulfate, mg/L	1.02951	11
TOTAL COUNT, CELLS/M	1.02817	12
Pompton extraction	1.02815	13
Hardness, Total mg/L as Ca	1.02666	14
Turbidity NTU	1.02510	15
TSS, mg/L	1.01978	16
SkyCover	1.01635	17
Pompton streamflow	1.01586	18
Passaic Streamflow	1.01434	19
Alkalinity mg/L as CaCO3	1.01290	20
PointRes extractions	1.00839	21
pH	1.00828	22
Ammonia, mg/L	1.00791	23
Initial Cyanophyta	1.00531	24
PrevPrecip	1.00436	25
TOC, mg/L	1.00325	26
Conductivity, umhos/cm	1.00061	27
T.Phosphorus/Orthophosph	1.00001	28
WindDir	0.99626	29
Passaic extractions	0.99261	30
DO, mg/L	0.98872	31

Table 5.3. Station 100 Chrysophyta two-week ahead predictions: Sensitivity Analysis

All Inputs		
HeatingDays	1.369502	1
Initial Chrysophyta	1.345050	2
Odor	1.319412	3
TOTAL COUNT, CELLS/M	1.129684	4
WindSpeed	1.117134	5
Hardness, Total mg/L as Ca	1.062057	6
Pompton extraction	1.054839	7
WindDir	1.043277	8
Chloride, mg/L	1.037207	9
DO, mg/L	1.03692	10
PrevPrecip	1.03425	11
Turbidity NTU	1.03239	12
Nitrite/Nitrate	1.02915	13
Sulfate, mg/L	1.01875	14
TOC, mg/L	1.01841	15
Alkalinity mg/L as CaCO3	1.01781	16
Ammonia, mg/L	1.01375	17
pH	1.01361	18
UV-254, cm-1	1.00616	19
Initial Chlorophyta	1.00580	20
WkPrecip	1.00158	21
Temp (0C)	1.00125	22
Conductivity, umhos/cm	1.00120	23
Passaic extractions	1.00061	24
Initial Cyanophyta	1.00002	25
TSS, mg/L	0.99965	26
T.Phosphorus/Orthophosph	0.99717	27
Pompton streamflow	0.99568	28
BOD, mg/L	0.99530	29
PointRes extractions	0.99431	30
SkyCover	0.99396	31
Passaic Streamflow	0.99216	32

Heating Days		
Initial Chrysophyta	1.162948	1
Odor	1.103051	2
Pompton extraction	1.088157	3
TOTAL COUNT, CELLS/M	1.069700	4
Temp (0C)	1.036843	5
WindSpeed	1.032075	6
Hardness, Total mg/L as Ca	1.031393	7
T.Phosphorus/Orthophosph	1.027745	8
Initial Chlorophyta	1.016594	9
TOC, mg/L	1.01643	10
DO, mg/L	1.01243	11
UV-254, cm-1	1.01065	12
Passaic Streamflow	1.00947	13
Ammonia, mg/L	1.00688	14
Turbidity NTU	1.00518	15
pH	1.00473	16
SkyCover	1.00449	17
WindDir	1.00312	18
PointRes extractions	1.00237	19
WkPrecip	1.00134	20
Alkalinity mg/L as CaCO3	1.00089	21
PrevPrecip	1.00047	22
Initial Cyanophyta	0.99970	23
Passaic extractions	0.99937	24
Pompton streamflow	0.99927	25
Sulfate, mg/L	0.99746	26
Conductivity, umhos/cm	0.99716	27
BOD, mg/L	0.99669	28
TSS, mg/L	0.99557	29
Nitrite/Nitrate	0.99536	30
Chloride, mg/L	0.97838	31

initital Chrysophyta level		
Pompton extraction	1.099987	1
Passaic Streamflow	1.094457	2
Hardness, Total mg/L as Ca	1.090044	3
HeatingDays	1.066225	4
Initial Chlorophyta	1.054302	5
Sulfate, mg/L	1.053777	6
Odor	1.046903	7
Temp (0C)	1.046726	8
WindSpeed	1.046397	9
Conductivity, umhos/cm	1.04105	10
pH	1.03934	11
WkPrecip	1.03243	12
TOTAL COUNT, CELLS/M	1.03072	13
UV-254, cm-1	1.02671	14
DO, mg/L	1.02639	15
Nitrite/Nitrate	1.02263	16
Alkalinity mg/L as CaCO3	1.01539	17
Chloride, mg/L	1.01416	18
Pompton streamflow	1.00779	19
T.Phosphorus/Orthophosph	1.00574	20
PrevPrecip	1.00405	21
PointRes extractions	1.00250	22
Initial Cyanophyta	1.00062	23
TOC, mg/L	1.00006	24
Ammonia, mg/L	1.00001	25
Passaic extractions	0.99681	26
WindDir	0.99676	27
TSS, mg/L	0.99446	28
BOD, mg/L	0.98454	29
SkyCover	0.97477	30
Turbidity NTU	0.95370	31

Table 5.3. Station 100 Chrysophyta two-week ahead predictions: Sensitivity Analysis (cont.)

Total Count		
Temp (0C)	1.222363	1
Initial Chlorophyta	1.131276	2
Initial Chrysophyta	1.125115	3
Pompton extraction	1.124591	4
PrevPrecip	1.082978	5
Odor	1.073291	6
Conductivity, umhos/cm	1.072499	7
SkyCover	1.061792	8
Passaic Streamflow	1.061662	9
HeatingDays	1.04932	10
TSS, mg/L	1.04336	11
DO, mg/L	1.04297	12
Nitrite/Nitrate	1.03586	13
WindSpeed	1.03222	14
TOC, mg/L	1.02034	15
Sulfate, mg/L	1.01061	16
Hardness, Total mg/L as Ca	1.00910	17
UV-254, cm-1	1.00608	18
T.Phosphorus/Orthophosph	1.00404	19
pH	1.00126	20
WindDir	0.99982	21
PointRes extractions	0.99906	22
Passaic extractions	0.99816	23
Ammonia, mg/L	0.99236	24
Initial Cyanophyta	0.98943	25
Alkalinity mg/L as CaCO3	0.98082	26
BOD, mg/L	0.97664	27
WkPrecip	0.96680	28
Chloride, mg/L	0.96387	29
Turbidity NTU	0.95362	30
Pompton streamflow	0.94463	31

Passaic Streamflow		
Initial Chrysophyta	1.094478	1
Odor	1.042687	2
WindSpeed	1.041707	3
TOTAL COUNT, CELLS/M	1.035010	4
HeatingDays	1.017126	5
WindDir	1.009761	6
PrevPrecip	1.008771	7
pH	1.008229	8
TSS, mg/L	1.007835	9
Conductivity, umhos/cm	1.00671	10
Temp (0C)	1.00545	11
Alkalinity mg/L as CaCO3	1.00508	12
Pompton extraction	1.00457	13
Initial Chlorophyta	1.00440	14
BOD, mg/L	1.00418	15
Hardness, Total mg/L as Ca	1.00372	16
TOC, mg/L	1.00351	17
T.Phosphorus/Orthophosph	1.00140	18
DO, mg/L	1.00127	19
WkPrecip	1.00127	20
Pompton streamflow	1.00093	21
Chloride, mg/L	1.00080	22
SkyCover	1.00052	23
UV-254, cm-1	1.00031	24
Sulfate, mg/L	1.00023	25
Nitrite/Nitrate	1.00020	26
PointRes extractions	0.99994	27
Passaic extractions	0.99988	28
Ammonia, mg/L	0.99979	29
Initial Cyanophyta	0.99840	30
Turbidity NTU	0.98485	31

SkyCover		
Temp (0C)	1.687350	1
Hardness, Total mg/L as Ca	1.477586	2
HeatingDays	1.424567	3
Pompton extraction	1.282256	4
Ammonia, mg/L	1.190907	5
Passaic Streamflow	1.142239	6
Odor	1.113555	7
Initial Chrysophyta	1.094975	8
WindSpeed	1.078744	9
TOC, mg/L	1.03008	10
WindDir	1.02630	11
WkPrecip	1.02625	12
pH	1.01471	13
BOD, mg/L	1.01334	14
Conductivity, umhos/cm	1.00627	15
Alkalinity mg/L as CaCO3	1.00454	16
TSS, mg/L	1.00354	17
Nitrite/Nitrate	0.99981	18
T.Phosphorus/Orthophosph	0.99799	19
PointRes extractions	0.99669	20
Initial Cyanophyta	0.99608	21
Chloride, mg/L	0.99530	22
DO, mg/L	0.99527	23
Passaic extractions	0.98904	24
Pompton streamflow	0.98883	25
PrevPrecip	0.98318	26
Sulfate, mg/L	0.97715	27
Initial Chlorophyta	0.93762	28
UV-254, cm-1	0.90223	29
TOTAL COUNT, CELLS/M	0.86645	30
Turbidity NTU	0.84067	31

Table 5.4. Station 101 Chrysophyta real-time predictions: Sensitivity Analysis

All Input		
Initial Chrysophyta	1.073253	1
Total Amorphous Material	1.046389	2
Pompton streamflow	1.045826	3
Odor	1.018599	4
Hardness Total, mg/L as Ca	1.015229	5
WkPrecip	1.008524	6
Temp 0C	1.006809	7
PrevPrecip	1.006508	8
Ammonia mg/L	1.005956	9
Conductivity umhos/cm	1.00481	10
Turbidity NTU	1.00479	11
WindDir	1.00372	12
Total Count, cells/ml	1.00326	13
WindSpeed	1.00291	14
UV254 cm-1	1.00287	15
DO, mg/L	1.00269	16
SkyCover	1.00265	17
HeatingDays	1.00238	18
PointRes extractions	1.00197	19
Color, Cu	0.99989	20
Chloride mg/L	0.99887	21
pH	0.99874	22
T.Phosphorus/Orthophosph	0.99783	23
Initial Chlorophyta	0.99742	24
BOD, mg/L	0.99654	25
Alkalinity mg/L as CaCO3	0.99602	26
Sulfate mg/L	0.99520	27
Initial Cyanophyta	0.99515	28
Passaic extractions	0.99386	29
TOC, mg/L	0.99340	30
Pompton extraction	0.99286	31
Nitrite/Nitrate	0.98760	32
JAPS extractions	0.98144	33

initial Chrystophyta level		
Nitrite/Nitrate	1.179575	1
T.Phosphorus/Orthophosph	1.161097	2
Total Amorphous Material	1.151384	3
SkyCover	1.121052	4
HeatingDays	1.101415	5
TOC, mg/L	1.060648	6
pH	1.056937	7
Odor	1.056462	8
Temp 0C	1.053802	9
Conductivity umhos/cm	1.04937	10
Sulfate mg/L	1.04380	11
Pompton extraction	1.04165	12
PrevPrecip	1.03956	13
BOD, mg/L	1.03762	14
JAPS extractions	1.02700	15
WkPrecip	1.02040	16
WindSpeed	1.01560	17
UV254 cm-1	1.01367	18
Hardness Total, mg/L as Ca	1.01157	19
Initial Chlorophyta	1.00916	20
Ammonia mg/L	1.00793	21
Turbidity NTU	1.00577	22
Initial Cyanophyta	1.00357	23
PointRes extractions	1.00050	24
WindDir	0.99626	25
DO, mg/L	0.99075	26
Pompton streamflow	0.98960	27
Total Count, cells/ml	0.98751	28
Alkalinity mg/L as CaCO3	0.98405	29
Passaic extractions	0.96706	30
Chloride mg/L	0.96405	31
Color, Cu	0.96147	32

Pompton streamflow		
Total Amorphous Material	1.200780	1
Color, Cu	1.168425	2
Ammonia mg/L	1.068740	3
Passaic extractions	1.054717	4
WkPrecip	1.048759	5
Temp 0C	1.046028	6
BOD, mg/L	1.043518	7
Pompton extraction	1.035491	8
Conductivity umhos/cm	1.035470	9
Initial Chrysophyta	1.03485	10
TOC, mg/L	1.03401	11
Sulfate mg/L	1.02773	12
HeatingDays	1.02281	13
WindSpeed	1.01574	14
Turbidity NTU	1.00940	15
Nitrite/Nitrate	1.00689	16
Total Count, cells/ml	1.00400	17
JAPS extractions	1.00348	18
Odor	1.00067	19
UV254 cm-1	0.99698	20
SkyCover	0.99292	21
PrevPrecip	0.98690	22
WindDir	0.98610	23
DO, mg/L	0.98574	24
Initial Cyanophyta	0.98455	25
PointRes extractions	0.98270	26
pH	0.98002	27
T.Phosphorus/Orthophosph	0.97720	28
Initial Chlorophyta	0.95779	29
Alkalinity mg/L as CaCO3	0.95169	30
Chloride mg/L	0.93873	31
Hardness Total, mg/L as Ca	0.92886	32

Table 5.4. Station 101 Chrysophyta real-time predictions: Sensitivity Analysis (cont.)

Total Hardness		
T.Phosphorus/Orthophosph	1.176839	1
Temp 0C	1.171748	2
Total Amorphous Material	1.161617	3
Passaic extractions	1.158385	4
Odor	1.158305	5
Sulfate mg/L	1.146857	6
BOD, mg/L	1.145556	7
pH	1.135018	8
Total Count, cells/ml	1.120272	9
Alkalinity mg/L as CaCO3	1.09180	10
Ammonia mg/L	1.08079	11
HeatingDays	1.05918	12
Chloride mg/L	1.05760	13
WindSpeed	1.05654	14
Conductivity umhos/cm	1.05100	15
Color, Cu	1.04990	16
PointRes extractions	1.04795	17
TOC, mg/L	1.04490	18
Initial Chrysophyta	1.03614	19
WindDir	1.02953	20
Pompton streamflow	1.02549	21
DO, mg/L	1.02290	22
WkPrecip	1.01756	23
Nitrite/Nitrate	1.01405	24
PrevPrecip	1.01377	25
Turbidity NTU	1.01172	26
Pompton extraction	1.00566	27
JAPS extractions	1.00034	28
UV254 cm-1	0.99566	29
Initial Cyanophyta	0.99048	30
SkyCover	0.97873	31
Initial Chlorophyta	0.96594	32

Nitrite/Nitrate		
Total Amorphous Material	1.151112	1
Initial Chrysophyta	1.150694	2
Passaic extractions	1.136191	3
Odor	1.135714	4
Temp 0C	1.126398	5
Pompton streamflow	1.118767	6
Conductivity umhos/cm	1.087240	7
WindDir	1.073090	8
Pompton extraction	1.047185	9
UV254 cm-1	1.03721	10
SkyCover	1.03660	11
T.Phosphorus/Orthophosph	1.03478	12
Alkalinity mg/L as CaCO3	1.03010	13
Color, Cu	1.02809	14
Total Count, cells/ml	1.02735	15
Sulfate mg/L	1.02572	16
Initial Cyanophyta	1.02467	17
WkPrecip	1.02449	18
Hardness Total, mg/L as Ca	1.02390	19
pH	1.02294	20
PrevPrecip	1.02253	21
TOC, mg/L	1.02078	22
Ammonia mg/L	1.01982	23
JAPS extractions	1.01663	24
BOD, mg/L	1.01485	25
WindSpeed	1.01434	26
Turbidity NTU	1.01320	27
Initial Chlorophyta	1.00705	28
Chloride mg/L	0.99867	29
DO, mg/L	0.99855	30
HeatingDays	0.99840	31
PointRes extractions	0.98517	32

JAPS extractions		
Color, Cu	1.184033	1
SkyCover	1.113545	2
Total Amorphous Material	1.111609	3
Initial Chlorophyta	1.102582	4
Total Count, cells/ml	1.098532	5
WindDir	1.095804	6
WkPrecip	1.094101	7
Odor	1.092980	8
T.Phosphorus/Orthophosph	1.084005	9
Alkalinity mg/L as CaCO3	1.07259	10
Initial Chrysophyta	1.05899	11
PrevPrecip	1.05013	12
pH	1.04909	13
Initial Cyanophyta	1.04382	14
Sulfate mg/L	1.03388	15
UV254 cm-1	1.03244	16
Conductivity umhos/cm	1.02645	17
TOC, mg/L	1.02632	18
Hardness Total, mg/L as Ca	1.01770	19
Passaic extractions	1.01576	20
Nitrite/Nitrate	1.01526	21
WindSpeed	1.01239	22
DO, mg/L	1.01228	23
PointRes extractions	1.00991	24
Pompton streamflow	1.00901	25
Temp 0C	1.00838	26
BOD, mg/L	1.00262	27
Turbidity NTU	1.00045	28
Ammonia mg/L	0.99747	29
Chloride mg/L	0.99495	30
Pompton extraction	0.99403	31
HeatingDays	0.96280	32

Total Amorphous Materials		
Initial Chrysophyta	1.056908	1
T.Phosphorus/Orthophosph	1.033379	2
TOC, mg/L	1.025763	3
WindDir	1.020496	4
Pompton extraction	1.016161	5
Nitrite/Nitrate	1.014760	6
Sulfate mg/L	1.011031	7
Initial Chlorophyta	1.010519	8
Hardness Total, mg/L as Ca	1.007204	9
PrevPrecip	1.00719	10
Conductivity umhos/cm	1.00694	11
PointRes extractions	1.00480	12
Color, Cu	1.00449	13
WindSpeed	1.00330	14
Initial Cyanophyta	1.00326	15
pH	1.00290	16
Passaic extractions	1.00238	17
Alkalinity mg/L as CaCO3	1.00232	18
JAPS extractions	1.00152	19
Pompton streamflow	1.00102	20
WkPrecip	1.00008	21
Temp 0C	1.00006	22
Total Count, cells/ml	0.99868	23
DO, mg/L	0.99849	24
SkyCover	0.99817	25
BOD, mg/L	0.99792	26
Chloride mg/L	0.99676	27
Turbidity NTU	0.99592	28
HeatingDays	0.99555	29
UV254 cm-1	0.99456	30
Ammonia mg/L	0.99433	31
Odor	0.98663	32

Table 5.5. Station 101 Chrysophyta one-week ahead prediction: Sensitivity Analyses

All Inputs		
WkPrecip	1.254895	1
Total Amorphous Material	1.146450	2
Temp 0C	1.117837	3
Initial Chrysophyta	1.111987	4
Pompton extraction	1.059052	5
SkyCover	1.056696	6
HeatingDays	1.046195	7
WindSpeed	1.041512	8
Initial Chlorophyta	1.036407	9
BOD, mg/L	1.03573	10
Chloride mg/L	1.03470	11
TOC, mg/L	1.03100	12
Ammonia mg/L	1.02686	13
PointRes extractions	1.02372	14
Sulfate mg/L	1.02348	15
WindDir	1.01896	16
Total Count, cells/ml	1.01870	17
UV254 cm-1	1.01746	18
Turbidity NTU	1.01077	19
Conductivity umhos/cm	1.00666	20
Odor	1.00568	21
PrevPrecip	1.00511	22
Initial Cyanophyta	1.00482	23
Nitrite/Nitrate	0.98698	24
pH	0.98479	25
DO, mg/L	0.98394	26
T.Phosphorus/Orthophosph	0.97900	27
Hardness Total, mg/L as Ca	0.97625	28
Alkalinity mg/L as CaCO3	0.96108	29
Pompton streamflow	0.95042	30
Passaic extractions	0.94585	31
Color, Cu	0.94433	32
JAPS extractions	0.91467	33

Weekly Precip		
Pompton extraction	1.085568	1
Initial Cyanophyta	1.061365	2
Initial Chlorophyta	1.046331	3
HeatingDays	1.033268	4
DO, mg/L	1.032708	5
Chloride mg/L	1.029676	6
Sulfate mg/L	1.024887	7
JAPS extractions	1.017837	8
Turbidity NTU	1.014765	9
Initial Chrysophyta	1.01311	10
Ammonia mg/L	1.01234	11
PrevPrecip	1.01150	12
PointRes extractions	1.00850	13
UV254 cm-1	1.00798	14
BOD, mg/L	1.00759	15
Temp 0C	1.00745	16
Color, Cu	1.00726	17
SkyCover	1.00677	18
TOC, mg/L	1.00433	19
Nitrite/Nitrate	1.00415	20
WindSpeed	1.00007	21
Total Amorphous Material	0.99966	22
Total Count, cells/ml	0.99728	23
pH	0.99630	24
Passaic extractions	0.99199	25
Alkalinity mg/L as CaCO3	0.98973	26
Conductivity umhos/cm	0.98757	27
Odor	0.98607	28
Pompton streamflow	0.97556	29
T.Phosphorus/Orthophosph	0.96922	30
Hardness Total, mg/L as Ca	0.96584	31
WindDir	0.00000	32

initial Chrysophyta level		
Total Amorphous Material	1.194037	1
WkPrecip	1.059465	2
Hardness Total, mg/L as Ca	1.051633	3
Ammonia mg/L	1.044773	4
JAPS extractions	1.040282	5
Odor	1.030377	6
SkyCover	1.028811	7
WindDir	1.015680	8
Total Count, cells/ml	1.015464	9
PrevPrecip	1.01392	10
Pompton streamflow	1.01366	11
Passaic extractions	1.01120	12
Turbidity NTU	1.00992	13
Chloride mg/L	1.00786	14
UV254 cm-1	1.00550	15
WindSpeed	1.00531	16
pH	1.00257	17
TOC, mg/L	1.00253	18
Color, Cu	1.00172	19
Initial Cyanophyta	1.00132	20
Initial Chlorophyta	0.99998	21
PointRes extractions	0.99931	22
Pompton extraction	0.99907	23
Alkalinity mg/L as CaCO3	0.99629	24
Temp 0C	0.99208	25
Sulfate mg/L	0.99199	26
BOD, mg/L	0.99121	27
Conductivity umhos/cm	0.99079	28
Nitrite/Nitrate	0.98888	29
HeatingDays	0.98678	30
T.Phosphorus/Orthophosph	0.98631	31
DO, mg/L	0.64311	32

Table 5.5. Station 101 Chrysophyta one-week ahead prediction: Sensitivity Analyses (cont.)

Temperature		
Total Amorphous Material	1.198263	1
Odor	1.146379	2
Ammonia mg/L	1.136185	3
Initial Chrysophyta	1.131821	4
T.Phosphorus/Orthophosph	1.121202	5
WkPrecip	1.119827	6
Total Count, cells/ml	1.114277	7
Nitrite/Nitrate	1.083003	8
WindSpeed	1.080656	9
Turbidity NTU	1.07509	10
TOC, mg/L	1.04817	11
WindDir	1.04561	12
BOD, mg/L	1.04491	13
HeatingDays	1.04252	14
Hardness Total, mg/L as Ca	1.04232	15
Sulfate mg/L	1.03772	16
UV254 cm-1	1.03573	17
Initial Chlorophyta	1.03453	18
Pompton extraction	1.02588	19
Conductivity umhos/cm	1.02501	20
Passaic extractions	1.02431	21
Color, Cu	1.01932	22
pH	1.01330	23
Chloride mg/L	1.01052	24
DO, mg/L	1.00952	25
PointRes extractions	1.00804	26
Alkalinity mg/L as CaCO3	1.00761	27
PrevPrecip	1.00731	28
Initial Cyanophyta	1.00343	29
SkyCover	0.99951	30
JAPS extractions	0.99625	31
Pompton streamflow	0.97037	32

Color		
WkPrecip	1.378420	1
Turbidity NTU	1.331938	2
WindSpeed	1.181706	3
Initial Chrysophyta	1.145049	4
Temp 0C	1.113968	5
BOD, mg/L	1.110555	6
Odor	1.109214	7
Alkalinity mg/L as CaCO3	1.079995	8
Hardness Total, mg/L as Ca	1.075211	9
Ammonia mg/L	1.04978	10
Sulfate mg/L	1.04972	11
PrevPrecip	1.04404	12
JAPS extractions	1.04325	13
Pompton extraction	1.04220	14
Total Amorphous Material	1.03458	15
pH	1.02829	16
Initial Chlorophyta	1.02431	17
Passaic extractions	1.00944	18
Total Count, cells/ml	1.00734	19
UV254 cm-1	1.00408	20
WindDir	1.00374	21
DO, mg/L	0.99940	22
PointRes extractions	0.99829	23
T.Phosphorus/Orthophosph	0.99646	24
Initial Cyanophyta	0.99557	25
TOC, mg/L	0.99509	26
Pompton streamflow	0.99297	27
SkyCover	0.99251	28
Chloride mg/L	0.99029	29
HeatingDays	0.98421	30
Conductivity umhos/cm	0.98414	31
Nitrite/Nitrate	0.97826	32

JAPS extractions		
Initial Chrysophyta	1.133837	1
Total Amorphous Material	1.130847	2
Pompton streamflow	1.089498	3
Odor	1.069622	4
WkPrecip	1.034079	5
T.Phosphorus/Orthophosph	1.029579	6
TOC, mg/L	1.019630	7
Turbidity NTU	1.017916	8
Hardness Total, mg/L as Ca	1.017117	9
Chloride mg/L	1.01696	10
HeatingDays	1.01324	11
Passaic extractions	1.01242	12
WindDir	1.01181	13
WindSpeed	1.01015	14
Color, Cu	1.00946	15
Alkalinity mg/L as CaCO3	1.00625	16
Total Count, cells/ml	1.00575	17
BOD, mg/L	1.00471	18
Ammonia mg/L	1.00140	19
pH	1.00031	20
Conductivity umhos/cm	1.00022	21
SkyCover	0.99667	22
UV254 cm-1	0.99615	23
Nitrite/Nitrate	0.99396	24
Initial Chlorophyta	0.99301	25
Sulfate mg/L	0.99280	26
Temp 0C	0.99103	27
PrevPrecip	0.98947	28
Pompton extraction	0.98735	29
DO, mg/L	0.97864	30
Initial Cyanophyta	0.93283	31
PointRes extractions	0.86997	32

Total Amorphous Materials		
T.Phosphorus/Orthophosph	1.440685	1
Odor	1.265549	2
Nitrite/Nitrate	1.164088	3
TOC, mg/L	1.117758	4
Conductivity umhos/cm	1.114637	5
HeatingDays	1.097790	6
Initial Chlorophyta	1.092208	7
Passaic extractions	1.079644	8
Initial Chrysophyta	1.068846	9
Ammonia mg/L	1.05573	10
JAPS extractions	1.05526	11
Total Count, cells/ml	1.04502	12
WindDir	1.03940	13
Pompton streamflow	1.03351	14
pH	1.03172	15
BOD, mg/L	1.03109	16
WindSpeed	1.02921	17
Initial Cyanophyta	1.02294	18
PrevPrecip	1.01664	19
Pompton extraction	1.01325	20
UV254 cm-1	1.01241	21
Chloride mg/L	1.01101	22
DO, mg/L	1.00911	23
Hardness Total, mg/L as Ca	1.00758	24
Turbidity NTU	1.00451	25
PointRes extractions	1.00411	26
WkPrecip	1.00355	27
Color, Cu	0.99929	28
Alkalinity mg/L as CaCO3	0.97577	29
SkyCover	0.97280	30
Sulfate mg/L	0.91529	31
Temp 0C	0.91276	32

Table 5.6. Station 101 Chrysophyta two-week ahead prediction: Sensitivity Analyses

All Inputs		
Total Amorphous Material	1.192245	1
Odor	1.160446	2
WkPrecip	1.089413	3
Alkalinity mg/L as CaCO3	1.057529	4
Ammonia mg/L	1.047529	5
Initial Cyanophyta	1.045941	6
Sulfate mg/L	1.040462	7
JAPS extractions	1.039249	8
DO, mg/L	1.036102	9
SkyCover	1.03311	10
Pompton extraction	1.03188	11
Initial Chrysophyta	1.03146	12
Nitrite/Nitrate	1.02717	13
Hardness Total, mg/L as Ca	1.01983	14
pH	1.01700	15
Initial Chlorophyta	1.01630	16
Turbidity NTU	1.01037	17
PointRes extractions	1.00389	18
Color, Cu	1.00387	19
BOD, mg/L	1.00271	20
UV254 cm-1	1.00046	21
Temp 0C	0.99859	22
Chloride mg/L	0.99414	23
T.Phosphorus/Orthophosph	0.99342	24
Total Count, cells/ml	0.99090	25
Pompton streamflow	0.99066	26
TOC, mg/L	0.98694	27
WindDir	0.98675	28
WindSpeed	0.98459	29
Conductivity umhos/cm	0.98006	30
PrevPrecip	0.97439	31
Passaic extractions	0.97264	32
HeatingDays	0.97021	33

Weekly Precip		
Total Amorphous Material	1.078492	1
Initial Chrysophyta	1.048187	2
UV254 cm-1	1.044152	3
JAPS extractions	1.041199	4
Chloride mg/L	1.040541	5
pH	1.034808	6
Nitrite/Nitrate	1.029987	7
Odor	1.028958	8
Temp 0C	1.018894	9
Color, Cu	1.01730	10
SkyCover	1.01476	11
DO, mg/L	1.01213	12
HeatingDays	1.01159	13
Conductivity umhos/cm	1.01151	14
TOC, mg/L	1.00982	15
Initial Cyanophyta	1.00947	16
PrevPrecip	1.00653	17
Initial Chlorophyta	1.00213	18
WindSpeed	1.00134	19
Passaic extractions	1.00093	20
Pompton extraction	0.99976	21
Sulfate mg/L	0.99573	22
Alkalinity mg/L as CaCO3	0.99556	23
Ammonia mg/L	0.99500	24
Hardness Total, mg/L as Ca	0.99494	25
BOD, mg/L	0.99437	26
Turbidity NTU	0.99330	27
Total Count, cells/ml	0.99244	28
T.Phosphorus/Orthophosph	0.98696	29
PointRes extractions	0.98086	30
WindDir	0.97380	31
Pompton streamflow	0.97187	32

Alkalinity		
HeatingDays	1.056241	1
Initial Chlorophyta	1.048184	2
Odor	1.039568	3
Conductivity umhos/cm	1.038182	4
Pompton streamflow	1.020725	5
WkPrecip	1.019652	6
Initial Chrysophyta	1.018667	7
TOC, mg/L	1.016638	8
BOD, mg/L	1.015654	9
pH	1.01527	10
T.Phosphorus/Orthophosph	1.01412	11
PrevPrecip	1.01302	12
SkyCover	1.01243	13
Hardness Total, mg/L as Ca	1.01195	14
Chloride mg/L	1.00987	15
Passaic extractions	1.00823	16
Ammonia mg/L	1.00613	17
Total Count, cells/ml	1.00424	18
Nitrite/Nitrate	1.00412	19
PointRes extractions	1.00221	20
Sulfate mg/L	1.00091	21
DO, mg/L	1.00039	22
UV254 cm-1	0.99949	23
Turbidity NTU	0.99926	24
JAPS extractions	0.99684	25
Color, Cu	0.99671	26
Initial Cyanophyta	0.99634	27
Temp 0C	0.99506	28
WindDir	0.99253	29
Pompton extraction	0.99010	30
WindSpeed	0.98345	31
Total Amorphous Material	0.96732	32

Table 5.6. Station 101 Chrysophyta two-week ahead prediction: Sensitivity Analyses (cont.)

Ammonia		
Total Amorphous Material	1.735225	1
Initial Cyanophyta	1.471929	2
Color, Cu	1.284074	3
Odor	1.282435	4
Turbidity NTU	1.201516	5
TOC, mg/L	1.163607	6
WkPrecip	1.155703	7
WindDir	1.081048	8
Pompton streamflow	1.076306	9
Chloride mg/L	1.07075	10
PrevPrecip	1.06752	11
JAPS extractions	1.06313	12
Initial Chrysophyta	1.05359	13
UV254 cm-1	1.04949	14
Temp 0C	1.04437	15
HeatingDays	1.04290	16
pH	1.03111	17
BOD, mg/L	1.02971	18
Passaic extractions	1.02829	19
T.Phosphorus/Orthophosph	1.02815	20
Alkalinity mg/L as CaCO3	1.01911	21
Total Count, cells/ml	1.01811	22
DO, mg/L	1.00950	23
SkyCover	1.00347	24
Sulfate mg/L	0.99972	25
Pompton extraction	0.99520	26
WindSpeed	0.98989	27
Nitrite/Nitrate	0.98859	28
Initial Chlorophyta	0.98849	29
PointRes extractions	0.98811	30
Conductivity umhos/cm	0.95183	31
Hardness Total, mg/L as Ca	0.93123	32

Passaic extractions		
Initial Cyanophyta	1.112667	1
WkPrecip	1.093473	2
Initial Chrysophyta	1.090499	3
Total Amorphous Material	1.059887	4
Alkalinity mg/L as CaCO3	1.025537	5
TOC, mg/L	1.019806	6
SkyCover	1.012752	7
Color, Cu	1.012467	8
Sulfate mg/L	1.011644	9
DO, mg/L	1.00937	10
Total Count, cells/ml	1.00878	11
PrevPrecip	1.00827	12
Initial Chlorophyta	1.00557	13
Turbidity NTU	1.00220	14
BOD, mg/L	1.00090	15
JAPS extractions	1.00076	16
Odor	0.99868	17
pH	0.99816	18
Hardness Total, mg/L as Ca	0.99769	19
PointRes extractions	0.99592	20
UV254 cm-1	0.99399	21
Pompton extraction	0.99151	22
Ammonia mg/L	0.98888	23
T.Phosphorus/Orthophosph	0.98878	24
Chloride mg/L	0.98489	25
WindDir	0.98467	26
Conductivity umhos/cm	0.98115	27
WindSpeed	0.97999	28
Nitrite/Nitrate	0.97993	29
Temp 0C	0.97792	30
HeatingDays	0.96965	31
Pompton streamflow	0.96479	32

Heating Days		
Total Amorphous Material	1.104495	1
Ammonia mg/L	1.048916	2
T.Phosphorus/Orthophosph	1.039721	3
Pompton streamflow	1.039050	4
pH	1.035641	5
UV254 cm-1	1.035288	6
Odor	1.026262	7
Conductivity umhos/cm	1.025448	8
BOD, mg/L	1.024946	9
PointRes extractions	1.02343	10
TOC, mg/L	1.02002	11
Pompton extraction	1.01974	12
Nitrite/Nitrate	1.01926	13
Alkalinity mg/L as CaCO3	1.01759	14
Color, Cu	1.01606	15
WindSpeed	1.01204	16
Chloride mg/L	1.00986	17
Initial Chrysophyta	1.00691	18
Temp 0C	1.00574	19
Initial Cyanophyta	1.00573	20
Total Count, cells/ml	1.00553	21
Hardness Total, mg/L as Ca	1.00543	22
Passaic extractions	1.00497	23
Initial Chlorophyta	1.00479	24
Sulfate mg/L	1.00273	25
WindDir	0.99636	26
SkyCover	0.99425	27
PrevPrecip	0.99280	28
WkPrecip	0.98761	29
JAPS extractions	0.97190	30
DO, mg/L	0.95801	31
Turbidity NTU	0.95113	32

Table 5.6. Station 101 Chrysophyta two-week ahead prediction: Sensitivity Analyses (cont.)

Total Amorphous Material		
Initial Chrysophyta	1.065364	1
SkyCover	1.034509	2
Initial Cyanophyta	1.032684	3
TOC, mg/L	1.018945	4
Passaic extractions	1.017028	5
Conductivity umhos/cm	1.013937	6
Odor	1.013629	7
JAPS extractions	1.011485	8
Sulfate mg/L	1.010888	9
Temp 0C	1.00800	10
Chloride mg/L	1.00784	11
Color, Cu	1.00702	12
Ammonia mg/L	1.00478	13
HeatingDays	1.00449	14
pH	1.00289	15
Pompton streamflow	1.00250	16
WindDir	1.00081	17
Hardness Total, mg/L as Ca	1.00027	18
Alkalinity mg/L as CaCO3	0.99884	19
WkPrecip	0.99835	20
PointRes extractions	0.99754	21
UV254 cm-1	0.99516	22
WindSpeed	0.99515	23
Nitrite/Nitrate	0.99496	24
Pompton extraction	0.99146	25
BOD, mg/L	0.98885	26
PrevPrecip	0.98735	27
DO, mg/L	0.98624	28
T.Phosphorus/Orthophosph	0.98592	29
Initial Chlorophyta	0.98085	30
Total Count, cells/ml	0.97969	31
Turbidity NTU	0.95520	32

Odor		
Total Amorphous Material	1.266751	1
Initial Cyanophyta	1.101840	2
Alkalinity mg/L as CaCO3	1.094590	3
Initial Chlorophyta	1.086225	4
WkPrecip	1.085294	5
TOC, mg/L	1.068619	6
Initial Chrysophyta	1.066937	7
pH	1.059968	8
T.Phosphorus/Orthophosph	1.053120	9
WindDir	1.04820	10
Nitrite/Nitrate	1.04813	11
Total Count, cells/ml	1.03369	12
Ammonia mg/L	1.03052	13
WindSpeed	1.02993	14
JAPS extractions	1.02871	15
BOD, mg/L	1.02612	16
UV254 cm-1	1.02603	17
Turbidity NTU	1.01931	18
Passaic extractions	1.01337	19
Color, Cu	1.00838	20
PointRes extractions	1.00582	21
Conductivity umhos/cm	1.00309	22
Chloride mg/L	1.00282	23
Pompton extraction	1.00027	24
Hardness Total, mg/L as Ca	1.00019	25
SkyCover	0.99783	26
HeatingDays	0.99642	27
DO, mg/L	0.99242	28
Temp 0C	0.98883	29
Sulfate mg/L	0.98180	30
PrevPrecip	0.96411	31
Pompton streamflow	0.92051	32

Table 5.7. Station 612 Chrysophyta real-time predictions: Sensitivity Analysis

All Input		
Total Amorphous Mater	1.4594	1
Odor	1.2498	2
Pompton extraction	1.2341	3
UV254 cm-1	1.1401	4
Initial Chrysophyta	1.1018	5
Conductivity umhos/cm	1.0955	6
Alkalinity mg/L as CaC(	1.0388	7
Passaic extractions	1.0361	8
Chloride mg/L	1.0296	9
Turbidity NTU	1.0288	10
Total Count, cells/ml	1.0285	11
TotalPhosphorus/Orthop	1.0230	12
pH	1.0208	13
DO, mg/L	1.0200	14
SkyCover	1.0178	15
Ammonia mg/L	1.0164	16
Nitrite/Nitrate	1.0087	17
JAPS extractions	1.0084	18
HeatingDays	1.0048	19
PointRes extractions	1.0011	20
Pompton streamflow	0.9971	21
TOC, mg/L	0.9970	22
Temp 0C	0.9966	23
Sulfate mg/L	0.9959	24
BOD, mg/L	0.9952	25
WindSpeed	0.9862	26
PrevPrecip	0.9832	27
Hardness Total, mg/L as	0.9810	28
Color, Cu	0.9799	29
WindDir	0.9764	30
WkPrecip	0.9736	31
Initial Chlorophyta	0.9726	32
Initial Cyanophyta	0.9703	33

Total Amorphous		
Alkalinity mg/L as CaC(	1.2640	1
Pompton extraction	1.1957	2
Odor	1.1884	3
Total Count, cells/ml	1.1763	4
Temp 0C	1.1121	5
Pompton streamflow	1.0710	6
Conductivity umhos/cm	1.0578	7
Sulfate mg/L	1.0570	8
Initial Chrysophyta	1.0568	9
WindSpeed	1.0514	10
WkPrecip	1.0461	11
WindDir	1.0321	12
Passaic extractions	1.0308	13
UV254 cm-1	1.0308	14
Hardness Total, mg/L as	1.0261	15
PrevPrecip	1.0245	16
HeatingDays	1.0152	17
pH	1.0058	18
Ammonia mg/L	1.0029	19
BOD, mg/L	1.0006	20
Initial Chlorophyta	1.0004	21
PointRes extractions	1.0002	22
TOC, mg/L	0.9997	23
TotalPhosphorus/Orthop	0.9993	24
Initial Cyanophyta	0.9990	25
Nitrite/Nitrate	0.9963	26
JAPS extractions	0.9911	27
DO, mg/L	0.9906	28
SkyCover	0.9875	29
Color, Cu	0.9850	30
Turbidity NTU	0.9849	31
Chloride mg/L	0.9808	32

Odor		
UV254 cm-1	1.5796	1
Total Amorphous Mater	1.5576	2
WkPrecip	1.3144	3
Hardness Total, mg/L as	1.2076	4
Total Count, cells/ml	1.1657	5
Pompton extraction	1.1529	6
pH	1.1433	7
Turbidity NTU	1.1266	8
SkyCover	1.1252	9
BOD, mg/L	1.1237	10
Passaic extractions	1.1149	11
WindSpeed	1.0923	12
Conductivity umhos/cm	1.0749	13
Sulfate mg/L	1.0700	14
DO, mg/L	1.0565	15
PrevPrecip	1.0538	16
Chloride mg/L	1.0500	17
Color, Cu	1.0468	18
Pompton streamflow	1.0461	19
Temp 0C	1.0320	20
Initial Chlorophyta	1.0273	21
Initial Cyanophyta	1.0234	22
TotalPhosphorus/Orthop	1.0161	23
HeatingDays	1.0123	24
Alkalinity mg/L as CaC(	1.0085	25
PointRes extractions	1.0007	26
WindDir	0.9993	27
TOC, mg/L	0.9977	28
Ammonia mg/L	0.9951	29
Initial Chrysophyta	0.9951	30
JAPS extractions	0.9944	31
Nitrite/Nitrate	0.9746	32

Table 5.7. Station 612 Chrysophyta real-time predictions: Sensitivity Analysis (cont.)

Pompton extraction		
UV254 cm-1	1.0998	1
WindSpeed	1.0896	2
pH	1.0302	3
Odor	1.0296	4
Initial Chlorophyta	1.0200	5
Conductivity umhos/cm	1.0183	6
WkPrecip	1.0182	7
Ammonia mg/L	1.0165	8
Initial Cyanophyta	1.0097	9
Total Amorphous Mater	1.0086	10
Temp 0C	1.0084	11
Color, Cu	1.0073	12
HeatingDays	1.0023	13
BOD, mg/L	1.0010	14
DO, mg/L	1.0004	15
TOC, mg/L	1.0001	16
PointRes extractions	0.9991	17
SkyCover	0.9990	18
TotalPhosphorus/Orthop	0.9971	19
Chloride mg/L	0.9957	20
Pompton streamflow	0.9951	21
JAPS extractions	0.9935	22
WindDir	0.9915	23
Turbidity NTU	0.9903	24
Sulfate mg/L	0.9896	25
Total Count, cells/ml	0.9860	26
PrevPrecip	0.9847	27
Nitrite/Nitrate	0.9757	28
Hardness Total, mg/L as	0.9404	29
Passaic extractions	0.9207	30
Alkalinity mg/L as CaC0	0.8707	31
Initial Chrysophyta	0.7877	32

UV254		
Total Amorphous Mater	1.4149	1
Pompton extraction	1.2025	2
Odor	1.0703	3
WkPrecip	1.0686	4
Total Count, cells/ml	1.0579	5
Alkalinity mg/L as CaC0	1.0571	6
Hardness Total, mg/L as	1.0427	7
PrevPrecip	1.0395	8
Sulfate mg/L	1.0346	9
Temp 0C	1.0293	10
Passaic extractions	1.0289	11
Ammonia mg/L	1.0274	12
Initial Chlorophyta	1.0238	13
WindDir	1.0216	14
TotalPhosphorus/Orthop	1.0083	15
TOC, mg/L	1.0070	16
JAPS extractions	1.0068	17
pH	1.0057	18
Conductivity umhos/cm	1.0038	19
Chloride mg/L	1.0016	20
PointRes extractions	1.0004	21
Turbidity NTU	1.0004	22
Initial Chrysophyta	1.0002	23
BOD, mg/L	0.9999	24
Pompton streamflow	0.9984	25
Nitrite/Nitrate	0.9983	26
SkyCover	0.9967	27
WindSpeed	0.9950	28
Color, Cu	0.9922	29
HeatingDays	0.9912	30
Initial Cyanophyta	0.9883	31
DO, mg/L	0.9871	32

initChrysop		
Total Amorphous Mater	1.6789	1
Pompton extraction	1.4992	2
Odor	1.2172	3
UV254 cm-1	1.1205	4
WkPrecip	1.1123	5
Alkalinity mg/L as CaC0	1.0904	6
DO, mg/L	1.0394	7
Temp 0C	1.0372	8
HeatingDays	1.0336	9
Hardness Total, mg/L as	1.0273	10
Chloride mg/L	1.0260	11
Total Count, cells/ml	1.0251	12
WindDir	1.0234	13
Sulfate mg/L	1.0230	14
Ammonia mg/L	1.0191	15
SkyCover	1.0165	16
Initial Cyanophyta	1.0095	17
PrevPrecip	1.0075	18
BOD, mg/L	1.0054	19
Initial Chlorophyta	1.0052	20
JAPS extractions	1.0045	21
TOC, mg/L	1.0043	22
Conductivity umhos/cm	1.0039	23
Turbidity NTU	1.0036	24
Nitrite/Nitrate	1.0013	25
PointRes extractions	1.0010	26
TotalPhosphorus/Orthop	0.9991	27
WindSpeed	0.9981	28
Color, Cu	0.9912	29
Passaic extractions	0.9852	30
pH	0.9783	31
Pompton streamflow	0.9781	32

initChlorop		
Pompton extraction	1.4902	1
Total Amorphous Mater	1.3897	2
Odor	1.3590	3
HeatingDays	1.3043	4
UV254 cm-1	1.3001	5
WkPrecip	1.2962	6
Ammonia mg/L	1.0931	7
Sulfate mg/L	1.0790	8
DO, mg/L	1.0672	9
Alkalinity mg/L as CaC0	1.0636	10
TOC, mg/L	1.0604	11
Initial Chrysophyta	1.0461	12
WindSpeed	1.0438	13
Temp 0C	1.0365	14
WindDir	1.0359	15
JAPS extractions	1.0340	16
pH	1.0211	17
Hardness Total, mg/L as	1.0182	18
Total Count, cells/ml	1.0141	19
Initial Cyanophyta	1.0130	20
PrevPrecip	1.0096	21
Chloride mg/L	1.0058	22
Conductivity umhos/cm	1.0055	23
BOD, mg/L	1.0019	24
Color, Cu	1.0007	25
PointRes extractions	0.9953	26
Nitrite/Nitrate	0.9861	27
Pompton streamflow	0.9851	28
Turbidity NTU	0.9757	29
Passaic extractions	0.9707	30
TotalPhosphorus/Orthop	0.9662	31
SkyCover	0.9424	32

Table 5.8. Station 612 Chrysophyta one-week ahead prediction: Sensitivity Analyses

All Inputs		
Initial Chrysophyta	1.2197	1
Total Count, cells/ml	1.0636	2
Passaic extractions	1.0520	3
Nitrite/Nitrate	1.0254	4
Color, Cu	1.0229	5
UV254 cm-1	1.0222	6
WkPrecip	1.0222	7
WindSpeed	1.0186	8
Conductivity umhos/cm	1.0173	9
Initial Cyanophyta	1.0140	10
Alkalinity mg/L as CaC(	1.0105	11
BOD, mg/L	1.0104	12
pH	1.0084	13
TotalPhosphorus/Orthop	1.0067	14
PointRes extractions	1.0055	15
Chloride mg/L	1.0053	16
Hardness Total, mg/L as	1.0040	17
Sulfate mg/L	1.0038	18
HeatingDays	1.0037	19
JAPS extractions	1.0024	20
Odor	1.0023	21
Temp 0C	1.0020	22
Pompton streamflow	1.0016	23
DO, mg/L	1.0011	24
Initial Chlorophyta	1.0004	25
WindDir	1.0002	26
PrevPrecip	1.0000	27
Total Amorphous Mater	0.9974	28
Turbidity NTU	0.9946	29
SkyCover	0.9943	30
TOC, mg/L	0.9933	31
Pompton extraction	0.9840	32
Ammonia mg/L	0.9741	33

initChrysop		
pH	1.2122	1
Total Count, cells/ml	1.1800	2
Alkalinity mg/L as CaC(	1.1772	3
UV254 cm-1	1.1559	4
Total Amorphous Mater	1.1316	5
Temp 0C	1.1194	6
Initial Chlorophyta	1.0743	7
PointRes extractions	1.0659	8
Initial Cyanophyta	1.0438	9
Passaic extractions	1.0361	10
Color, Cu	1.0343	11
Turbidity NTU	1.0314	12
WindDir	1.0297	13
Ammonia mg/L	1.0235	14
Pompton extraction	1.0182	15
WindSpeed	1.0175	16
Conductivity umhos/cm	1.0160	17
SkyCover	1.0146	18
TOC, mg/L	1.0127	19
Hardness Total, mg/L as	1.0104	20
Nitrite/Nitrate	1.0101	21
Sulfate mg/L	1.0087	22
TotalPhosphorus/Orthop	1.0082	23
WkPrecip	1.0079	24
Odor	1.0071	25
BOD, mg/L	1.0007	26
Chloride mg/L	0.9990	27
PrevPrecip	0.9987	28
JAPS extractions	0.9930	29
DO, mg/L	0.9878	30
Pompton streamflow	0.9864	31
HeatingDays	0.9840	32

Total Count		
Color, Cu	1.1401	1
Passaic extractions	1.1387	2
Initial Chrysophyta	1.0840	3
Temp 0C	1.0699	4
Odor	1.0686	5
WkPrecip	1.0506	6
HeatingDays	1.0443	7
Total Amorphous Mater	1.0443	8
Alkalinity mg/L as CaC(	1.0288	9
Initial Chlorophyta	1.0284	10
Conductivity umhos/cm	1.0231	11
TotalPhosphorus/Orthop	1.0222	12
PrevPrecip	1.0161	13
Pompton extraction	1.0130	14
JAPS extractions	1.0125	15
Chloride mg/L	1.0095	16
Pompton streamflow	1.0083	17
UV254 cm-1	1.0079	18
DO, mg/L	1.0038	19
Sulfate mg/L	1.0027	20
PointRes extractions	1.0014	21
WindSpeed	0.9996	22
Hardness Total, mg/L as	0.9994	23
WindDir	0.9984	24
SkyCover	0.9951	25
Nitrite/Nitrate	0.9950	26
Ammonia mg/L	0.9895	27
BOD, mg/L	0.9753	28
Turbidity NTU	0.9747	29
TOC, mg/L	0.9639	30
pH	0.9617	31
Initial Cyanophyta	0.9615	32

Table 5.8. Station 612 Chrysophyta one-week ahead prediction: Sensitivity Analyses (cont.)

Passaic extractions		
Initial Chrysophyta	1.5640	1
Total Count, cells/ml	1.1725	2
WindSpeed	1.0923	3
DO, mg/L	1.0867	4
Total Amorphous Mater	1.0821	5
Initial Cyanophyta	1.0698	6
JAPS extractions	1.0641	7
Initial Chlorophyta	1.0543	8
Alkalinity mg/L as CaC	1.0439	9
Hardness Total, mg/L as	1.0406	10
pH	1.0399	11
BOD, mg/L	1.0383	12
Color, Cu	1.0378	13
Odor	1.0296	14
UV254 cm-1	1.0226	15
HeatingDays	1.0216	16
Ammonia mg/L	1.0166	17
Turbidity NTU	1.0147	18
PrevPrecip	1.0122	19
Sulfate mg/L	1.0090	20
Conductivity umhos/cm	1.0052	21
Pompton extraction	1.0038	22
SkyCover	1.0031	23
Chloride mg/L	1.0029	24
Pompton streamflow	1.0020	25
Nitrite/Nitrate	1.0016	26
PointRes extractions	0.9997	27
TotalPhosphorus/Orthop	0.9977	28
WindDir	0.9951	29
TOC, mg/L	0.9941	30
Temp 0C	0.9904	31
WkPrecip	0.9792	32

Pompton Flow		
Initial Chrysophyta	1.4047	1
Total Amorphous Mater	1.1375	2
Hardness Total, mg/L as	1.0956	3
Pompton streamflow	1.0936	4
Ammonia mg/L	1.0635	5
Total Count, cells/ml	1.0479	6
DO, mg/L	1.0381	7
Initial Cyanophyta	1.0283	8
Initial Chlorophyta	1.0244	9
UV254 cm-1	1.0227	10
Conductivity umhos/cm	1.0197	11
Color, Cu	1.0177	12
Passaic extractions	1.0172	13
Temp 0C	1.0163	14
HeatingDays	1.0126	15
WkPrecip	1.0091	16
pH	1.0091	17
Odor	1.0086	18
WindDir	1.0062	19
BOD, mg/L	1.0058	20
Sulfate mg/L	1.0010	21
Turbidity NTU	1.0004	22
PointRes extractions	1.0002	23
Chloride mg/L	0.9998	24
SkyCover	0.9996	25
TOC, mg/L	0.9995	26
Nitrite/Nitrate	0.9981	27
TotalPhosphorus/Orthop	0.9957	28
JAPS extractions	0.9945	29
WindSpeed	0.9936	30
Alkalinity mg/L as CaC	0.9934	31
PrevPrecip	0.9821	32

Ammonia		
Initial Chrysophyta	1.2322	1
UV254 cm-1	1.1895	2
Color, Cu	1.1772	3
HeatingDays	1.1464	4
JAPS extractions	1.1303	5
Total Amorphous Mater	1.1017	6
Hardness Total, mg/L as	1.0918	7
Pompton extraction	1.0729	8
WkPrecip	1.0678	9
pH	1.0674	10
Nitrite/Nitrate	1.0630	11
Passaic extractions	1.0618	12
Initial Chlorophyta	1.0588	13
Initial Cyanophyta	1.0538	14
Alkalinity mg/L as CaC	1.0321	15
DO, mg/L	1.0290	16
Temp 0C	1.0253	17
Odor	1.0229	18
Total Count, cells/ml	1.0200	19
Turbidity NTU	1.0148	20
PrevPrecip	1.0141	21
BOD, mg/L	1.0076	22
TotalPhosphorus/Orthop	1.0047	23
PointRes extractions	1.0025	24
Pompton streamflow	0.9970	25
TOC, mg/L	0.9969	26
Chloride mg/L	0.9964	27
WindSpeed	0.9953	28
Sulfate mg/L	0.9831	29
Conductivity umhos/cm	0.9785	30
SkyCover	0.9614	31
WindDir	0.9225	32

Table 5.9. Station 612 Chrysophyta two-week ahead prediction: Sensitivity Analyses

All Inputs		
Pompton extraction	1.1055	1
Turbidity NTU	1.0566	2
Sulfate mg/L	1.0531	3
Initial Chrysophyta	1.0375	4
SkyCover	1.0295	5
UV254 cm-1	1.0255	6
Chloride mg/L	1.0242	7
pH	1.0235	8
BOD, mg/L	1.0216	9
Odor	1.0191	10
Conductivity umhos/cm	1.0148	11
Nitrite/Nitrate	1.0130	12
Hardness Total, mg/L as	1.0091	13
Temp 0C	1.0073	14
TOC, mg/L	1.0060	15
PointRes extractions	1.0049	16
Initial Cyanophyta	1.0043	17
DO, mg/L	1.0042	18
Pompton streamflow	1.0033	19
TotalPhosphorus/Orthop	1.0019	20
JAPS extractions	1.0003	21
WindSpeed	1.0002	22
Color, Cu	0.9998	23
WkPrecip	0.9977	24
WindDir	0.9954	25
PrevPrecip	0.9944	26
Passaic extractions	0.9867	27
Alkalinity mg/L as CaC(	0.9828	28
HeatingDays	0.9713	29
Initial Chlorophyta	0.9623	30
Total Count, cells/ml	0.9601	31
Ammonia mg/L	0.9577	32
Total Amorphous Mater	0.9267	33

PomptonFlow		
Initial Chrysophyta	1.6024	1
Total Amorphous Mater	1.1467	2
Total Count, cells/ml	1.1195	3
WkPrecip	1.0996	4
UV254 cm-1	1.0843	5
DO, mg/L	1.0574	6
Sulfate mg/L	1.0377	7
Hardness Total, mg/L as	1.0321	8
Passaic extractions	1.0286	9
Chloride mg/L	1.0274	10
Nitrite/Nitrate	1.0270	11
Turbidity NTU	1.0265	12
BOD, mg/L	1.0243	13
PointRes extractions	1.0217	14
TOC, mg/L	1.0153	15
SkyCover	1.0131	16
pH	1.0127	17
Initial Cyanophyta	1.0064	18
WindDir	0.9994	19
Pompton streamflow	0.9962	20
Color, Cu	0.9932	21
JAPS extractions	0.9931	22
Ammonia mg/L	0.9930	23
Odor	0.9919	24
Alkalinity mg/L as CaC(	0.9915	25
WindSpeed	0.9911	26
HeatingDays	0.9852	27
Temp 0C	0.9793	28
Conductivity umhos/cm	0.9777	29
PrevPrecip	0.9757	30
TotalPhosphorus/Orthop	0.9732	31
Initial Chlorophyta	0.9469	32

Turbidity		
Initial Chrysophyta	1.7061	1
Total Amorphous Mater	1.3950	2
HeatingDays	1.2550	3
Alkalinity mg/L as CaC(	1.1990	4
Odor	1.1707	5
Hardness Total, mg/L as	1.1334	6
UV254 cm-1	1.1105	7
Pompton extraction	1.1041	8
Total Count, cells/ml	1.0854	9
WkPrecip	1.0710	10
Ammonia mg/L	1.0685	11
PrevPrecip	1.0510	12
Initial Cyanophyta	1.0489	13
SkyCover	1.0354	14
Temp 0C	1.0274	15
Chloride mg/L	1.0237	16
Color, Cu	1.0232	17
Passaic extractions	1.0206	18
BOD, mg/L	1.0205	19
Sulfate mg/L	1.0187	20
Initial Chlorophyta	1.0134	21
TotalPhosphorus/Orthop	1.0112	22
PointRes extractions	1.0106	23
WindSpeed	1.0088	24
Nitrite/Nitrate	1.0083	25
Conductivity umhos/cm	1.0072	26
DO, mg/L	1.0059	27
WindDir	1.0027	28
pH	1.0000	29
JAPS extractions	1.0000	30
TOC, mg/L	0.9957	31
Pompton streamflow	0.9950	32

Table 5.9. Station 612 Chrysophyta two-week ahead prediction: Sensitivity Analyses (cont.)

Sulfate		
Initial Chrysophyta	1.3981	1
Total Count, cells/ml	1.2530	2
Total Amorphous Mater	1.2377	3
Pompton streamflow	1.2243	4
Odor	1.1273	5
UV254 cm-1	1.1245	6
HeatingDays	1.0682	7
Pompton extraction	1.0647	8
WindSpeed	1.0561	9
Nitrite/Nitrate	1.0391	10
BOD, mg/L	1.0357	11
Initial Cyanophyta	1.0287	12
JAPS extractions	1.0263	13
Turbidity NTU	1.0218	14
WindDir	1.0190	15
TOC, mg/L	1.0187	16
Passaic extractions	1.0098	17
SkyCover	1.0096	18
Color, Cu	1.0074	19
DO, mg/L	1.0019	20
pH	1.0011	21
Temp 0C	1.0009	22
TotalPhosphorus/Orthop	1.0006	23
Ammonia mg/L	1.0004	24
Initial Chlorophyta	0.9988	25
PointRes extractions	0.9985	26
WkPrecip	0.9937	27
Alkalinity mg/L as CaC(	0.9773	28
Hardness Total, mg/L as	0.9694	29
Conductivity umhos/cm	0.9653	30
PrevPrecip	0.9588	31
Chloride mg/L	0.9273	32

Ammonia		
Initial Chrysophyta	1.7297	1
Odor	1.0758	2
Alkalinity mg/L as CaC(	1.0357	3
Temp 0C	1.0333	4
WkPrecip	1.0207	5
Total Count, cells/ml	1.0193	6
HeatingDays	1.0172	7
JAPS extractions	1.0165	8
Pompton extraction	1.0060	9
Sulfate mg/L	1.0058	10
Passaic extractions	1.0049	11
Initial Cyanophyta	1.0026	12
UV254 cm-1	0.9999	13
PointRes extractions	0.9996	14
Turbidity NTU	0.9992	15
WindDir	0.9975	16
TotalPhosphorus/Orthop	0.9967	17
Color, Cu	0.9964	18
pH	0.9955	19
TOC, mg/L	0.9940	20
WindSpeed	0.9923	21
Initial Chlorophyta	0.9921	22
Hardness Total, mg/L as	0.9921	23
BOD, mg/L	0.9895	24
Nitrite/Nitrate	0.9891	25
Pompton streamflow	0.9855	26
Chloride mg/L	0.9853	27
SkyCover	0.9845	28
Conductivity umhos/cm	0.9767	29
DO, mg/L	0.9732	30
Total Amorphous Mater	0.9701	31
PrevPrecip	0.9575	32

TotalCount		
Initial Chrysophyta	2.1446	1
Odor	1.2804	2
Total Amorphous Mater	1.1114	3
SkyCover	1.0592	4
DO, mg/L	1.0451	5
Hardness Total, mg/L as	1.0289	6
Ammonia mg/L	1.0248	7
Chloride mg/L	1.0203	8
Initial Chlorophyta	1.0187	9
Conductivity umhos/cm	1.0134	10
pH	1.0126	11
Temp 0C	1.0100	12
PointRes extractions	1.0100	13
PrevPrecip	1.0089	14
JAPS extractions	1.0089	15
WindDir	1.0074	16
Nitrite/Nitrate	1.0066	17
Pompton streamflow	1.0027	18
TotalPhosphorus/Orthop	1.0009	19
UV254 cm-1	1.0005	20
Alkalinity mg/L as CaC(	1.0003	21
Passaic extractions	0.9998	22
BOD, mg/L	0.9993	23
Sulfate mg/L	0.9963	24
Initial Cyanophyta	0.9960	25
TOC, mg/L	0.9953	26
Turbidity NTU	0.9923	27
Color, Cu	0.9918	28
WkPrecip	0.9872	29
Pompton extraction	0.9813	30
WindSpeed	0.9805	31
HeatingDays	0.9749	32

Total Amorphous		
Nitrite/Nitrate	1.4023	1
Initial Chrysophyta	1.2966	2
Pompton extraction	1.2366	3
Turbidity NTU	1.1473	4
Initial Cyanophyta	1.0973	5
Initial Chlorophyta	1.0929	6
SkyCover	1.0834	7
Conductivity umhos/cm	1.0822	8
pH	1.0577	9
HeatingDays	1.0536	10
Odor	1.0505	11
Total Count, cells/ml	1.0340	12
PointRes extractions	1.0309	13
Passaic extractions	1.0301	14
Hardness Total, mg/L as	1.0299	15
Temp 0C	1.0253	16
WindSpeed	1.0199	17
Pompton streamflow	1.0192	18
Alkalinity mg/L as CaC(	1.0097	19
WkPrecip	1.0097	20
Color, Cu	1.0080	21
TOC, mg/L	1.0036	22
DO, mg/L	0.9952	23
Ammonia mg/L	0.9896	24
JAPS extractions	0.9895	25
WindDir	0.9892	26
Chloride mg/L	0.9575	27
UV254 cm-1	0.9572	28
BOD, mg/L	0.9490	29
PrevPrecip	0.9362	30
Sulfate mg/L	0.7812	31
TotalPhosphorus/Orthop	0.6700	32

Table 6.1. Station 100 Chlorophyta real-time predictions: Sensitivity Analysis

All Inputs		
Initial Chlorophyta	1.281750	1
Odor	1.261100	2
Hardness, Total mg/L as Ca	1.025934	3
SkyCover	1.022173	4
BOD, mg/L	1.009857	5
Nitrite/Nitrate	1.008824	6
Initial Chrysophyta	1.008073	7
TOC, mg/L	1.006693	8
TSS, mg/L	1.006438	9
WkPrecip	1.00591	10
Conductivity, umhos/cm	1.00411	11
Alkalinity mg/L as CaCO3	1.00365	12
Ammonia, mg/L	1.00317	13
Passaic extractions	1.00252	14
Sulfate, mg/L	1.00233	15
T.Phosphorus/Orthophosph	1.00134	16
Initial Cyanophyta	1.00071	17
PrevPrecip	1.00034	18
Turbidity NTU	0.99991	19
Chloride, mg/L	0.99991	20
Temp (0C)	0.99972	21
HeatingDays	0.99930	22
Total Count	0.99916	23
Pompton extractions	0.99892	24
JAPS extractions	0.99822	25
UV-254, cm-1	0.99790	26
Pompton streamflow	0.99777	27
PointRes extractions	0.99396	28
DO, mg/L	0.99107	29
pH	0.99072	30
WindDir	0.98417	31
WindSpeed	0.97570	32

Initial Chlorophyta Level		
Total Count	1.648109	1
WkPrecip	1.586708	2
Hardness, Total mg/L as Ca	1.442138	3
Pompton extractions	1.324828	4
SkyCover	1.142668	5
Odor	1.130442	6
Initial Cyanophyta	1.126053	7
HeatingDays	1.110791	8
Initial Chrysophyta	1.073880	9
Conductivity, umhos/cm	1.06665	10
UV-254, cm-1	1.05455	11
WindSpeed	1.04700	12
JAPS extractions	1.04264	13
TOC, mg/L	1.03792	14
Sulfate, mg/L	1.03775	15
Turbidity NTU	1.03611	16
Temp (0C)	1.02386	17
Ammonia, mg/L	1.02229	18
Alkalinity mg/L as CaCO3	1.01907	19
Chloride, mg/L	1.01725	20
PointRes extractions	1.01671	21
Pompton streamflow	1.00699	22
TSS, mg/L	0.99989	23
pH	0.99756	24
T.Phosphorus/Orthophosph	0.99574	25
WindDir	0.99109	26
Nitrite/Nitrate	0.98493	27
Passaic extractions	0.96719	28
DO, mg/L	0.96248	29
BOD, mg/L	0.94884	30
PrevPrecip	0.94649	31

Total Hardness		
Odor	1.423534	1
Initial Chlorophyta	1.372274	2
HeatingDays	1.150668	3
BOD, mg/L	1.105103	4
Total Count	1.098167	5
Pompton extractions	1.090051	6
Nitrite/Nitrate	1.063858	7
DO, mg/L	1.054350	8
Passaic extractions	1.041736	9
T.Phosphorus/Orthophosph	1.03857	10
Conductivity, umhos/cm	1.03656	11
Ammonia, mg/L	1.03623	12
Sulfate, mg/L	1.03525	13
Temp (0C)	1.02308	14
UV-254, cm-1	1.01282	15
Initial Cyanophyta	1.01252	16
Initial Chrysophyta	1.01072	17
SkyCover	1.00557	18
TSS, mg/L	1.00144	19
Pompton streamflow	0.99904	20
Chloride, mg/L	0.99857	21
TOC, mg/L	0.99835	22
PointRes extractions	0.99788	23
PrevPrecip	0.99492	24
pH	0.99268	25
JAPS extractions	0.98985	26
WkPrecip	0.98907	27
WindSpeed	0.98598	28
WindDir	0.97715	29
Alkalinity mg/L as CaCO3	0.97043	30
Turbidity NTU	0.96687	31

Table 6.1. Station 100 Chlorophyta real-time predictions: Sensitivity Analysis (cont.)

TotalCount		
Nitrite/Nitrate	1.568263	1
TSS, mg/L	1.428364	2
Initial Chlorophyta	1.420116	3
HeatingDays	1.383860	4
Sulfate, mg/L	1.365570	5
Odor	1.298430	6
Pompton extractions	1.277101	7
Passaic extractions	1.217977	8
Temp (0C)	1.187153	9
Hardness, Total mg/L as Ca	1.18638	10
BOD, mg/L	1.17652	11
Alkalinity mg/L as CaCO3	1.17088	12
DO, mg/L	1.16297	13
WkPrecip	1.10591	14
Chloride, mg/L	1.08864	15
Initial Chrysophyta	1.08402	16
Conductivity, umhos/cm	1.07952	17
WindSpeed	1.06325	18
pH	1.06018	19
TOC, mg/L	1.03294	20
Turbidity NTU	1.01798	21
JAPS extractions	1.00598	22
Pompton streamflow	1.00547	23
Ammonia, mg/L	1.00546	24
PrevPrecip	1.00407	25
UV-254, cm-1	1.00175	26
Initial Cyanophyta	1.00093	27
T.Phosphorus/Orthophosph	0.99965	28
PointRes extractions	0.99954	29
WindDir	0.98447	30
SkyCover	0.92969	31

Total Organic Carbon (TOC)		
Odor	1.574653	1
Initial Chlorophyta	1.563348	2
BOD, mg/L	1.193752	3
WkPrecip	1.156286	4
Nitrite/Nitrate	1.123759	5
HeatingDays	1.120192	6
Passaic extractions	1.113737	7
SkyCover	1.112534	8
Pompton extractions	1.112374	9
Initial Chrysophyta	1.10715	10
PrevPrecip	1.05026	11
Alkalinity mg/L as CaCO3	1.04499	12
Temp (0C)	1.03927	13
DO, mg/L	1.03483	14
WindSpeed	1.02995	15
Chloride, mg/L	1.02536	16
Pompton streamflow	1.02528	17
TSS, mg/L	1.01701	18
pH	1.01268	19
Turbidity NTU	1.01097	20
T.Phosphorus/Orthophosph	1.00368	21
Initial Cyanophyta	1.00301	22
Sulfate, mg/L	1.00203	23
Ammonia, mg/L	1.00203	24
JAPS extractions	1.00112	25
Total Count	0.99982	26
UV-254, cm-1	0.99838	27
Hardness, Total mg/L as Ca	0.99733	28
WindDir	0.99691	29
PointRes extractions	0.99648	30
Conductivity, umhos/cm	0.99255	31

Biological Oxygen Demand (BOD)		
Initial Chlorophyta	1.176859	1
HeatingDays	1.158747	2
Nitrite/Nitrate	1.140247	3
Odor	1.087205	4
Pompton extractions	1.074838	5
Total Count	1.045054	6
Sulfate, mg/L	1.026180	7
Passaic extractions	1.023583	8
WindDir	1.021550	9
TOC, mg/L	1.01649	10
Hardness, Total mg/L as Ca	1.01593	11
PrevPrecip	1.01555	12
TSS, mg/L	1.01160	13
Chloride, mg/L	1.01103	14
WindSpeed	1.00970	15
pH	1.00930	16
Conductivity, umhos/cm	1.00839	17
Initial Chrysophyta	1.00822	18
Turbidity NTU	1.00782	19
DO, mg/L	1.00764	20
UV-254, cm-1	1.00570	21
Temp (0C)	1.00564	22
Pompton streamflow	1.00354	23
Initial Cyanophyta	1.00135	24
Ammonia, mg/L	1.00060	25
T.Phosphorus/Orthophosph	1.00012	26
SkyCover	0.99578	27
PointRes extractions	0.99517	28
WkPrecip	0.99110	29
Alkalinity mg/L as CaCO3	0.99028	30
JAPS extractions	0.99015	31

Table 6.2. Station 100 Chlorophyta one-week ahead: Sensitivity Analysis

All Inputs		
Initial Chlorophyta	1.239026	1
Total Count	1.134465	2
Odor	1.048919	3
Temp (0C)	1.043805	4
Nitrite/Nitrate	1.042051	5
T.Phosphorus/Orthophosph	1.032525	6
TSS, mg/L	1.026284	7
Pompton extractions	1.014156	8
HeatingDays	1.013947	9
WindSpeed	1.00941	10
Sulfate, mg/L	1.00912	11
TOC, mg/L	1.00612	12
Passaic extractions	1.00439	13
WkPrecip	1.00360	14
PrevPrecip	1.00357	15
Initial Cyanophyta	1.00354	16
SkyCover	1.00214	17
DO, mg/L	1.00118	18
UV-254, cm-1	1.00008	19
Pompton streamflow	0.99983	20
PointRes extractions	0.99943	21
Alkalinity mg/L as CaCO3	0.99912	22
Chloride, mg/L	0.99792	23
JAPS extractions	0.99452	24
Ammonia, mg/L	0.99244	25
WindDir	0.99203	26
pH	0.98975	27
Conductivity, umhos/cm	0.98881	28
Hardness, Total mg/L as Ca	0.98637	29
Initial Chrysophyta	0.98569	30
Turbidity NTU	0.98380	31
BOD, mg/L	0.98318	32

Initial Chlorophyta Level		
Total Count	1.762184	1
HeatingDays	1.427612	2
Odor	1.289688	3
Pompton extractions	1.270339	4
Nitrite/Nitrate	1.153973	5
WkPrecip	1.151181	6
T.Phosphorus/Orthophosph	1.106473	7
BOD, mg/L	1.103998	8
Sulfate, mg/L	1.082924	9
WindDir	1.07913	10
TOC, mg/L	1.07564	11
PrevPrecip	1.07563	12
Temp (0C)	1.06758	13
DO, mg/L	1.06748	14
Ammonia, mg/L	1.06020	15
WindSpeed	1.03856	16
Pompton streamflow	1.03432	17
pH	1.02004	18
TSS, mg/L	1.01919	19
SkyCover	1.01287	20
UV-254, cm-1	1.00671	21
Initial Cyanophyta	1.00594	22
PointRes extractions	1.00088	23
JAPS extractions	0.99816	24
Passaic extractions	0.99777	25
Chloride, mg/L	0.98460	26
Alkalinity mg/L as CaCO3	0.97874	27
Conductivity, umhos/cm	0.97181	28
Initial Chrysophyta	0.96859	29
Hardness, Total mg/L as Ca	0.96234	30
Turbidity NTU	0.94119	31

Total Count		
Initial Chlorophyta	1.260112	1
Nitrite/Nitrate	1.055072	2
HeatingDays	1.018180	3
WindDir	1.015507	4
Pompton extractions	1.012003	5
Temp (0C)	1.009513	6
Odor	1.009355	7
Initial Chrysophyta	1.005116	8
WkPrecip	1.004800	9
WindSpeed	1.00442	10
Initial Cyanophyta	1.00259	11
PrevPrecip	1.00227	12
UV-254, cm-1	1.00203	13
Conductivity, umhos/cm	1.00186	14
Hardness, Total mg/L as Ca	1.00071	15
Turbidity NTU	1.00071	16
TSS, mg/L	1.00067	17
BOD, mg/L	1.00004	18
Alkalinity mg/L as CaCO3	1.00001	19
JAPS extractions	0.99995	20
Pompton streamflow	0.99986	21
Chloride, mg/L	0.99968	22
PointRes extractions	0.99965	23
SkyCover	0.99962	24
Sulfate, mg/L	0.99962	25
TOC, mg/L	0.99956	26
Passaic extractions	0.99943	27
Ammonia, mg/L	0.99941	28
T.Phosphorus/Orthophosph	0.99678	29
pH	0.99627	30
DO, mg/L	0.99564	31

Table 6.2. Station 100 Chlorophyta one-week ahead: Sensitivity Analysis (cont.)

Temperature		
Initial Chlorophyta	1.414721	1
Odor	1.116413	2
HeatingDays	1.052038	3
Pompton extractions	1.046926	4
Nitrite/Nitrate	1.042233	5
TOC, mg/L	1.034920	6
SkyCover	1.027590	7
Sulfate, mg/L	1.024739	8
Passaic extractions	1.022050	9
Total Count	1.02183	10
Hardness, Total mg/L as Ca	1.02100	11
Chloride, mg/L	1.01853	12
DO, mg/L	1.01100	13
Turbidity NTU	1.01031	14
PointRes extractions	1.01022	15
TSS, mg/L	1.00954	16
Pompton streamflow	1.00943	17
Ammonia, mg/L	1.00905	18
PrevPrecip	1.00250	19
T.Phosphorus/Orthophosph	1.00192	20
Initial Cyanophyta	1.00179	21
Conductivity, umhos/cm	1.00168	22
Alkalinity mg/L as CaCO3	1.00133	23
UV-254, cm-1	1.00054	24
WindDir	1.00053	25
Initial Chrysophyta	1.00025	26
pH	0.99986	27
JAPS extractions	0.99977	28
BOD, mg/L	0.99885	29
WindSpeed	0.99742	30
WkPrecip	0.99692	31

Turbidity		
Initial Chlorophyta	1.127143	1
Pompton extractions	1.017046	2
Odor	1.008750	3
TOC, mg/L	1.008178	4
WindDir	1.006315	5
Passaic extractions	1.003492	6
Initial Cyanophyta	1.003013	7
Nitrite/Nitrate	1.002250	8
Pompton streamflow	1.001947	9
UV-254, cm-1	1.00081	10
JAPS extractions	1.00074	11
BOD, mg/L	1.00053	12
WkPrecip	1.00035	13
PointRes extractions	1.00007	14
Ammonia, mg/L	0.99999	15
Initial Chrysophyta	0.99970	16
pH	0.99969	17
Alkalinity mg/L as CaCO3	0.99960	18
Chloride, mg/L	0.99808	19
PrevPrecip	0.99800	20
TSS, mg/L	0.99773	21
Sulfate, mg/L	0.99706	22
Conductivity, umhos/cm	0.99549	23
Total Count	0.99396	24
T.Phosphorus/Orthophosph	0.99329	25
Hardness, Total mg/L as Ca	0.98655	26
WindSpeed	0.98370	27
HeatingDays	0.98158	28
Temp (0C)	0.97849	29
SkyCover	0.97355	30
DO, mg/L	0.97171	31

Biological Oxygen Demand (BOD)		
Odor	1.812162	1
Initial Chlorophyta	1.632833	2
HeatingDays	1.338975	3
Nitrite/Nitrate	1.331936	4
WkPrecip	1.311877	5
Chloride, mg/L	1.264274	6
SkyCover	1.205583	7
Pompton extractions	1.205278	8
Temp (0C)	1.192345	9
Hardness, Total mg/L as Ca	1.15013	10
Turbidity NTU	1.08720	11
TSS, mg/L	1.07466	12
WindDir	1.07442	13
pH	1.07175	14
Pompton streamflow	1.06187	15
Total Count	1.04466	16
Initial Chrysophyta	1.02723	17
TOC, mg/L	1.02565	18
PointRes extractions	1.02537	19
Passaic extractions	1.01923	20
JAPS extractions	1.01134	21
Alkalinity mg/L as CaCO3	1.00966	22
Conductivity, umhos/cm	1.00829	23
Sulfate, mg/L	1.00779	24
Initial Cyanophyta	0.99874	25
UV-254, cm-1	0.99603	26
T.Phosphorus/Orthophosph	0.99505	27
WindSpeed	0.99052	28
Ammonia, mg/L	0.98557	29
DO, mg/L	0.98485	30
PrevPrecip	0.97480	31

Table 6.3. Station 100 Chlorophyta two-week ahead: Sensitivity Analysis

All Inputs		
Odor	1.367970	1
Pompton extractions	1.228128	2
TSS, mg/L	1.117581	3
WindDir	1.098201	4
Initial Chlorophyta	1.089286	5
TOC, mg/L	1.088152	6
Pompton streamflow	1.075544	7
BOD, mg/L	1.067879	8
Alkalinity mg/L as CaCO3	1.061340	9
Passaic extractions	1.05478	10
HeatingDays	1.04758	11
DO, mg/L	1.04467	12
WkPrecip	1.03250	13
Initial Chrysophyta	1.03164	14
Hardness, Total mg/L as Ca	1.02913	15
PrevPrecip	1.02379	16
Turbidity NTU	1.01788	17
pH	1.01730	18
Nitrite/Nitrate	1.01324	19
PointRes extractions	1.00374	20
Chloride, mg/L	1.00206	21
T.Phosphorus/Orthophosph	1.00203	22
Initial Cyanophyta	0.99817	23
Total Count	0.99266	24
Ammonia, mg/L	0.99238	25
Temp (0C)	0.98837	26
JAPS extractions	0.98718	27
SkyCover	0.98694	28
Conductivity, umhos/cm	0.98275	29
WindSpeed	0.96758	30
Sulfate, mg/L	0.96079	31
UV-254, cm-1	0.94133	32

Pompton extractions		
Passaic extractions	1.186309	1
Odor	1.169165	2
Nitrite/Nitrate	1.122885	3
HeatingDays	1.095486	4
Temp (0C)	1.094520	5
Total Count	1.089963	6
TSS, mg/L	1.067330	7
Initial Chlorophyta	1.056496	8
Conductivity, umhos/cm	1.045989	9
WkPrecip	1.04058	10
Sulfate, mg/L	1.03869	11
WindDir	1.03805	12
UV-254, cm-1	1.03693	13
DO, mg/L	1.01555	14
BOD, mg/L	1.01202	15
T.Phosphorus/Orthophosph	1.01052	16
SkyCover	1.01026	17
Hardness, Total mg/L as Ca	1.00994	18
Chloride, mg/L	1.00890	19
PrevPrecip	1.00716	20
pH	1.00325	21
Initial Cyanophyta	1.00089	22
JAPS extractions	0.99954	23
Pompton streamflow	0.99889	24
PointRes extractions	0.99834	25
Turbidity NTU	0.99692	26
Alkalinity mg/L as CaCO3	0.99354	27
Initial Chrysophyta	0.99071	28
Ammonia, mg/L	0.98965	29
WindSpeed	0.98710	30
TOC, mg/L	0.98418	31

Total Suspended Solids (TSS)		
Odor	1.223861	1
Hardness, Total mg/L as Ca	1.078404	2
Pompton extractions	1.068525	3
HeatingDays	1.037840	4
Turbidity NTU	1.035971	5
TOC, mg/L	1.032389	6
Conductivity, umhos/cm	1.022542	7
Ammonia, mg/L	1.020799	8
Pompton streamflow	1.014880	9
UV-254, cm-1	1.01092	10
BOD, mg/L	1.01062	11
Initial Cyanophyta	1.00923	12
WindSpeed	1.00832	13
Chloride, mg/L	1.00749	14
SkyCover	1.00716	15
Nitrite/Nitrate	1.00706	16
WindDir	1.00573	17
Initial Chlorophyta	1.00506	18
PointRes extractions	1.00321	19
T.Phosphorus/Orthophosph	0.99956	20
PrevPrecip	0.99749	21
JAPS extractions	0.99723	22
Alkalinity mg/L as CaCO3	0.99706	23
pH	0.99657	24
Passaic extractions	0.99555	25
DO, mg/L	0.98562	26
Sulfate, mg/L	0.98403	27
WkPrecip	0.98193	28
Temp (0C)	0.98153	29
Total Count	0.94912	30
Initial Chrysophyta	0.93738	31

Table 6.3. Station 100 Chlorophyta two-week ahead: Sensitivity Analysis (cont.)

Wind Direction		
TSS, mg/L	1.103298	1
Odor	1.102476	2
Nitrite/Nitrate	1.074975	3
Initial Chlorophyta	1.070559	4
Pompton extractions	1.056536	5
HeatingDays	1.029506	6
SkyCover	1.025022	7
PointRes extractions	1.020117	8
WkPrecip	1.013360	9
Ammonia, mg/L	1.01299	10
Initial Chrysophyta	1.01296	11
Pompton streamflow	1.01269	12
WindSpeed	1.00917	13
Temp (0C)	1.00836	14
PrevPrecip	1.00672	15
Total Count	1.00605	16
DO, mg/L	1.00601	17
Sulfate, mg/L	1.00552	18
Turbidity NTU	1.00491	19
UV-254, cm-1	1.00385	20
JAPS extractions	1.00327	21
Initial Cyanophyta	1.00257	22
Alkalinity mg/L as CaCO3	1.00188	23
BOD, mg/L	1.00026	24
Hardness, Total mg/L as Ca	0.99970	25
Chloride, mg/L	0.99942	26
Passaic extractions	0.99595	27
pH	0.99452	28
Conductivity, umhos/cm	0.99422	29
T.Phosphorus/Orthophosph	0.99069	30
TOC, mg/L	0.98451	31

UV254		
Pompton extractions	1.180075	1
Odor	1.179062	2
WindDir	1.150384	3
HeatingDays	1.134862	4
Hardness, Total mg/L as Ca	1.126561	5
SkyCover	1.117963	6
TSS, mg/L	1.115313	7
Nitrite/Nitrate	1.083264	8
Sulfate, mg/L	1.074582	9
Initial Chlorophyta	1.06844	10
PrevPrecip	1.05572	11
DO, mg/L	1.04808	12
BOD, mg/L	1.04179	13
WindSpeed	1.04045	14
pH	1.04037	15
Alkalinity mg/L as CaCO3	1.03886	16
Chloride, mg/L	1.03025	17
Conductivity, umhos/cm	1.02572	18
Initial Chrysophyta	1.02161	19
WkPrecip	1.01468	20
Temp (0C)	1.01014	21
Turbidity NTU	1.00861	22
T.Phosphorus/Orthophosph	1.00785	23
Initial Cyanophyta	1.00427	24
Total Count	1.00299	25
PointRes extractions	1.00057	26
Pompton streamflow	0.98790	27
TOC, mg/L	0.98266	28
Passaic extractions	0.97962	29
JAPS extractions	0.97320	30
Ammonia, mg/L	0.89302	31

Biological Oxygen Demand (BOD)		
Nitrite/Nitrate	1.176551	1
Odor	1.152154	2
HeatingDays	1.127099	3
Pompton extractions	1.105380	4
Initial Chlorophyta	1.098734	5
Initial Cyanophyta	1.074545	6
Turbidity NTU	1.049385	7
PrevPrecip	1.039092	8
TSS, mg/L	1.033321	9
Ammonia, mg/L	1.02538	10
WindDir	1.02395	11
WindSpeed	1.01321	12
Hardness, Total mg/L as Ca	1.01320	13
Pompton streamflow	1.01217	14
Sulfate, mg/L	1.01040	15
WkPrecip	1.00914	16
PointRes extractions	1.00811	17
T.Phosphorus/Orthophosph	1.00779	18
Passaic extractions	1.00636	19
Initial Chrysophyta	1.00543	20
Temp (0C)	1.00436	21
Total Count	1.00404	22
Alkalinity mg/L as CaCO3	1.00368	23
TOC, mg/L	1.00283	24
Chloride, mg/L	1.00237	25
Conductivity, umhos/cm	1.00105	26
JAPS extractions	1.00008	27
UV-254, cm-1	0.99777	28
SkyCover	0.99289	29
pH	0.99272	30
DO, mg/L	0.99098	31

Table 6.4. Station 101 Chlorophyta real-time predictions: Sensitivity Analysis

All Inputs		
Initial Chlorophyta	1.421731	1
HeatingDays	1.367347	2
Total Amorphous Material	1.200328	3
Total Count, cells/ml	1.163760	4
Chloride mg/L	1.150006	5
T.Phosphorus/Orthophosph	1.140828	6
pH	1.095427	7
Temp 0C	1.093145	8
Pompton streamflow	1.080394	9
JAPS extractions	1.07461	10
UV254 cm-1	1.05942	11
PrevPrecip	1.05923	12
TOC, mg/L	1.05809	13
PointRes extractions	1.05662	14
Hardness Total, mg/L as Ca	1.04457	15
WindDir	1.02502	16
Initial Cyanophyta	1.02409	17
WindSpeed	1.01598	18
WkPrecip	1.01572	19
BOD, mg/L	1.01507	20
Alkalinity mg/L as CaCO3	1.01431	21
Color, Cu	1.01229	22
DO, mg/L	1.00628	23
Initial Chrysophyta	1.00176	24
Passaic extractions	1.00164	25
Turbidity NTU	0.99969	26
Pompton extractions	0.99657	27
Odor	0.99082	28
Ammonia mg/L	0.98726	29
Nitrite/Nitrate	0.97669	30
SkyCover	0.97607	31
Sulfate mg/L	0.96781	32
Conductivity umhos/cm	0.90765	33

Initial Chlorophyta Level		
PointRes extractions	2.315708	1
Total Amorphous Material	1.760214	2
Initial Cyanophyta	1.693744	3
Total Count, cells/ml	1.547738	4
SkyCover	1.326540	5
UV254 cm-1	1.173389	6
Odor	1.171671	7
Color, Cu	1.103165	8
Temp 0C	1.082197	9
WkPrecip	1.05691	10
Passaic extractions	1.04697	11
TOC, mg/L	1.04167	12
HeatingDays	1.04017	13
WindDir	1.03851	14
BOD, mg/L	1.03186	15
Hardness Total, mg/L as Ca	1.02996	16
Chloride mg/L	1.02790	17
Initial Chrysophyta	1.02257	18
DO, mg/L	1.01480	19
pH	1.01053	20
Pompton streamflow	1.00636	21
Sulfate mg/L	1.00454	22
Alkalinity mg/L as CaCO3	1.00444	23
Nitrite/Nitrate	1.00343	24
Conductivity umhos/cm	1.00312	25
T.Phosphorus/Orthophosph	1.00248	26
Ammonia mg/L	1.00104	27
JAPS extractions	1.00017	28
PrevPrecip	0.99996	29
Turbidity NTU	0.99963	30
Pompton extractions	0.99487	31
WindSpeed	0.99137	32

Heating Days		
Initial Chlorophyta	1.155996	1
Temp 0C	1.064685	2
Hardness Total, mg/L as Ca	1.044026	3
Conductivity umhos/cm	1.042725	4
Total Count, cells/ml	1.038313	5
TOC, mg/L	1.025636	6
WindDir	1.019359	7
Total Amorphous Material	1.016442	8
T.Phosphorus/Orthophosph	1.015045	9
Turbidity NTU	1.01101	10
UV254 cm-1	1.01077	11
SkyCover	1.00974	12
PrevPrecip	1.00650	13
Ammonia mg/L	1.00266	14
Nitrite/Nitrate	1.00249	15
Pompton streamflow	1.00216	16
Color, Cu	1.00216	17
Initial Cyanophyta	1.00169	18
Initial Chrysophyta	1.00106	19
PointRes extractions	1.00039	20
Chloride mg/L	1.00008	21
Sulfate mg/L	0.99977	22
DO, mg/L	0.99936	23
WkPrecip	0.99921	24
WindSpeed	0.99910	25
Alkalinity mg/L as CaCO3	0.99770	26
Odor	0.99753	27
BOD, mg/L	0.99606	28
pH	0.99513	29
Passaic extractions	0.98960	30
JAPS extractions	0.98837	31
Pompton extractions	0.97786	32

Table 6.4. Station 101Chlorophyta real-time predictions: Sensitivity Analysis (cont.)

Total Count		
PointRes extractions	1.366046	1
Initial Chlorophyta	1.120021	2
Hardness Total, mg/L as Ca	1.067889	3
Conductivity umhos/cm	1.046559	4
pH	1.036516	5
TOC, mg/L	1.028338	6
Sulfate mg/L	1.014930	7
PrevPrecip	1.007893	8
Nitrite/Nitrate	1.005969	9
Initial Chrysophyta	1.00370	10
BOD, mg/L	1.00219	11
Turbidity NTU	1.00095	12
Passaic extractions	0.99809	13
WindSpeed	0.99723	14
Pompton streamflow	0.99706	15
Chloride mg/L	0.99697	16
WindDir	0.99656	17
DO, mg/L	0.99615	18
JAPS extractions	0.99529	19
Color, Cu	0.99120	20
Alkalinity mg/L as CaCO3	0.98909	21
Pompton extractions	0.98720	22
T.Phosphorus/Orthophosph	0.98464	23
WkPrecip	0.98398	24
Ammonia mg/L	0.98108	25
Temp 0C	0.97443	26
UV254 cm-1	0.97305	27
Total Amorphous Material	0.96791	28
HeatingDays	0.96659	29
SkyCover	0.96211	30
Odor	0.95814	31
Initial Cyanophyta	0.85973	32

Sulfate		
Initial Chlorophyta	1.742778	1
Initial Cyanophyta	1.351989	2
Total Count, cells/ml	1.248747	3
PointRes extractions	1.141899	4
DO, mg/L	1.140954	5
Total Amorphous Material	1.088081	6
Odor	1.071832	7
TOC, mg/L	1.053476	8
PrevPrecip	1.046632	9
pH	1.04551	10
Color, Cu	1.04314	11
WindDir	1.04255	12
SkyCover	1.03569	13
Pompton extractions	1.02655	14
UV254 cm-1	1.02154	15
Alkalinity mg/L as CaCO3	1.01900	16
Nitrite/Nitrate	1.01886	17
Chloride mg/L	1.01574	18
Conductivity umhos/cm	1.01502	19
HeatingDays	1.01383	20
Ammonia mg/L	1.01028	21
Temp 0C	1.00832	22
Initial Chrysophyta	1.00245	23
JAPS extractions	1.00036	24
Turbidity NTU	0.99664	25
WindSpeed	0.99622	26
BOD, mg/L	0.99451	27
WkPrecip	0.99441	28
Passaic extractions	0.99142	29
Pompton streamflow	0.98223	30
Hardness Total, mg/L as Ca	0.97456	31
T.Phosphorus/Orthophosph	0.95950	32

Conductivity		
PointRes extractions	2.300281	1
Initial Cyanophyta	1.509903	2
Total Amorphous Material	1.354182	3
HeatingDays	1.306848	4
Total Count, cells/ml	1.252143	5
UV254 cm-1	1.142082	6
Alkalinity mg/L as CaCO3	1.069049	7
Initial Chlorophyta	1.066804	8
Odor	1.044285	9
SkyCover	1.03617	10
WindSpeed	1.01435	11
Hardness Total, mg/L as Ca	1.01000	12
Ammonia mg/L	1.00984	13
DO, mg/L	1.00715	14
TOC, mg/L	1.00678	15
PrevPrecip	1.00661	16
T.Phosphorus/Orthophosph	1.00597	17
JAPS extractions	1.00560	18
Chloride mg/L	1.00489	19
WindDir	1.00394	20
Nitrite/Nitrate	1.00261	21
Color, Cu	1.00190	22
BOD, mg/L	1.00150	23
Temp 0C	1.00039	24
pH	0.99988	25
WkPrecip	0.99887	26
Sulfate mg/L	0.99446	27
Passaic extractions	0.99373	28
Initial Chrysophyta	0.99356	29
Pompton extractions	0.99157	30
Turbidity NTU	0.99054	31
Pompton streamflow	0.98985	32

Table 6.6. Station 101 Chlorophyta one-week ahead: Sensitivity Analysis

All Inputs		
Initial Chlorophyta	1.199592	1
Initial Cyanophyta	1.118203	2
pH	1.053455	3
Pompton streamflow	1.052429	4
Total Amorphous Material	1.044186	5
SkyCover	1.031766	6
WindDir	1.018561	7
PointRes extractions	1.016731	8
Hardness Total, mg/L as Ca	1.015178	9
Ammonia mg/L	1.01468	10
UV254 cm-1	1.01425	11
WkPrecip	1.00998	12
T.Phosphorus/Orthophosph	1.00942	13
Pompton extractions	1.00924	14
TOC, mg/L	1.00576	15
Sulfate mg/L	1.00523	16
PrevPrecip	1.00519	17
HeatingDays	1.00430	18
Nitrite/Nitrate	1.00374	19
DO, mg/L	1.00358	20
Initial Chrysophyta	1.00280	21
Color, Cu	1.00275	22
Total Count, cells/ml	1.00132	23
JAPS extractions	0.99916	24
Alkalinity mg/L as CaCO3	0.99749	25
Passaic extractions	0.99734	26
Temp 0C	0.99383	27
Turbidity NTU	0.99276	28
Conductivity umhos/cm	0.99275	29
BOD, mg/L	0.99265	30
Chloride mg/L	0.99258	31
WindSpeed	0.96477	32
Odor	0.92541	33

Initial Chlorophyta Level		
Total Amorphous Material	1.289474	1
T.Phosphorus/Orthophosph	1.202950	2
Total Count, cells/ml	1.198182	3
SkyCover	1.074913	4
Temp 0C	1.067624	5
DO, mg/L	1.055285	6
Odor	1.035987	7
PointRes extractions	1.033139	8
WindDir	1.029155	9
JAPS extractions	1.02405	10
Ammonia mg/L	1.02226	11
UV254 cm-1	1.01811	12
HeatingDays	1.01635	13
BOD, mg/L	1.01555	14
Turbidity NTU	1.01269	15
WkPrecip	1.01052	16
Pompton streamflow	1.01034	17
Pompton extractions	1.00724	18
Chloride mg/L	1.00616	19
Initial Cyanophyta	1.00572	20
Conductivity umhos/cm	1.00562	21
WindSpeed	1.00427	22
pH	1.00403	23
Alkalinity mg/L as CaCO3	1.00392	24
Color, Cu	1.00349	25
Sulfate mg/L	1.00298	26
Nitrite/Nitrate	1.00191	27
TOC, mg/L	1.00145	28
Hardness Total, mg/L as Ca	1.00005	29
PrevPrecip	0.99873	30
Passaic extractions	0.99747	31
Initial Chrysophyta	0.99210	32

Initial Cyanobacteria Level		
Total Amorphous Material	1.234029	1
HeatingDays	1.126178	2
Initial Chlorophyta	1.086147	3
Pompton streamflow	1.083754	4
pH	1.081516	5
BOD, mg/L	1.047186	6
Turbidity NTU	1.046796	7
Initial Chrysophyta	1.040051	8
Sulfate mg/L	1.034229	9
Odor	1.03053	10
Hardness Total, mg/L as Ca	1.02393	11
WkPrecip	1.02182	12
Nitrite/Nitrate	1.01972	13
PointRes extractions	1.01834	14
UV254 cm-1	1.01379	15
Pompton extractions	1.00936	16
Passaic extractions	1.00842	17
Alkalinity mg/L as CaCO3	1.00682	18
TOC, mg/L	1.00589	19
JAPS extractions	1.00445	20
Chloride mg/L	1.00388	21
Ammonia mg/L	0.99931	22
DO, mg/L	0.99656	23
WindSpeed	0.99532	24
Conductivity umhos/cm	0.99245	25
PrevPrecip	0.99243	26
Temp 0C	0.99241	27
Total Count, cells/ml	0.99161	28
WindDir	0.99103	29
T.Phosphorus/Orthophosph	0.98501	30
SkyCover	0.97396	31
Color, Cu	0.93859	32

Table 6.6. Station 101 Chlorophyta one-week ahead: Sensitivity Analysis (cont.)

pH Level		
Initial Cyanophyta	1.414460	1
Total Amorphous Material	1.165987	2
Odor	1.070169	3
Total Count, cells/ml	1.045213	4
T.Phosphorus/Orthophosph	1.042813	5
PointRes extractions	1.039296	6
WkPrecip	1.039023	7
Sulfate mg/L	1.038493	8
Initial Chlorophyta	1.037693	9
Pompton streamflow	1.03139	10
Color, Cu	1.02600	11
Ammonia mg/L	1.01703	12
Conductivity umhos/cm	1.01577	13
HeatingDays	1.01027	14
SkyCover	1.00961	15
Temp 0C	1.00908	16
Alkalinity mg/L as CaCO3	1.00539	17
BOD, mg/L	1.00456	18
Nitrite/Nitrate	1.00411	19
Turbidity NTU	1.00168	20
Chloride mg/L	1.00130	21
WindDir	1.00054	22
Passaic extractions	1.00048	23
WindSpeed	0.99998	24
Hardness Total, mg/L as Ca	0.99966	25
JAPS extractions	0.99822	26
PrevPrecip	0.99731	27
TOC, mg/L	0.99645	28
UV254 cm-1	0.99425	29
Initial Chrysophyta	0.99420	30
Pompton extractions	0.99325	31
DO, mg/L	0.92299	32

Wind Speed		
Total Amorphous Material	1.276763	1
SkyCover	1.113989	2
JAPS extractions	1.083444	3
Hardness Total, mg/L as Ca	1.076541	4
Passaic extractions	1.060385	5
Initial Chlorophyta	1.056926	6
Temp 0C	1.043817	7
T.Phosphorus/Orthophosph	1.039347	8
HeatingDays	1.034509	9
TOC, mg/L	1.03166	10
Pompton extractions	1.02078	11
Odor	1.02020	12
Nitrite/Nitrate	1.01584	13
BOD, mg/L	1.01381	14
Color, Cu	1.01367	15
pH	1.01226	16
PointRes extractions	1.01210	17
Total Count, cells/ml	1.01110	18
WkPrecip	1.01055	19
Initial Chrysophyta	1.00877	20
Initial Cyanophyta	1.00832	21
DO, mg/L	1.00505	22
Alkalinity mg/L as CaCO3	1.00244	23
UV254 cm-1	1.00221	24
Sulfate mg/L	1.00171	25
Chloride mg/L	1.00138	26
Ammonia mg/L	1.00077	27
Turbidity NTU	0.99944	28
Conductivity umhos/cm	0.99885	29
PrevPrecip	0.99754	30
WindDir	0.99742	31
Pompton streamflow	0.93758	32

Chloride		
Initial Chlorophyta	1.311291	1
Total Amorphous Material	1.195894	2
Odor	1.064403	3
Pompton streamflow	1.049318	4
WkPrecip	1.048905	5
Temp 0C	1.046194	6
BOD, mg/L	1.044802	7
PrevPrecip	1.042257	8
Passaic extractions	1.038128	9
Nitrite/Nitrate	1.03666	10
Initial Chrysophyta	1.03303	11
Ammonia mg/L	1.02733	12
PointRes extractions	1.02478	13
Hardness Total, mg/L as Ca	1.02028	14
DO, mg/L	1.02027	15
Initial Cyanophyta	1.01717	16
WindDir	1.01483	17
Sulfate mg/L	1.01220	18
UV254 cm-1	1.01049	19
Turbidity NTU	1.00904	20
Alkalinity mg/L as CaCO3	1.00825	21
Total Count, cells/ml	1.00813	22
SkyCover	1.00766	23
JAPS extractions	1.00652	24
TOC, mg/L	1.00346	25
Color, Cu	1.00203	26
Pompton extractions	0.99877	27
Conductivity umhos/cm	0.99735	28
pH	0.99646	29
WindSpeed	0.99100	30
HeatingDays	0.98496	31
T.Phosphorus/Orthophosph	0.98452	32

Table 6.7. Station 101 Chlorophyta two-week ahead: Sensitivity Analysis

All Inputs		
PointRes extractions	2.809965	1
Initial Chlorophyta	2.445626	2
Odor	1.722810	3
Conductivity umhos/cm	1.557692	4
Total Count, cells/ml	1.395877	5
WkPrecip	1.194609	6
Initial Chrysophyta	1.193266	7
Turbidity NTU	1.143334	8
Alkalinity mg/L as CaCO3	1.133159	9
Initial Cyanophyta	1.09815	10
BOD, mg/L	1.06748	11
TOC, mg/L	1.05178	12
Ammonia mg/L	1.04791	13
Total Amorphous Material	1.04481	14
UV254 cm-1	1.03295	15
PrevPrecip	1.03192	16
WindSpeed	1.03096	17
T.Phosphorus/Orthophosph	1.02906	18
pH	1.02414	19
HeatingDays	1.01657	20
Passaic extractions	1.01506	21
Chloride mg/L	1.01025	22
Temp 0C	1.00855	23
SkyCover	1.00715	24
Nitrite/Nitrate	1.00162	25
Pompton extractions	0.99803	26
DO, mg/L	0.99399	27
Sulfate mg/L	0.98693	28
WindDir	0.97419	29
JAPS extractions	0.97113	30
Pompton streamflow	0.96561	31
Color, Cu	0.96389	32
Hardness Total, mg/L as Ca	0.96251	33

Point View Reservoir		
Total Amorphous Material	1.285735	1
BOD, mg/L	1.130398	2
Sulfate mg/L	1.095817	3
Odor	1.084567	4
Conductivity umhos/cm	1.078270	5
Turbidity NTU	1.077877	6
Initial Chlorophyta	1.054878	7
Pompton extractions	1.047978	8
Passaic extractions	1.043987	9
UV254 cm-1	1.03963	10
PrevPrecip	1.03642	11
Total Count, cells/ml	1.02414	12
T.Phosphorus/Orthophosph	1.02027	13
TOC, mg/L	1.01768	14
SkyCover	1.01605	15
Alkalinity mg/L as CaCO3	1.01333	16
Color, Cu	1.01026	17
Pompton streamflow	1.00638	18
Ammonia mg/L	1.00580	19
Initial Chrysophyta	1.00489	20
Temp 0C	1.00407	21
Hardness Total, mg/L as Ca	1.00370	22
WindSpeed	0.99932	23
WkPrecip	0.99510	24
DO, mg/L	0.98570	25
HeatingDays	0.98530	26
pH	0.97090	27
Nitrite/Nitrate	0.96762	28
Initial Cyanophyta	0.96193	29
WindDir	0.96051	30
JAPS extractions	0.94866	31
Chloride mg/L	0.93350	32

Initial Chlorophyta Level		
PointRes extractions	1.292639	1
Total Amorphous Material	1.284148	2
Total Count, cells/ml	1.198862	3
BOD, mg/L	1.158460	4
Color, Cu	1.115282	5
Odor	1.079854	6
Hardness Total, mg/L as Ca	1.056583	7
Initial Cyanophyta	1.051906	8
Temp 0C	1.042717	9
DO, mg/L	1.03610	10
Nitrite/Nitrate	1.03424	11
Sulfate mg/L	1.03358	12
UV254 cm-1	1.02980	13
HeatingDays	1.02820	14
TOC, mg/L	1.02174	15
Chloride mg/L	1.01170	16
Pompton extractions	1.01041	17
SkyCover	1.00738	18
PrevPrecip	1.00434	19
Turbidity NTU	1.00376	20
WkPrecip	1.00275	21
Conductivity umhos/cm	1.00254	22
Initial Chrysophyta	0.98459	23
JAPS extractions	0.97999	24
Alkalinity mg/L as CaCO3	0.97780	25
Passaic extractions	0.97572	26
pH	0.97409	27
WindSpeed	0.97309	28
WindDir	0.95868	29
Ammonia mg/L	0.95575	30
T.Phosphorus/Orthophosph	0.95474	31
Pompton streamflow	0.77659	32

Table 6.7. Station 101 Chlorophyta two-week ahead: Sensitivity Analysis (cont.)

Conductivity		
Initial Chlorophyta	2.446241	1
PointRes extractions	1.804198	2
Total Amorphous Material	1.178761	3
BOD, mg/L	1.131614	4
Odor	1.111713	5
Pompton extractions	1.077993	6
Initial Cyanophyta	1.063180	7
Ammonia mg/L	1.060472	8
Alkalinity mg/L as CaCO3	1.050481	9
Sulfate mg/L	1.05042	10
UV254 cm-1	1.04974	11
Color, Cu	1.04960	12
Hardness Total, mg/L as Ca	1.03072	13
Initial Chrysophyta	1.02596	14
HeatingDays	1.02258	15
Nitrite/Nitrate	1.02132	16
WkPrecip	1.01483	17
Temp 0C	1.01104	18
WindDir	1.01084	19
Passaic extractions	1.00976	20
Total Count, cells/ml	1.00916	21
PrevPrecip	1.00911	22
Pompton streamflow	1.00907	23
JAPS extractions	1.00515	24
SkyCover	1.00294	25
WindSpeed	1.00112	26
T.Phosphorus/Orthophosph	1.00029	27
DO, mg/L	1.00002	28
Chloride mg/L	0.99772	29
pH	0.99461	30
Turbidity NTU	0.99199	31
TOC, mg/L	0.98779	32

Color		
PointRes extractions	1.651958	1
Initial Chlorophyta	1.459006	2
Total Amorphous Material	1.157379	3
Temp 0C	1.151950	4
BOD, mg/L	1.143379	5
Turbidity NTU	1.095591	6
Initial Cyanophyta	1.077217	7
Total Count, cells/ml	1.070158	8
JAPS extractions	1.069775	9
Ammonia mg/L	1.05573	10
Pompton extractions	1.05002	11
WkPrecip	1.04796	12
Nitrite/Nitrate	1.03740	13
DO, mg/L	1.03601	14
SkyCover	1.02391	15
HeatingDays	1.02318	16
PrevPrecip	1.01013	17
Chloride mg/L	1.00830	18
Alkalinity mg/L as CaCO3	1.00757	19
WindSpeed	1.00646	20
WindDir	1.00557	21
Hardness Total, mg/L as Ca	1.00423	22
Sulfate mg/L	1.00249	23
Conductivity umhos/cm	1.00189	24
Passaic extractions	0.99805	25
Pompton streamflow	0.99772	26
pH	0.99098	27
Odor	0.98665	28
Initial Chrysophyta	0.98505	29
T.Phosphorus/Orthophosph	0.98289	30
TOC, mg/L	0.97365	31
UV254 cm-1	0.96505	32

Total Hardness		
Initial Chlorophyta	1.354768	1
PointRes extractions	1.317083	2
TOC, mg/L	1.216018	3
Nitrite/Nitrate	1.138564	4
BOD, mg/L	1.118192	5
Total Amorphous Material	1.056985	6
Initial Cyanophyta	1.046686	7
Passaic extractions	1.035449	8
SkyCover	1.026812	9
Sulfate mg/L	1.02507	10
Chloride mg/L	1.02138	11
Color, Cu	1.02096	12
pH	1.02081	13
WindDir	1.01365	14
Pompton streamflow	1.01305	15
HeatingDays	1.01288	16
Pompton extractions	1.00748	17
JAPS extractions	1.00637	18
Initial Chrysophyta	1.00529	19
WindSpeed	1.00485	20
Turbidity NTU	1.00360	21
DO, mg/L	1.00302	22
Total Count, cells/ml	1.00241	23
T.Phosphorus/Orthophosph	1.00203	24
WkPrecip	1.00006	25
Temp 0C	1.00000	26
UV254 cm-1	0.99573	27
Ammonia mg/L	0.99441	28
Conductivity umhos/cm	0.99287	29
Odor	0.94916	30
Alkalinity mg/L as CaCO3	0.94179	31
PrevPrecip	0.93635	32

Table 6.7. Station 612 Chlorophyta real-time predictions: Sensitivity Analysis

Real time Prediction

All Inputs		
Total Count, cells/ml	1.216237	1
Total Amorphous Material	1.146256	2
Chloride mg/L	1.113846	3
SkyCover	1.109945	4
Initial Cyanophyta	1.105973	5
UV254 cm-1	1.085981	6
Pompton extractions	1.081929	7
Turbidity NTU	1.049824	8
Initial Chrysophyta	1.049660	9
Initial Chlorophyta	1.03463	10
BOD, mg/L	1.03028	11
WindSpeed	1.02966	12
Color, Cu	1.02943	13
Hardness Total, mg/L as Ca	1.02237	14
Conductivity umhos/cm	1.02143	15
Sulfate mg/L	1.01945	16
WkPrecip	1.01723	17
PrevPrecip	1.01666	18
pH	1.01598	19
TotalPhosphorus/Orthophos	1.01596	20
DO, mg/L	1.01568	21
TOC, mg/L	1.01406	22
Odor	1.01329	23
PointRes extractions	1.00601	24
WindDir	1.00467	25
Passaic extractions	1.00286	26
Ammonia mg/L	1.00074	27
Alkalinity mg/L as CaCO3	0.99747	28
Temp 0C	0.99404	29
JAPS extractions	0.99288	30
Nitrite/Nitrate	0.98189	31
Pompton streamflow	0.98082	32
HeatingDays	0.97527	33

Total Count		
UV254 cm-1	1.460400	1
Initial Chlorophyta	1.263191	2
Total Amorphous Material	1.178476	3
Odor	1.121083	4
Hardness Total, mg/L as Ca	1.116396	5
WkPrecip	1.111598	6
Conductivity umhos/cm	1.079944	7
Initial Chrysophyta	1.077507	8
HeatingDays	1.059798	9
TotalPhosphorus/Orthophos	1.04656	10
Alkalinity mg/L as CaCO3	1.04593	11
Sulfate mg/L	1.03462	12
WindSpeed	1.02239	13
Pompton streamflow	1.02183	14
DO, mg/L	1.02117	15
Turbidity NTU	1.01730	16
Initial Cyanophyta	1.01648	17
Temp 0C	1.01287	18
SkyCover	1.00822	19
Nitrite/Nitrate	1.00786	20
pH	1.00684	21
Color, Cu	1.00584	22
JAPS extractions	1.00163	23
PointRes extractions	0.99944	24
Passaic extractions	0.99750	25
Chloride mg/L	0.99747	26
Ammonia mg/L	0.98711	27
TOC, mg/L	0.98472	28
PrevPrecip	0.97849	29
WindDir	0.95165	30
Pompton extractions	0.94403	31
BOD, mg/L	0.93088	32

Chloride		
Alkalinity mg/L as CaCO3	2.273833	1
Odor	1.585574	2
Turbidity NTU	1.409454	3
Total Amorphous Material	1.323109	4
Ammonia mg/L	1.295478	5
HeatingDays	1.266574	6
DO, mg/L	1.229185	7
Initial Chlorophyta	1.210368	8
Sulfate mg/L	1.177427	9
WkPrecip	1.16046	10
Hardness Total, mg/L as Ca	1.12275	11
SkyCover	1.11489	12
Pompton extractions	1.09252	13
WindSpeed	1.07896	14
Initial Chrysophyta	1.07201	15
Conductivity umhos/cm	1.03943	16
Total Count, cells/ml	1.03834	17
pH	1.03700	18
Temp 0C	1.03131	19
Pompton streamflow	1.02829	20
PointRes extractions	1.02660	21
JAPS extractions	1.02439	22
Initial Cyanophyta	1.00746	23
TOC, mg/L	1.00391	24
WindDir	1.00280	25
Color, Cu	1.00141	26
Passaic extractions	0.99690	27
TotalPhosphorus/Orthophos	0.98946	28
BOD, mg/L	0.98763	29
Nitrite/Nitrate	0.96966	30
UV254 cm-1	0.94312	31
PrevPrecip	0.93664	32

Table 6.7. Station 612 Chlorophyta real-time predictions: Sensitivity Analysis (cont.)

Sky Cover		
Alkalinity mg/L as CaCO3	1.821475	1
Total Amorphous Material	1.627167	2
Hardness Total, mg/L as Ca	1.468328	3
HeatingDays	1.230011	4
Temp 0C	1.221178	5
Color, Cu	1.204079	6
UV254 cm-1	1.159043	7
Odor	1.108238	8
Pompton streamflow	1.051568	9
WindDir	1.04569	10
Sulfate mg/L	1.03431	11
Initial Cyanophyta	1.03206	12
PrevPrecip	1.03138	13
Pompton extractions	1.02172	14
TotalPhosphorus/Orthophos	1.01639	15
pH	1.00881	16
DO, mg/L	1.00736	17
Turbidity NTU	1.00561	18
TOC, mg/L	1.00406	19
Passaic extractions	1.00348	20
JAPS extractions	1.00280	21
WkPrecip	1.00079	22
PointRes extractions	1.00046	23
WindSpeed	1.00036	24
Conductivity umhos/cm	0.99953	25
BOD, mg/L	0.99903	26
Chloride mg/L	0.99702	27
Ammonia mg/L	0.99672	28
Initial Chrysophyta	0.99280	29
Total Count, cells/ml	0.98166	30
Nitrite/Nitrate	0.95822	31
Initial Chlorophyta	0.80032	32

Pompton streamflow		
Odor	1.115067	1
Initial Chlorophyta	1.100318	2
Total Amorphous Material	1.061637	3
BOD, mg/L	1.051187	4
Conductivity umhos/cm	1.051166	5
Pompton extractions	1.042638	6
HeatingDays	1.033645	7
Sulfate mg/L	1.023902	8
WkPrecip	1.020220	9
PrevPrecip	1.01958	10
Passaic extractions	1.01693	11
UV254 cm-1	1.01477	12
SkyCover	1.01160	13
Hardness Total, mg/L as Ca	1.00970	14
Alkalinity mg/L as CaCO3	1.00877	15
Ammonia mg/L	1.00692	16
WindSpeed	1.00661	17
Color, Cu	1.00648	18
Total Count, cells/ml	1.00629	19
TOC, mg/L	1.00451	20
Chloride mg/L	1.00040	21
Initial Chrysophyta	1.00027	22
PointRes extractions	0.99989	23
TotalPhosphorus/Orthophos	0.99889	24
Turbidity NTU	0.99846	25
Initial Cyanophyta	0.99767	26
Temp 0C	0.99725	27
DO, mg/L	0.99653	28
pH	0.99446	29
JAPS extractions	0.99392	30
WindDir	0.99046	31
Nitrite/Nitrate	0.98240	32

Heating Days		
UV254 cm-1	1.044705	1
Initial Chlorophyta	1.040541	2
Odor	1.030498	3
WkPrecip	1.015859	4
DO, mg/L	1.014205	5
Temp 0C	1.013155	6
Nitrite/Nitrate	1.011871	7
Initial Cyanophyta	1.010263	8
TOC, mg/L	1.010069	9
WindSpeed	1.00974	10
SkyCover	1.00952	11
Sulfate mg/L	1.00832	12
Conductivity umhos/cm	1.00676	13
Turbidity NTU	1.00653	14
Ammonia mg/L	1.00538	15
Color, Cu	1.00426	16
Chloride mg/L	1.00412	17
Passaic extractions	1.00323	18
Total Count, cells/ml	1.00286	19
Pompton extractions	1.00236	20
WindDir	1.00210	21
JAPS extractions	1.00185	22
PointRes extractions	1.00153	23
pH	1.00122	24
PrevPrecip	1.00084	25
TotalPhosphorus/Orthophos	1.00069	26
Total Amorphous Material	1.00016	27
Initial Chrysophyta	0.99277	28
BOD, mg/L	0.99239	29
Alkalinity mg/L as CaCO3	0.99006	30
Hardness Total, mg/L as Ca	0.97616	31
Pompton streamflow	0.54252	32

Table 6.8. Station 612 Chlorophyta one-week ahead: Sensitivity Analysis

All Inputs		
Total Count, cells/ml	1.893741	1
Initial Chlorophyta	1.469271	2
Initial Chrysophyta	1.359864	3
Total Amorphous Material	1.311196	4
Pompton streamflow	1.279299	5
Temp 0C	1.271309	6
Nitrite/Nitrate	1.264677	7
Initial Cyanophyta	1.257147	8
Hardness Total, mg/L as Ca	1.251432	9
TOC, mg/L	1.21370	10
BOD, mg/L	1.18365	11
Turbidity NTU	1.17951	12
Conductivity umhos/cm	1.12453	13
Ammonia mg/L	1.09679	14
WindDir	1.09399	15
Odor	1.08295	16
pH	1.06335	17
Sulfate mg/L	1.06191	18
WindSpeed	1.04368	19
PrevPrecip	1.04032	20
WkPrecip	1.03475	21
Color, Cu	1.02210	22
Alkalinity mg/L as CaCO3	1.02134	23
Passaic extractions	1.01209	24
SkyCover	1.01140	25
UV254 cm-1	1.00441	26
PointRes extractions	1.00108	27
JAPS extractions	1.00065	28
Chloride mg/L	1.00017	29
DO, mg/L	0.99172	30
HeatingDays	0.99117	31
TotalPhosphorus/Orthophos	0.98125	32
Pompton extractions	0.98046	33

Total Count		
Hardness Total, mg/L as Ca	1.200786	1
Odor	1.183910	2
Nitrite/Nitrate	1.134341	3
WkPrecip	1.082445	4
BOD, mg/L	1.059896	5
Chloride mg/L	1.057246	6
Pompton streamflow	1.054184	7
Alkalinity mg/L as CaCO3	1.052035	8
Total Amorphous Material	1.051552	9
SkyCover	1.04397	10
Conductivity umhos/cm	1.03406	11
Initial Cyanophyta	1.00995	12
WindSpeed	1.00331	13
PointRes extractions	1.00290	14
TotalPhosphorus/Orthophos	1.00188	15
pH	1.00079	16
JAPS extractions	0.99626	17
Pompton extractions	0.99580	18
Passaic extractions	0.99553	19
PrevPrecip	0.99408	20
Turbidity NTU	0.99225	21
Temp 0C	0.98786	22
Color, Cu	0.98547	23
Sulfate mg/L	0.98010	24
TOC, mg/L	0.97903	25
Initial Chrysophyta	0.96387	26
Ammonia mg/L	0.92350	27
UV254 cm-1	0.91841	28
DO, mg/L	0.88845	29
WindDir	0.88199	30
HeatingDays	0.86527	31
Initial Chlorophyta	0.77207	32

Initial Chlorophyta Level		
UV254 cm-1	1.443685	1
Pompton streamflow	1.265532	2
Conductivity umhos/cm	1.252007	3
Total Count, cells/ml	1.232338	4
WkPrecip	1.222923	5
Hardness Total, mg/L as Ca	1.178474	6
Nitrite/Nitrate	1.173689	7
Total Amorphous Material	1.133498	8
TOC, mg/L	1.125819	9
Odor	1.09438	10
Ammonia mg/L	1.06903	11
Chloride mg/L	1.04482	12
Sulfate mg/L	1.04022	13
PrevPrecip	1.03796	14
PointRes extractions	1.03601	15
BOD, mg/L	1.03427	16
pH	1.02995	17
HeatingDays	1.02292	18
Initial Cyanophyta	1.01899	19
Passaic extractions	1.01663	20
SkyCover	1.01258	21
WindDir	1.01252	22
DO, mg/L	1.00691	23
Color, Cu	1.00467	24
JAPS extractions	1.00445	25
Temp 0C	1.00201	26
Turbidity NTU	1.00093	27
Alkalinity mg/L as CaCO3	0.99769	28
TotalPhosphorus/Orthophos	0.99589	29
WindSpeed	0.99579	30
Initial Chrysophyta	0.99187	31
Pompton extractions	0.99142	32

Table 6.8. Station 612 Chlorophyta one-week ahead: Sensitivity Analysis (cont.)

Initial Chrysophyta Level		
Pompton streamflow	1.120408	1
Total Amorphous Material	1.106618	2
BOD, mg/L	1.056037	3
Temp 0C	1.043641	4
TOC, mg/L	1.038774	5
TotalPhosphorus/Orthophos	1.026642	6
Conductivity umhos/cm	1.022334	7
SkyCover	1.022305	8
Passaic extractions	1.020373	9
Ammonia mg/L	1.01478	10
Turbidity NTU	1.00682	11
Initial Cyanophyta	1.00550	12
JAPS extractions	1.00511	13
Sulfate mg/L	1.00439	14
WkPrecip	1.00354	15
pH	1.00039	16
Nitrite/Nitrate	0.99714	17
PointRes extractions	0.99499	18
Pompton extractions	0.99424	19
DO, mg/L	0.99401	20
UV254 cm-1	0.99245	21
HeatingDays	0.98846	22
Total Count, cells/ml	0.98584	23
Hardness Total, mg/L as Ca	0.98445	24
Color, Cu	0.98345	25
Initial Chlorophyta	0.98250	26
Odor	0.97980	27
Chloride mg/L	0.97881	28
Alkalinity mg/L as CaCO3	0.97465	29
WindSpeed	0.97360	30
WindDir	0.94019	31
PrevPrecip	0.88140	32

Total Phosphorous		
UV254 cm-1	2.534786	1
Passaic extractions	1.961012	2
Hardness Total, mg/L as Ca	1.769942	3
Nitrite/Nitrate	1.727551	4
Conductivity umhos/cm	1.605322	5
Pompton streamflow	1.602616	6
WkPrecip	1.493034	7
Initial Chlorophyta	1.488465	8
PrevPrecip	1.358238	9
Total Amorphous Material	1.26591	10
pH	1.22075	11
BOD, mg/L	1.21983	12
WindDir	1.17736	13
HeatingDays	1.16047	14
Sulfate mg/L	1.13014	15
Color, Cu	1.12016	16
Total Count, cells/ml	1.11410	17
SkyCover	1.11049	18
Chloride mg/L	1.04947	19
WindSpeed	1.01818	20
Alkalinity mg/L as CaCO3	1.01496	21
Initial Chrysophyta	1.00364	22
DO, mg/L	0.98197	23
Pompton extractions	0.96202	24
JAPS extractions	0.95171	25
Ammonia mg/L	0.94041	26
Odor	0.93177	27
Temp 0C	0.91029	28
Turbidity NTU	0.89728	29
TOC, mg/L	0.87311	30
Initial Cyanophyta	0.78231	31
PointRes extractions	0.78125	32

Pompton extractions		
Nitrite/Nitrate	1.385281	1
Initial Chlorophyta	1.266899	2
WindSpeed	1.170518	3
Pompton streamflow	1.129236	4
HeatingDays	1.110737	5
PrevPrecip	1.097176	6
Initial Chrysophyta	1.082522	7
Hardness Total, mg/L as Ca	1.075616	8
TotalPhosphorus/Orthophos	1.062107	9
JAPS extractions	1.04660	10
WkPrecip	1.03628	11
Total Count, cells/ml	1.02991	12
DO, mg/L	1.02772	13
TOC, mg/L	1.02234	14
SkyCover	1.02076	15
WindDir	1.01912	16
Ammonia mg/L	1.01556	17
pH	1.01378	18
Alkalinity mg/L as CaCO3	1.01296	19
Passaic extractions	1.01083	20
Initial Cyanophyta	1.00135	21
BOD, mg/L	1.00023	22
Sulfate mg/L	1.00003	23
PointRes extractions	0.99923	24
Total Amorphous Material	0.99540	25
Color, Cu	0.99432	26
Turbidity NTU	0.98278	27
UV254 cm-1	0.96694	28
Temp 0C	0.92622	29
Conductivity umhos/cm	0.90044	30
Chloride mg/L	0.89470	31
Odor	0.53152	32

Table 6.9. Station 612 Chlorophyta two-week ahead: Sensitivity Analysis

All Inputs		
Odor	1.864002	1
Total Amorphous Material	1.367747	2
UV254 cm-1	1.234113	3
WkPrecip	1.216126	4
WindDir	1.177500	5
Pompton extractions	1.130850	6
DO, mg/L	1.125240	7
Ammonia mg/L	1.118466	8
Initial Chlorophyta	1.050733	9
Turbidity NTU	1.04935	10
WindSpeed	1.04866	11
Sulfate mg/L	1.04768	12
Hardness Total, mg/L as Ca	1.04491	13
pH	1.04478	14
Chloride mg/L	1.04047	15
HeatingDays	1.03384	16
Initial Cyanophyta	1.03040	17
BOD, mg/L	1.02834	18
Total Count, cells/ml	1.02443	19
TotalPhosphorus/Orthophos	1.01585	20
Nitrite/Nitrate	1.01540	21
Pompton streamflow	1.01251	22
PrevPrecip	1.01212	23
Conductivity umhos/cm	1.01091	24
Initial Chrysophyta	0.99948	25
Passaic extractions	0.99845	26
Temp 0C	0.99738	27
PointRes extractions	0.99728	28
JAPS extractions	0.99631	29
Alkalinity mg/L as CaCO3	0.99288	30
SkyCover	0.98577	31
Color, Cu	0.97930	32
TOC, mg/L	0.97665	33

UV254		
Odor	1.357717	1
DO, mg/L	1.274950	2
Initial Chlorophyta	1.078414	3
BOD, mg/L	1.077971	4
WindDir	1.069943	5
Total Amorphous Material	1.061871	6
Color, Cu	1.057715	7
WkPrecip	1.050494	8
Pompton extractions	1.038281	9
Chloride mg/L	1.03593	10
Total Count, cells/ml	1.03556	11
TotalPhosphorus/Orthophos	1.03297	12
Passaic extractions	1.02895	13
PrevPrecip	1.02881	14
SkyCover	1.02829	15
HeatingDays	1.02389	16
PointRes extractions	1.02278	17
Hardness Total, mg/L as Ca	1.02208	18
Initial Cyanophyta	1.01888	19
Ammonia mg/L	1.01062	20
Conductivity umhos/cm	1.00877	21
pH	1.00662	22
Turbidity NTU	1.00361	23
Alkalinity mg/L as CaCO3	1.00301	24
JAPS extractions	1.00162	25
Temp 0C	1.00159	26
TOC, mg/L	1.00046	27
WindSpeed	1.00019	28
Sulfate mg/L	0.99974	29
Initial Chrysophyta	0.99919	30
Pompton streamflow	0.99717	31
PrevPrecip	0.94649	31

Weekly Precip		
Pompton extractions	1.147850	1
Total Amorphous Material	1.136221	2
Pompton streamflow	1.083261	3
Nitrite/Nitrate	1.075072	4
Odor	1.072119	5
Color, Cu	1.056793	6
WindDir	1.051409	7
UV254 cm-1	1.037164	8
TotalPhosphorus/Orthophos	1.018050	9
PrevPrecip	1.01773	10
HeatingDays	1.01390	11
Temp 0C	1.00895	12
BOD, mg/L	1.00865	13
SkyCover	1.00577	14
PointRes extractions	1.00497	15
JAPS extractions	1.00410	16
Initial Cyanophyta	0.99852	17
DO, mg/L	0.99448	18
Passaic extractions	0.99428	19
TOC, mg/L	0.99141	20
Turbidity NTU	0.98983	21
Initial Chlorophyta	0.98825	22
Chloride mg/L	0.97518	23
WindSpeed	0.97054	24
Ammonia mg/L	0.95988	25
Hardness Total, mg/L as Ca	0.95810	26
Sulfate mg/L	0.94937	27
Conductivity umhos/cm	0.93760	28
pH	0.91552	29
Alkalinity mg/L as CaCO3	0.90996	30
Total Count, cells/ml	0.88228	31
Turbidity NTU	0.96687	31

Table 6.9. Station 612 Chlorophyta two-week ahead: Sensitivity Analysis (cont.)

WindDirection		
Hardness Total, mg/L as Ca	1.182814	1
Ammonia mg/L	1.123820	2
Initial Chlorophyta	1.078373	3
PrevPrecip	1.057439	4
Pompton streamflow	1.034531	5
UV254 cm-1	1.033335	6
Color, Cu	1.029335	7
Odor	1.023149	8
Turbidity NTU	1.022418	9
TOC, mg/L	1.01760	10
Passaic extractions	1.00917	11
JAPS extractions	1.00517	12
Chloride mg/L	1.00109	13
SkyCover	1.00069	14
Conductivity umhos/cm	0.99931	15
pH	0.99926	16
BOD, mg/L	0.99852	17
PointRes extractions	0.99613	18
WkPrecip	0.99499	19
Initial Cyanophyta	0.99465	20
Sulfate mg/L	0.99320	21
Alkalinity mg/L as CaCO3	0.98905	22
Temp 0C	0.98713	23
Total Count, cells/ml	0.98680	24
Initial Chrysophyta	0.98301	25
DO, mg/L	0.97326	26
Nitrite/Nitrate	0.95925	27
HeatingDays	0.94781	28
WindSpeed	0.92713	29
Pompton extractions	0.91612	30
Total Amorphous Material	0.87429	31
SkyCover	0.92969	31

Color		
Odor	1.515678	1
Initial Chlorophyta	1.287332	2
Temp 0C	1.276527	3
Ammonia mg/L	1.260693	4
Total Amorphous Material	1.208859	5
WindDir	1.148828	6
HeatingDays	1.119587	7
DO, mg/L	1.115082	8
Chloride mg/L	1.094062	9
SkyCover	1.09002	10
UV254 cm-1	1.08309	11
WkPrecip	1.07043	12
JAPS extractions	1.05431	13
Turbidity NTU	1.05269	14
WindSpeed	1.04223	15
BOD, mg/L	1.04114	16
Sulfate mg/L	1.03688	17
Nitrite/Nitrate	1.03551	18
Initial Chrysophyta	1.03061	19
pH	1.02985	20
Passaic extractions	1.02721	21
Pompton extractions	1.02138	22
Initial Cyanophyta	1.01086	23
Total Count, cells/ml	1.00916	24
PointRes extractions	1.00419	25
Conductivity umhos/cm	1.00343	26
Hardness Total, mg/L as Ca	1.00104	27
TOC, mg/L	1.00086	28
PrevPrecip	0.99245	29
Alkalinity mg/L as CaCO3	0.98684	30
Pompton streamflow	0.97132	31
Conductivity, umhos/cm	0.99255	31

Total Organic Carbon (TOC)		
Odor	1.331649	1
Total Amorphous Material	1.124594	2
Initial Chlorophyta	1.083793	3
Pompton extractions	1.076756	4
PrevPrecip	1.070329	5
HeatingDays	1.060034	6
BOD, mg/L	1.058214	7
Nitrite/Nitrate	1.052286	8
Pompton streamflow	1.044558	9
DO, mg/L	1.03737	10
UV254 cm-1	1.03003	11
SkyCover	1.02831	12
Ammonia mg/L	1.02704	13
pH	1.02619	14
WkPrecip	1.01545	15
WindDir	1.01429	16
Chloride mg/L	1.00627	17
JAPS extractions	1.00382	18
WindSpeed	1.00317	19
Initial Chrysophyta	1.00191	20
Total Count, cells/ml	1.00189	21
PointRes extractions	1.00108	22
TotalPhosphorus/Orthopho	1.00014	23
Passaic extractions	0.99949	24
Turbidity NTU	0.99941	25
Temp 0C	0.99923	26
Conductivity umhos/cm	0.99906	27
Initial Cyanophyta	0.99877	28
Hardness Total, mg/L as Ca	0.99859	29
Color, Cu	0.99110	30
Alkalinity mg/L as CaCO3	0.98994	31
JAPS extractions	0.99015	31

Table 6.9. Station 612 Chlorophyta two-week ahead: Sensitivity Analysis (cont.)

Odor		
DO, mg/L	1.127136	1
WindSpeed	1.083826	2
PointRes extractions	1.074182	3
Pompton extractions	1.045053	4
Sulfate mg/L	1.040699	5
WindDir	1.033659	6
WkPrecip	1.028533	7
Ammonia mg/L	1.026697	8
UV254 cm-1	1.025438	9
Temp 0C	1.02045	10
Alkalinity mg/L as CaCO3	1.01635	11
Nitrite/Nitrate	1.01454	12
pH	1.01133	13
Chloride mg/L	1.01044	14
HeatingDays	1.00944	15
Total Count, cells/ml	1.00757	16
Passaic extractions	1.00701	17
BOD, mg/L	1.00658	18
Hardness Total, mg/L as Ca	1.00514	19
Initial Chrysophyta	1.00403	20
PrevPrecip	1.00263	21
Pompton streamflow	1.00009	22
TOC, mg/L	1.00008	23
SkyCover	0.99949	24
JAPS extractions	0.99915	25
Conductivity umhos/cm	0.99895	26
Initial Chlorophyta	0.99786	27
TotalPhosphorus/Orthophos	0.99222	28
Color, Cu	0.98977	29
Initial Cyanophyta	0.98011	30
Turbidity NTU	0.97858	31
Total Amorphous Material	0.96750	32

Total Amorphous Materials		
WkPrecip	1.213818	1
Sulfate mg/L	1.171231	2
UV254 cm-1	1.082317	3
Total Count, cells/ml	1.077943	4
Hardness Total, mg/L as Ca	1.058659	5
Initial Cyanophyta	1.057412	6
HeatingDays	1.037176	7
WindDir	1.021696	8
TotalPhosphorus/Orthophos	1.019635	9
TOC, mg/L	1.01802	10
JAPS extractions	1.01674	11
Odor	1.01499	12
WindSpeed	1.00992	13
Pompton extractions	1.00847	14
Chloride mg/L	1.00474	15
Passaic extractions	1.00246	16
PointRes extractions	1.00210	17
Color, Cu	1.00170	18
SkyCover	1.00153	19
DO, mg/L	1.00149	20
Temp 0C	1.00036	21
Alkalinity mg/L as CaCO3	0.99900	22
Conductivity umhos/cm	0.99885	23
Turbidity NTU	0.99875	24
PrevPrecip	0.99810	25
Initial Chlorophyta	0.99600	26
Pompton streamflow	0.99473	27
Ammonia mg/L	0.99246	28
BOD, mg/L	0.99082	29
Nitrite/Nitrate	0.98373	30
pH	0.97526	31
Initial Chrysophyta	0.97524	32

Table 6.10. Average Parameter Ratio values and Rankings from Sensitivity Analysis for predicting Cyanobacteria prediction at Station 100

Real time Prediction

TSS, mg/L	1.9608	11
DO, mg/L	1.8868	4
Alkalinity mg/L as CaCO3	1.8303	7
Odor	1.7752	6
Pompton extraction	1.7567	10
WindDir	1.6868	19
Nitrite/Nitrate	1.5468	8
PrevPrecip	1.5458	16
T.Phosphorus/Orthophospha	1.3555	14
Turbidity NTU	1.3502	14
BOD, mg/L	1.2759	11
Passaic extraction	1.2133	15
Ammonia, mg/L	1.1622	9
WindSpeed	1.1594	21
Pompton streamflow	1.1396	20
HeatingDays	1.1251	17
Temp (0C)	1.1029	21
SkyCover	1.0841	16
Sulfate, mg/L	1.0726	17
UV-254, cm-1	1.0717	14
WkPrecip	1.0665	23
PointRes	1.0581	18
TOC, mg/L	1.0537	21
Initial Cyanophyta	1.0433	19
Total Count, cells/ml	1.0334	18
pH	1.0310	17
Initial Chrysophyta	1.0289	18
Hardness, Total mg/L as Ca(	1.0289	22
Conductivity, umhos/cm	1.0107	18
Chloride, mg/L	1.0014	22
JAPS	0.9994	24
Initial Chlorophyta	0.9951	25

2-week Prediction Period

Nitrite/Nitrate	2.2134	3
Sulfate, mg/L	2.0524	6
HeatingDays	1.7165	4
pH	1.6321	12
Passaic extraction	1.6170	4
DO, mg/L	1.4987	7
TOC, mg/L	1.4274	11
TSS, mg/L	1.3319	10
SkyCover	1.3212	10
Ammonia, mg/L	1.2580	14
Turbidity NTU	1.2513	15
Initial Chrysophyta	1.1734	15
WkPrecip	1.1710	12
Pompton extraction	1.1691	18
Hardness, Total mg/L as Ca(	1.1410	20
BOD, mg/L	1.1245	18
Alkalinity mg/L as CaCO3	1.1228	17
WindDir	1.1154	19
Odor	1.1038	21
Initial Chlorophyta	1.0859	19
Pompton streamflow	1.0756	20
Conductivity, umhos/cm	1.0738	21
Chloride, mg/L	1.0714	17
Temp (0C)	1.0666	19
WindSpeed	1.0631	19
Total Count, cells/ml	1.0420	22
T.Phosphorus/Orthophospha	1.0318	23
UV-254, cm-1	1.0262	23
PrevPrecip	1.0234	18
JAPS	1.0096	25
Initial Cyanophyta	1.0011	26
PointRes	0.9996	24

1-week Prediction Period

DO, mg/L	1.9892	2
Alkalinity mg/L as CaC(	1.7181	4
Pompton extraction	1.6805	6
Odor	1.6480	5
TSS, mg/L	1.5964	6
WindDir	1.5662	14
Nitrite/Nitrate	1.3530	12
BOD, mg/L	1.2764	15
Turbidity NTU	1.2510	14
Sulfate, mg/L	1.2377	13
T.Phosphorus/Orthophos	1.1938	15
Total Count, cells/ml	1.1790	17
WindSpeed	1.1735	19
Ammonia, mg/L	1.1725	12
Hardness, Total mg/L as	1.1608	15
PrevPrecip	1.1546	17
Passaic extraction	1.1440	15
PointRes	1.1415	18
Temp (0C)	1.0976	16
UV-254, cm-1	1.0883	12
HeatingDays	1.0835	18
SkyCover	1.0701	19
TOC, mg/L	1.0559	22
Pompton streamflow	1.0467	20
Initial Cyanophyta	1.0406	21
Conductivity, umhos/cm	1.0279	24
Initial Chlorophyta	1.0223	22
Chloride, mg/L	1.0202	23
Initial Chrysophyta	1.0188	24
pH	1.0142	25
WkPrecip	1.0104	24
JAPS	1.0014	26

Table 6.11. Average Parameter Ratio values and Rankings from Sensitivity Analysis for predicting Cyanobacteria prediction at Station 101

Real time

PointResPVR	3.0247	9
Total Amorphous Material	2.0885	13
UV254	1.7869	11
HeatingDays	1.3897	6
Conductivity	1.3699	11
Sulfate	1.3083	9
Color	1.2194	12
Initial Chlorophyta	1.1955	12
Chloride	1.1858	14
PrevPrecip	1.1745	15
T.Phosphorus/Orthophospha	1.1711	12
TOC	1.1478	17
WkPrecip	1.1337	13
BOD	1.1063	13
Alkalinity	1.1046	16
SkyCover	1.0954	17
Initial Cyanophyta	1.0888	21
Temp 0C	1.0857	15
Nitrite/Nitrate	1.0676	17
Total Count, cells/ml	1.0517	16
pH	1.0480	17
Odor	1.0308	17
Hardness Total	1.0292	21
Passaic extraction	1.0246	19
Ammonia	1.0198	19
Initial Chrysophyta	1.0175	20
WindDir	1.0157	19
Pompton streamflow	1.0107	22
Turbidity NTU	1.0089	24
WindSpeed	1.0062	22
Pompton extraction	1.0029	24
JAPS	1.0013	25
DO	0.9885	23

2-week Prediction Period

Sulfate mg/L	1.7252	10
WkPrecip	1.6117	9
T.Phosphorus/Orthophospha	1.5046	8
Total Amorphous Material	1.4264	13
Conductivity umhos/cm	1.3372	16
HeatingDays	1.3368	15
Odor	1.2930	11
Hardness Total, mg/L as Ca(	1.2924	13
Color, Cu	1.2803	14
Chloride mg/L	1.2729	19
PrevPrecip	1.2722	13
UV254 cm-1	1.2337	17
PointResPVR	1.2215	16
BOD, mg/L	1.2160	19
Nitrite/Nitrate	1.1805	10
SkyCover	1.1798	10
WindDir	1.1735	24
DO, mg/L	1.1613	11
Initial Chlorophyta	1.1395	13
Temp 0C	1.1331	18
Pompton streamflow	1.1003	17
Alkalinity mg/L as CaCO3	1.0930	17
WindSpeed	1.0878	15
TOC, mg/L	1.0844	16
Pompton extraction	1.0831	16
Total Count, cells/ml	1.0480	28
Ammonia mg/L	1.0460	20
pH	1.0427	24
Initial Cyanophyta	1.0331	21
Passaic extraction	1.0216	21
Turbidity NTU	1.0087	21
JAPS	1.0083	24
Initial Chrysophyta	0.9747	25

1-week Prediction Period

Initial Cyanophyta	2.2764	13
WkPrecip	2.0303	1
Total Amorphous Materi	1.9201	10
WindSpeed	1.7700	4
BOD, mg/L	1.7638	10
T.Phosphorus/Orthophos	1.5499	7
TOC, mg/L	1.5282	11
HeatingDays	1.4641	9
Temp 0C	1.3808	12
UV254 cm-1	1.3503	21
PrevPrecip	1.3470	17
Alkalinity mg/L as CaC(	1.2677	12
Hardness Total, mg/L as	1.2652	17
JAPS	1.2528	19
PointResPVR	1.2352	16
Odor	1.1902	19
Ammonia mg/L	1.1578	22
pH	1.1540	18
Total Count, cells/ml	1.1466	21
Initial Chlorophyta	1.1424	18
Pompton extraction	1.1191	17
Passaic extraction	1.1185	20
Initial Chrysophyta	1.0735	15
SkyCover	1.0662	25
Sulfate mg/L	1.0633	19
Chloride mg/L	1.0567	19
DO, mg/L	1.0330	19
Turbidity NTU	1.0307	21
Color, Cu	1.0248	22
Conductivity umhos/cm	1.0232	20
Pompton streamflow	1.0177	22
WindDir	1.0165	17
Nitrite/Nitrate	1.0124	24

Table 6.12. Average Parameter Ratio values and Rankings from Sensitivity Analysis for predicting Cyanobacteria prediction at Station 612

Real time

Color, Cu	1.5097	3
Odor	1.4203	4
Total Amorphous Material	1.2167	8
DO, mg/L	1.2078	13
Initial Cyanophyta	1.1836	17
Turbidity NTU	1.1835	8
WkPrecip	1.1715	13
BOD, mg/L	1.1555	9
HeatingDays	1.1464	14
TotalPhosphorus/Orthophos	1.1014	15
SkyCover	1.1000	11
Sulfate mg/L	1.0911	13
PrevPrecip	1.0891	14
Alkalinity mg/L as CaCO3	1.0732	14
pH	1.0670	15
Temp 0C	1.0654	15
Total Count, cells/ml	1.0550	15
Conductivity umhos/cm	1.0454	19
Ammonia mg/L	1.0298	13
Initial Chrysophyta	1.0295	18
WindDir	1.0267	16
Nitrite/Nitrate	1.0244	17
Passaic extraction	1.0204	22
TOC, mg/L	1.0149	22
Pompton extraction	1.0066	20
PointRes	1.0030	20
Hardness Total, mg/L as Ca	1.0010	24
WindSpeed	1.0007	24
UV254 cm-1	0.9940	22
Chloride mg/L	0.9903	24
JAPS	0.9850	27
Initial Chlorophyta	0.9843	26
Pompton streamflow	0.9542	28

2-week Prediction Period

Total Amorphous Material	2.6249	1
Turbidity NTU	1.8530	4
Total Count, cells/ml	1.5965	11
WkPrecip	1.5902	12
Initial Cyanophyta	1.5774	8
Odor	1.5253	12
Sulfate mg/L	1.5136	10
DO, mg/L	1.4435	11
Temp 0C	1.4232	15
UV254 cm-1	1.4195	20
HeatingDays	1.3818	12
Ammonia mg/L	1.3657	11
Color, Cu	1.3383	11
WindDir	1.2984	8
PrevPrecip	1.2932	14
pH	1.2883	13
PointRes	1.2724	14
SkyCover	1.2408	15
Passaic extraction	1.2325	21
Alkalinity mg/L as CaCO3	1.1769	15
BOD, mg/L	1.1305	15
Initial Chlorophyta	1.1095	18
TotalPhosphorus/Orthophos	1.0830	21
Pompton extraction	1.0660	18
Conductivity umhos/cm	1.0593	22
WindSpeed	1.0235	26
Chloride mg/L	1.0168	25
Hardness Total, mg/L as Ca	0.9993	25
TOC, mg/L	0.9985	26
Initial Chrysophyta	0.9977	26
Nitrite/Nitrate	0.9933	26
Pompton streamflow	0.9924	27
JAPS	0.9609	27

1-week Prediction Period

Color, Cu	6.2532	2
Initial Cyanophyta	5.7964	2
Turbidity NTU	5.6590	2
Total Count, cells/ml	2.7408	9
PointRes	2.4599	11
pH	1.8964	10
Ammonia mg/L	1.7299	9
DO, mg/L	1.6813	14
BOD, mg/L	1.6377	13
Total Amorphous Materi	1.5727	11
HeatingDays	1.3532	16
WkPrecip	1.3007	15
PrevPrecip	1.2853	15
Alkalinity mg/L as CaC	1.2836	16
UV254 cm-1	1.2244	17
WindSpeed	1.1849	18
Initial Chrysophyta	1.1795	19
TotalPhosphorus/Orthop	1.1733	17
Sulfate mg/L	1.1678	15
Temp 0C	1.1507	21
Passaic extraction	1.1403	22
Hardness Total, mg/L as	1.1298	20
Conductivity umhos/cm	1.1254	19
Odor	1.1141	20
Pompton extraction	1.1133	19
SkyCover	1.0886	21
WindDir	1.0783	21
Pompton streamflow	1.0495	22
Initial Chlorophyta	1.0454	24
Nitrite/Nitrate	1.0402	24
JAPS	1.0088	25
Chloride mg/L	1.0072	25
TOC, mg/L	0.9921	25

Table 6.13. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chrysophyta predictions at Station 100

Real time Prediction

Variable	Ratio	Rank
Initial Chrysophyta	1.1742	12
HeatingDays	1.1433	10
Odor	1.1356	6
Hardness, Total mg/L as Ca(	1.1072	8
TOTAL COUNT, CELLS/M	1.0954	17
Initial Chlorophyta	1.0490	7
Turbidity NTU	1.0372	19
Sulfate, mg/L	1.0348	17
Passaic Streamflow	1.0316	11
pH	1.0295	22
Nitrite/Nitrate	1.0284	12
Pompton Streamflow	1.0263	15
SkyCover	1.0241	15
Alkalinity mg/L as CaCO3	1.0219	13
TOC, mg/L	1.0217	10
BOD, mg/L	1.0191	19
T.Phosphorus/Orthophospha	1.0170	15
WindSpeed	1.0167	18
Ammonia, mg/L	1.0158	20
DO, mg/L	1.0067	20
WkPrecip	1.0066	15
PointRes	1.0060	17
JAPS	1.0057	18
USGS Pompton	1.0047	21
Conductivity, umhos/cm	1.0046	21
UV-254, cm-1	1.0046	23
Temp (0C)	1.0045	21
PrevPrecip	1.0040	15
WindDir	1.0034	19
Chloride, mg/L	1.0005	24
Initial Cyanophyta	0.9987	21
TSS, mg/L	0.9986	14

1-week Prediction Period

Variable	Ratio	Rank
Initial Chrysophyta	1.1004	5
Odor	1.0998	7
TOTAL COUNT, CELLS/M	1.0951	7
Passaic Streamflow	1.0629	11
HeatingDays	1.0590	9
BOD, mg/L	1.0539	8
Temp (0C)	1.0412	9
Hardness, Total mg/L as Ca(	1.0409	12
Pompton Streamflow	1.0306	13
Initial Chlorophyta	1.0285	10
Turbidity NTU	1.0251	11
WindSpeed	1.0220	10
Nitrite/Nitrate	1.0204	16
USGS Pompton	1.0195	14
Chloride, mg/L	1.0133	16
WkPrecip	1.0127	16
TOC, mg/L	1.0122	17
T.Phosphorus/Orthophospha	1.0117	16
Initial Cyanophyta	1.0105	18
PointRes	1.0083	17
Sulfate, mg/L	1.0064	22
Conductivity, umhos/cm	1.0064	20
PrevPrecip	1.0063	20
SkyCover	1.0049	23
TSS, mg/L	1.0043	23
UV-254, cm-1	1.0042	19
Ammonia, mg/L	1.0041	21
DO, mg/L	1.0006	23
Alkalinity mg/L as CaCO3	1.0004	24
JAPS	0.9996	22
pH	0.9953	25
WindDir	0.9933	26

2-week Prediction Period

Variable	Ratio	Rank
Temp (0C)	1.1997	6
HeatingDays	1.1393	6
Hardness, Total mg/L as	1.1224	9
Pompton Streamflow	1.1199	9
Initial Chrysophyta	1.1194	9
Passaic Streamflow	1.0770	8
Odor	1.0759	7
WindSpeed	1.0462	11
Ammonia, mg/L	1.0380	19
Initial Chlorophyta	1.0288	10
Conductivity, umhos/cm	1.0247	14
PrevPrecip	1.0159	15
DO, mg/L	1.0157	16
TOC, mg/L	1.0141	14
pH	1.0137	14
Nitrite/Nitrate	1.0108	15
SkyCover	1.0104	22
TSS, mg/L	1.0090	16
Sulfate, mg/L	1.0078	16
T.Phosphorus/Orthophos	1.0074	16
WindDir	1.0072	14
WkPrecip	1.0056	18
Alkalinity mg/L as CaC(	1.0013	18
TOTAL COUNT, CELL	1.0005	19
PointRes	1.0001	19
Initial Cyanophyta	0.9968	25
JAPS	0.9967	26
BOD, mg/L	0.9951	23
Chloride, mg/L	0.9905	24
UV-254, cm-1	0.9892	21
USGS Pompton	0.9883	22
Turbidity NTU	0.9476	30

Table 6.14. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chrysophyta predictions at Station 101

Real time Prediction

Variable	Ratio	Rank
Total Amorphous Material	1.1553	2
T.Phosphorus/Orthophospha	1.0779	9
Odor	1.0718	13
Temp 0C	1.0677	12
Initial Chrysophyta	1.0675	9
Color, Cu	1.0661	13
Passaic WSPS	1.0557	13
Sulfate mg/L	1.0482	11
Nitrite/Nitrate	1.0461	14
Conductivity umhos/cm	1.0427	12
pH	1.0411	15
BOD, mg/L	1.0403	18
SkyCover	1.0402	16
Total Count, cells/ml	1.0394	16
TOC, mg/L	1.0354	13
WkPrecip	1.0342	15
WindDir	1.0335	14
USGSPompton	1.0288	20
Ammonia mg/L	1.0282	20
Pompton WSPSQ	1.0234	15
HeatingDays	1.0234	20
Alkalinity mg/L as CaCO3	1.0221	18
PrevPrecip	1.0200	17
WindSpeed	1.0197	18
UV254 cm-1	1.0118	21
JAPS	1.0098	21
Initial Chlorophyta	1.0088	20
Initial Cyanophyta	1.0084	21
Turbidity NTU	1.0061	24
PointResPVR	1.0052	23
DO, mg/L	1.0015	25
Hardness Total, mg/L as Ca(	0.9978	20
Chloride mg/L	0.9918	27

1-week Prediction Period

Variable	Ratio	Rank
Initial Chrysophyta	1.1363	5
Odor	1.1063	9
Turbidity NTU	1.0966	10
T.Phosphorus/Orthophospha	1.0841	16
Total Amorphous Material	1.0814	12
Ammonia mg/L	1.0506	12
Nitrite/Nitrate	1.0505	16
TOC, mg/L	1.0472	12
Chloride mg/L	1.0471	16
HeatingDays	1.0441	12
Hardness Total, mg/L as Ca(	1.0433	15
BOD, mg/L	1.0427	14
JAPS	1.0412	14
Pompton WSPSQ	1.0372	16
Initial Chlorophyta	1.0364	15
WkPrecip	1.0342	15
Color, Cu	1.0307	17
Total Count, cells/ml	1.0262	18
Conductivity umhos/cm	1.0246	21
Passaic WSPS	1.0215	18
Alkalinity mg/L as CaCO3	1.0198	20
WindSpeed	1.0197	18
pH	1.0171	20
Temp 0C	1.0151	19
USGSPompton	1.0094	22
DO, mg/L	1.0077	21
UV254 cm-1	1.0043	21
Initial Cyanophyta	1.0043	22
SkyCover	1.0025	24
PrevPrecip	1.0022	22
Sulfate mg/L	1.0012	20
PointResPVR	0.9773	25
WindDir	0.8601	17

2-week Prediction Period

Variable	Ratio	Rank
Total Amorphous Materi	1.2020	7
Initial Cyanophyta	1.1044	10
Odor	1.0649	8
WkPrecip	1.0567	12
Initial Chrysophyta	1.0500	7
Color, Cu	1.0489	13
TOC, mg/L	1.0454	8
pH	1.0254	11
Alkalinity mg/L as CaC(	1.0252	14
UV254 cm-1	1.0205	15
Chloride mg/L	1.0181	15
Turbidity NTU	1.0174	22
Initial Chlorophyta	1.0166	17
JAPS	1.0163	16
T.Phosphorus/Orthophos	1.0138	18
HeatingDays	1.0135	17
Ammonia mg/L	1.0124	15
Passaic WSPS	1.0121	17
BOD, mg/L	1.0115	17
WindDir	1.0111	21
SkyCover	1.0100	16
Nitrite/Nitrate	1.0093	19
Total Count, cells/ml	1.0061	20
PrevPrecip	1.0057	20
Temp 0C	1.0055	20
Conductivity umhos/cm	1.0036	16
Sulfate mg/L	1.0005	20
USGSPompton	0.9994	19
PointResPVR	0.9991	22
WindSpeed	0.9988	23
Pompton WSPSQ	0.9983	23
DO, mg/L	0.9954	22
Hardness Total, mg/L as	0.9917	22

Table 6.15. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chrysophyta predictions at Station 612

Real time Prediction

Variable	Ratio	Rank
Total Amorphous Material	1.4099	3
Pompton Streamflow	1.3081	3
UV254 cm-1	1.2262	5
Odor	1.1729	3
WkPrecip	1.1426	6
Total Count, cells/ml	1.0708	12
HeatingDays	1.0598	16
Alkalinity mg/L as CaCO3	1.0590	13
WindSpeed	1.0450	16
Hardness Total, mg/L as Ca(	1.0437	14
Temp 0C	1.0426	11
Sulfate mg/L	1.0422	13
pH	1.0307	16
Conductivity umhos/cm	1.0274	15
Ammonia mg/L	1.0257	15
DO, mg/L	1.0235	18
BOD, mg/L	1.0221	19
PrevPrecip	1.0199	18
WindDir	1.0173	17
Initial Chlorophyta	1.0153	16
Turbidity NTU	1.0136	23
USGSPompton	1.0123	22
TOC, mg/L	1.0115	19
SkyCover	1.0112	22
Chloride mg/L	1.0100	20
Passaic Streamflow	1.0085	21
Initial Cyanophyta	1.0072	21
JAPS	1.0041	22
Color, Cu	1.0039	24
PointRes	0.9994	23
TotalPhosphorus/Orthophos	0.9977	23
Nitrite/Nitrate	0.9887	27
Initial Chrysophyta	0.9772	21

1-week Prediction Period

Variable	Ratio	Rank
Initial Chrysophyta	1.3212	2
Total Count, cells/ml	1.1051	7
Total Amorphous Material	1.0995	5
Color, Cu	1.0814	8
UV254 cm-1	1.0797	10
Passaic Streamflow	1.0634	9
pH	1.0581	14
Alkalinity mg/L as CaCO3	1.0551	13
Initial Chlorophyta	1.0480	9
Hardness Total, mg/L as Ca(	1.0476	13
Temp 0C	1.0443	14
HeatingDays	1.0418	15
JAPS	1.0389	17
Initial Cyanophyta	1.0314	14
DO, mg/L	1.0291	15
Odor	1.0274	16
Pompton Streamflow	1.0270	15
Ammonia mg/L	1.0233	16
WkPrecip	1.0229	17
WindSpeed	1.0197	20
USGSPompton	1.0175	20
PointRes	1.0140	21
Nitrite/Nitrate	1.0136	22
Conductivity umhos/cm	1.0085	18
Turbidity NTU	1.0072	20
TotalPhosphorus/Orthophos	1.0057	23
BOD, mg/L	1.0055	22
PrevPrecip	1.0046	23
Chloride mg/L	1.0015	24
Sulfate mg/L	1.0009	22
SkyCover	0.9948	24
TOC, mg/L	0.9934	26
WindDir	0.9904	23

2-week Prediction Period

Variable	Ratio	Rank
Initial Chrysophyta	1.6463	1
Total Amorphous Materi	1.1722	8
Odor	1.1161	8
Total Count, cells/ml	1.1023	6
Nitrite/Nitrate	1.0787	15
Pompton Streamflow	1.0785	12
HeatingDays	1.0590	14
UV254 cm-1	1.0462	13
Turbidity NTU	1.0374	14
USGSPompton	1.0371	20
Alkalinity mg/L as CaC(	1.0356	17
Hardness Total, mg/L as	1.0310	15
SkyCover	1.0309	15
WkPrecip	1.0303	16
Initial Cyanophyta	1.0300	14
Passaic Streamflow	1.0156	15
Ammonia mg/L	1.0153	18
pH	1.0133	18
DO, mg/L	1.0131	19
Temp 0C	1.0127	16
PointRes	1.0119	17
Initial Chlorophyta	1.0105	19
WindSpeed	1.0081	21
JAPS	1.0057	19
TOC, mg/L	1.0038	22
Conductivity umhos/cm	1.0037	22
Color, Cu	1.0033	21
BOD, mg/L	1.0031	20
WindDir	1.0026	20
Chloride mg/L	0.9903	20
PrevPrecip	0.9814	25
Sulfate mg/L	0.9679	18
TotalPhosphorus/Orthop	0.9421	24

Table 6.16. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chlorophyta predictions at Station 100

Real time Prediction

Variable	Ratio	Rank
Initial Chlorophyta	1.3629	2
Odor	1.2959	3
TOTAL COUNT, CELLS/M	1.1581	12
HeatingDays	1.1539	8
Nitrite/Nitrate	1.1483	8
Pompton Streamflow	1.1464	9
WkPrecip	1.1392	14
Hardness, Total mg/L as Ca(	1.1335	11
BOD, mg/L	1.0868	11
Sulfate, mg/L	1.0782	13
TSS, mg/L	1.0775	14
Passaic Streamflow	1.0611	12
Initial Chrysophyta	1.0487	13
Temp (0C)	1.0465	16
DO, mg/L	1.0356	19
SkyCover	1.0347	16
Alkalinity mg/L as CaCO3	1.0332	19
Conductivity, umhos/cm	1.0313	16
Initial Cyanophyta	1.0241	19
Chloride, mg/L	1.0235	18
WindSpeed	1.0186	20
TOC, mg/L	1.0185	15
UV-254, cm-1	1.0119	21
Ammonia, mg/L	1.0116	19
pH	1.0105	22
Turbidity NTU	1.0066	21
T.Phosphorus/Orthophospha	1.0065	21
USGS Pompton	1.0063	22
JAPS	1.0047	24
PrevPrecip	1.0019	20
PointRes	1.0000	27
WindDir	0.9926	26

1-week Prediction Period

Variable	Ratio	Rank
Initial Chlorophyta	1.3348	1
Odor	1.2142	3
TOTAL COUNT, CELLS/M	1.1914	11
HeatingDays	1.1387	8
Nitrite/Nitrate	1.1046	5
Pompton Streamflow	1.0943	5
WkPrecip	1.0781	13
Temp (0C)	1.0583	12
Chloride, mg/L	1.0438	18
SkyCover	1.0369	18
WindDir	1.0280	14
TOC, mg/L	1.0250	13
TSS, mg/L	1.0213	15
T.Phosphorus/Orthophospha	1.0210	19
Sulfate, mg/L	1.0202	17
USGS Pompton	1.0179	17
Hardness, Total mg/L as Ca(	1.0178	20
BOD, mg/L	1.0173	20
pH	1.0129	22
PrevPrecip	1.0095	18
Ammonia, mg/L	1.0078	22
Passaic Streamflow	1.0077	17
PointRes	1.0059	19
DO, mg/L	1.0053	23
Turbidity NTU	1.0046	21
WindSpeed	1.0040	20
Initial Cyanophyta	1.0026	17
UV-254, cm-1	1.0010	19
JAPS	1.0007	21
Alkalinity mg/L as CaCO3	0.9981	22
Initial Chrysophyta	0.9978	21
Conductivity, umhos/cm	0.9947	23

2-week Prediction Period

Variable	Ratio	Rank
Odor	1.1991	2
Pompton Streamflow	1.1277	3
TSS, mg/L	1.0874	5
Nitrite/Nitrate	1.0797	8
HeatingDays	1.0787	5
Initial Chlorophyta	1.0648	8
WindDir	1.0633	9
Hardness, Total mg/L as	1.0428	13
Passaic Streamflow	1.0364	19
BOD, mg/L	1.0265	14
SkyCover	1.0234	17
PrevPrecip	1.0217	15
Turbidity NTU	1.0189	16
USGS Pompton	1.0170	16
Alkalinity mg/L as CaC(	1.0161	20
WkPrecip	1.0154	16
DO, mg/L	1.0152	19
Initial Cyanophyta	1.0149	18
Temp (0C)	1.0145	19
TOC, mg/L	1.0125	21
Sulfate, mg/L	1.0123	19
Conductivity, umhos/cm	1.0120	20
Chloride, mg/L	1.0084	20
TOTAL COUNT, CELL	1.0075	21
pH	1.0075	23
PointRes	1.0057	19
WindSpeed	1.0043	19
T.Phosphorus/Orthophos	1.0031	22
Initial Chrysophyta	1.0000	21
UV-254, cm-1	0.9982	21
JAPS	0.9934	25
Ammonia, mg/L	0.9890	19

Table 6.17. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chlorophyta predictions at Station 101

Real time Prediction

Variable	Ratio	Rank
PointResPVR	1.6249	5
Initial Cyanophyta	1.2834	11
Total Count, cells/ml	1.2717	4
Initial Chlorophyta	1.2714	3
Total Amorphous Material	1.2374	9
HeatingDays	1.0819	17
SkyCover	1.0740	14
UV254 cm-1	1.0642	13
Odor	1.0487	16
DO, mg/L	1.0317	16
TOC, mg/L	1.0312	9
Color, Cu	1.0283	16
Conductivity umhos/cm	1.0269	13
Temp 0C	1.0260	17
Hardness Total, mg/L as Ca(	1.0253	13
WindDir	1.0202	14
pH	1.0175	18
Alkalinity mg/L as CaCO3	1.0159	19
PrevPrecip	1.0135	15
Chloride mg/L	1.0091	18
WkPrecip	1.0067	22
Nitrite/Nitrate	1.0067	17
BOD, mg/L	1.0052	21
Initial Chrysophyta	1.0047	20
Passaic WSPS	1.0040	22
Sulfate mg/L	1.0034	20
Ammonia mg/L	1.0010	20
Turbidity NTU	0.9998	22
WindSpeed	0.9997	22
JAPS	0.9980	24
Pompton WSPSQ	0.9956	26
USGSPompton	0.9955	23
T.Phosphorus/Orthophospha	0.9935	21

1-week Prediction Period

Variable	Ratio	Rank
Total Amorphous Material	1.2324	1
Initial Chlorophyta	1.1230	5
Initial Cyanophyta	1.1114	15
T.Phosphorus/Orthophospha	1.0509	15
Total Count, cells/ml	1.0508	15
Odor	1.0443	7
SkyCover	1.0360	15
HeatingDays	1.0345	14
Temp 0C	1.0318	12
WkPrecip	1.0262	12
PointResPVR	1.0255	12
BOD, mg/L	1.0252	12
Hardness Total, mg/L as Ca(	1.0241	17
pH	1.0236	18
JAPS	1.0233	17
USGSPompton	1.0225	13
Passaic WSPS	1.0210	17
Sulfate mg/L	1.0179	17
Nitrite/Nitrate	1.0156	16
Turbidity NTU	1.0139	18
Initial Chrysophyta	1.0136	20
Ammonia mg/L	1.0133	17
TOC, mg/L	1.0078	22
UV254 cm-1	1.0078	20
WindDir	1.0066	22
Pompton WSPSQ	1.0059	21
PrevPrecip	1.0057	24
Alkalinity mg/L as CaCO3	1.0054	21
Chloride mg/L	1.0032	22
Conductivity umhos/cm	1.0020	23
DO, mg/L	1.0000	20
WindSpeed	0.9976	25
Color, Cu	0.9968	22

2-week Prediction Period

Variable	Ratio	Rank
Initial Chlorophyta	1.5787	3
PointResPVR	1.5165	2
Total Amorphous Materi	1.1926	3
BOD, mg/L	1.1364	4
Total Count, cells/ml	1.0609	13
Color, Cu	1.0490	12
TOC, mg/L	1.0434	19
Odor	1.0424	15
Temp 0C	1.0420	16
Sulfate mg/L	1.0415	12
Initial Cyanophyta	1.0402	12
Nitrite/Nitrate	1.0398	14
Pompton WSPSQ	1.0388	12
Turbidity NTU	1.0346	17
Hardness Total, mg/L as	1.0238	16
Conductivity umhos/cm	1.0189	20
UV254 cm-1	1.0160	19
SkyCover	1.0154	16
Ammonia mg/L	1.0144	19
HeatingDays	1.0144	17
Passaic WSPS	1.0126	18
DO, mg/L	1.0122	20
WkPrecip	1.0121	20
JAPS	1.0020	21
Initial Chrysophyta	1.0012	21
PrevPrecip	0.9993	20
Alkalinity mg/L as CaC(	0.9982	20
WindSpeed	0.9970	23
Chloride mg/L	0.9945	21
T.Phosphorus/Orthophos	0.9920	25
pH	0.9903	25
WindDir	0.9899	23
USGSPompton	0.9606	23

Table 6.18. Average Parameter Ratio values and Rankings from Sensitivity Analysis for Chlorophyta predictions at Station 612

Real time Prediction

Variable	Ratio	Rank
Alkalinity mg/L as CaCO3	1.4280	12
Total Amorphous Material	1.2381	8
Odor	1.1921	4
HeatingDays	1.1475	7
Hardness Total, mg/L as Ca(	1.1387	13
UV254 cm-1	1.1244	10
Turbidity NTU	1.0875	15
Initial Chlorophyta	1.0829	9
WkPrecip	1.0618	10
Ammonia mg/L	1.0583	18
Sulfate mg/L	1.0557	10
Temp 0C	1.0552	15
DO, mg/L	1.0537	14
Color, Cu	1.0444	18
SkyCover	1.0361	14
Conductivity umhos/cm	1.0354	13
Initial Chrysophyta	1.0271	20
WindSpeed	1.0236	16
Pompton Streamflow	1.0207	17
Initial Cyanophyta	1.0128	17
TotalPhosphorus/Orthophosp	1.0104	21
pH	1.0097	22
Total Count, cells/ml	1.0073	21
PointRes	1.0056	23
JAPS	1.0049	24
Passaic Streamflow	1.0036	20
TOC, mg/L	1.0015	20
Chloride mg/L	0.9998	23
WindDir	0.9985	23
PrevPrecip	0.9934	22
BOD, mg/L	0.9922	24
Nitrite/Nitrate	0.9860	24
USGSPompton	0.9110	19

1-week Prediction Period

Variable	Ratio	Rank
UV254 cm-1	1.3713	16
Nitrite/Nitrate	1.2836	6
Hardness Total, mg/L as Ca(	1.2419	8
USGSPompton	1.2344	4
Passaic Streamflow	1.2009	14
WkPrecip	1.1676	8
Conductivity umhos/cm	1.1628	11
Initial Chlorophyta	1.1275	17
Total Amorphous Material	1.1106	11
Total Count, cells/ml	1.0905	14
BOD, mg/L	1.0741	12
PrevPrecip	1.0738	16
pH	1.0531	16
SkyCover	1.0420	14
WindSpeed	1.0323	19
Sulfate mg/L	1.0310	18
HeatingDays	1.0296	18
TotalPhosphorus/Orthophosp	1.0216	15
Color, Cu	1.0176	23
Initial Chrysophyta	1.0105	22
Alkalinity mg/L as CaCO3	1.0105	21
TOC, mg/L	1.0078	17
WindDir	1.0062	22
Chloride mg/L	1.0050	19
JAPS	1.0008	18
Ammonia mg/L	0.9927	18
Pompton Streamflow	0.9859	23
DO, mg/L	0.9798	22
Turbidity NTU	0.9760	23
Temp 0C	0.9740	22
Initial Cyanophyta	0.9636	19
PointRes	0.9629	21
Odor	0.9443	20

2-week Prediction Period

Variable	Ratio	Rank
Odor	1.2192	5
DO, mg/L	1.0748	12
Initial Chlorophyta	1.0729	12
WkPrecip	1.0623	10
Total Amorphous Materi	1.0622	13
Ammonia mg/L	1.0573	14
WindDir	1.0566	8
UV254 cm-1	1.0486	8
Temp 0C	1.0420	17
Pompton Streamflow	1.0363	12
Hardness Total, mg/L as	1.0323	18
HeatingDays	1.0303	13
BOD, mg/L	1.0260	15
PrevPrecip	1.0239	15
SkyCover	1.0220	15
Sulfate mg/L	1.0216	19
Color, Cu	1.0211	16
Chloride mg/L	1.0182	14
USGSPompton	1.0180	18
Nitrite/Nitrate	1.0167	19
PointRes	1.0151	17
JAPS	1.0121	17
Passaic Streamflow	1.0098	17
Initial Cyanophyta	1.0085	20
Turbidity NTU	1.0065	21
WindSpeed	1.0053	19
TOC, mg/L	1.0047	20
Total Count, cells/ml	1.0002	19
pH	0.9949	21
Conductivity umhos/cm	0.9923	24
Alkalinity mg/L as CaC(	0.9849	24
TotalPhosphorus/Orthop	0.9648	21
Initial Chrysophyta	0.9635	25

Table 6.19. Statistical Comparison of ANN and LM performance

CYANOBACTERIA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	15.01	41.25	2.82	10.37	32.93	93.2
Real-Time Correlation Coefficient	0.96	0.46	0.97	0.0039	0.93	0.5
One-Week Mean Absolute Error	22.55	50.08	2.25	5.85	11.38	24.19
One-Week Correlation Coefficient	0.94	0.13	0.95	0.35	0.99	0.5
Two-Week Mean Absolute Error	15.48	42.86	4.56	16.8	22.39	43.57
Two-Week Correlation Coefficient	0.96	0.49	0.94	0.42	0.94	0.5

CHRYSOPHYTA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	35.97	66.0471	37.93	38.72	42.15	106.25
Real-Time Correlation Coefficient	0.86	0.2310	0.39	0.65	0.84	0.18
One-Week Mean Absolute Error	42.88	89.9135	31.11	29.40	50.55	44.39
One-Week Correlation Coefficient	0.85	0.1818	0.75	0.48	0.75	0.78
Two-Week Mean Absolute Error	28.64	78.1125	26.52	23.56	20.83	23.33
Two-Week Correlation Coefficient	0.89	0.4744	0.59	0.62	0.73	0.54

CHLOROPHYTA	Station 100		Station 101		Station 612	
	ANN	LM	ANN	LM	ANN	LM
Real-Time Mean Absolute Error	37.47	71.7835	14.28	30.99	27.75	94.34
Real-Time Correlation Coefficient	0.75	0.5899	0.89	0.65	0.76	0.24
One-Week Mean Absolute Error	30.57	40.5150	14.95	33.43	19.89	29.03
One-Week Correlation Coefficient	0.73	0.6825	0.94	0.65	0.91	0.32
Two-Week Mean Absolute Error	30.91	53.5609	25.53	30.02	15.30	20.12
Two-Week Correlation Coefficient	0.75	0.5038	0.81	0.57	0.96	0.61

APPENDIX A-3d

PVWC (INITIAL) ORIGINAL MODELING

ANN Models for combined data from three stations

1. DESCRIPTIVE STATISTICS

Statistics	Real-time Predictions			
	Overall	Training	Selection	Test
Data Mean	29.52	38.22	22.96	18.45
Data S.D.	128.99	169.30	75.57	53.63
Error Mean	3.60	-0.87	-10.94	27.21
Error S.D.	147.57	95.37	70.19	252.02
Abs E. Mean	38.05	34.32	28.94	54.70
S.D. Ratio	1.14	0.56	0.93	4.70
Correlation	0.45	0.84	0.38	0.06

Statistics	One-week ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	30.23	48.70	8.65	14.58
Data S.D.	131.82	179.28	33.17	49.89
Error Mean	3.03	-3.11	16.70	1.72
Error S.D.	84.81	113.86	19.87	45.71
Abs E. Mean	32.09	43.10	20.09	21.91
S.D. Ratio	0.64	0.64	0.60	0.92
Correlation	0.77	0.77	0.83	0.51

Statistics	Two-weeks ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	33.74	59.50	9.40	6.16
Data S.D.	141.18	193.93	35.86	15.81
Error Mean	-1.62	-12.33	9.95	8.39
Error S.D.	66.12	89.14	28.16	16.83
Abs E. Mean	27.21	36.99	19.10	15.59
S.D. Ratio	0.47	0.46	0.79	1.06
Correlation	0.88	0.89	0.62	-0.03

2. CHRYSOPHYTA

Statistics	Real-time Predictions			
	Overall	Training	Selection	Test
Data Mean	78.24	75.16	84.96	77.75
Data S.D.	86.99	86.04	101.41	71.54
Error Mean	0.31	4.88	-11.76	3.13
Error S.D.	66.61	54.44	79.98	72.58
Abs E. Mean	43.74	38.78	43.80	53.72
S.D. Ratio	0.77	0.63	0.79	1.01
Correlation	0.65	0.77	0.62	0.37

Statistics	One-week ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	77.21	75.85	83.61	73.61
Data S.D.	83.73	80.88	104.01	64.10
Error Mean	-3.26	-1.93	-6.30	-2.95
Error S.D.	61.47	51.15	71.97	68.90
Abs E. Mean	38.58	33.72	44.84	42.28
S.D. Ratio	0.73	0.63	0.69	1.07
Correlation	0.69	0.77	0.72	0.45

Statistics	Two- weeks ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	86.60	95.24	77.43	78.10
Data S.D.	106.97	121.53	102.11	73.04
Error Mean	1.21	-2.53	9.04	1.03
Error S.D.	63.55	62.12	52.49	74.82
Abs E. Mean	45.16	43.60	41.06	52.43
S.D. Ratio	0.59	0.51	0.51	1.02
Correlation	0.81	0.86	0.87	0.31

3. CHLOROPHYTA

Statistics	Real-time Predictions			
	Overall	Training	Selection	Test
Data Mean	46.69	42.89	57.72	43.43
Data S.D.	81.31	69.19	96.61	86.30
Error Mean	-3.88	0.60	-1.15	-15.78
Error S.D.	54.46	36.65	62.48	71.74
Abs E. Mean	31.48	23.13	40.69	39.31
S.D. Ratio	0.67	0.53	0.65	0.83
Correlation	0.74	0.85	0.76	0.56

Statistics	One-week ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	46.63	43.47	50.79	48.82
Data S.D.	79.50	68.74	104.94	69.29
Error Mean	-1.77	0.68	-6.96	-1.52
Error S.D.	48.87	29.27	53.38	70.55
Abs E. Mean	28.58	20.55	33.20	40.16
S.D. Ratio	0.61	0.43	0.51	1.02
Correlation	0.80	0.91	0.86	0.57

Statistics	Two-weeks ahead Predictions			
	Overall	Training	Selection	Test
Data Mean	46.99	44.59	44.38	54.49
Data S.D.	77.45	68.42	67.34	100.31
Error Mean	-0.86	-0.07	-0.30	-3.00
Error S.D.	61.73	52.91	47.78	85.93
Abs E. Mean	34.42	30.66	31.90	44.59
S.D. Ratio	0.80	0.77	0.71	0.86
Correlation	0.60	0.63	0.70	0.52

1. CYANOBACTERIA

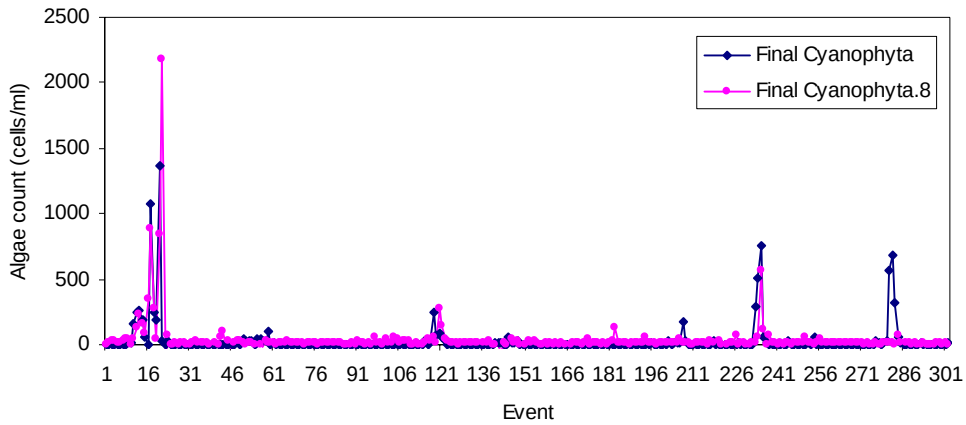

Figure 1.1. Time-series plot of measured cyanobacteria counts from all three stations against ANN real-time predicted values

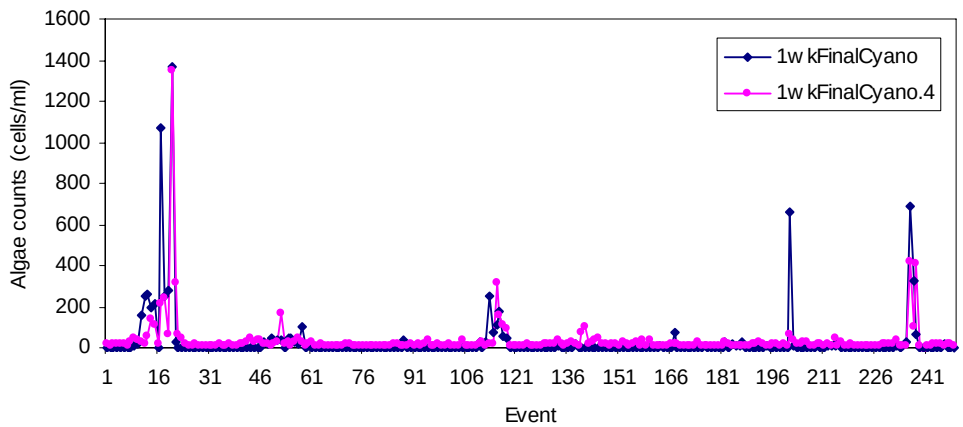

Figure 1.2. Time-series plot of measured cyanobacteria counts from all three stations against ANN one-week ahead predicted values

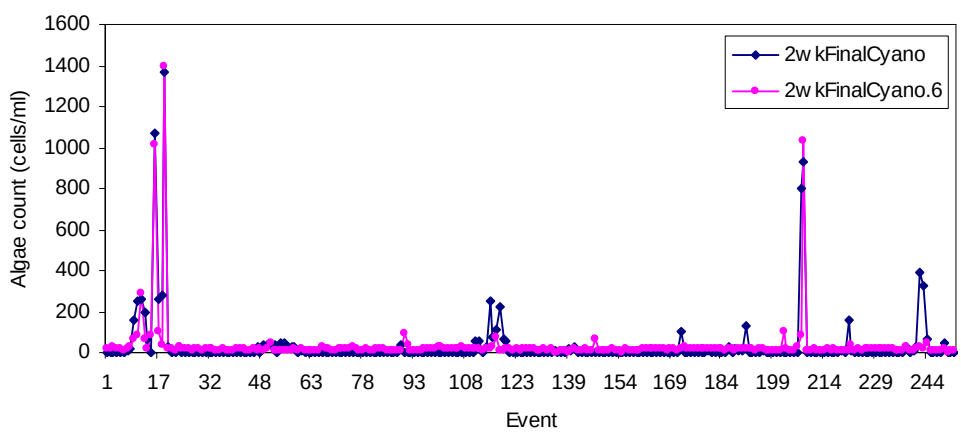

Figure 2.3. Time-series plot of measured cyanobacteria counts from all three stations against ANN two-week ahead predicted values

2. CHRYSOPHYTA

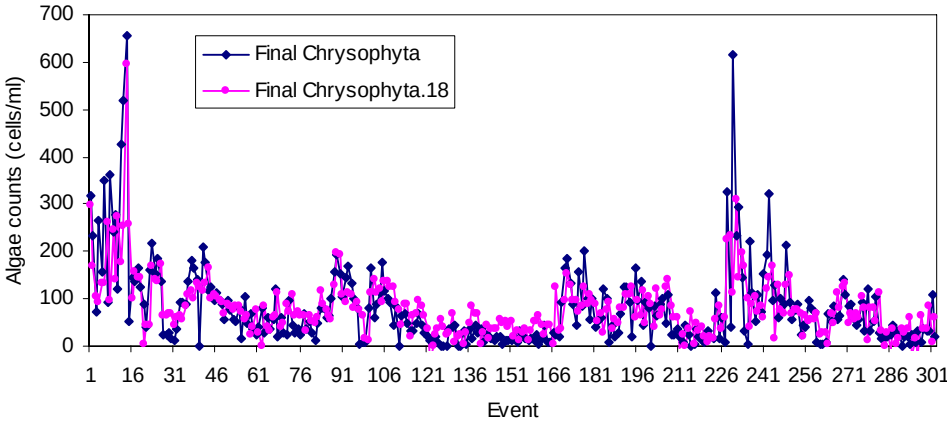

Figure 2.1. Time-series plot of measured chrysophytes counts from all three stations against ANN real-time predicted values

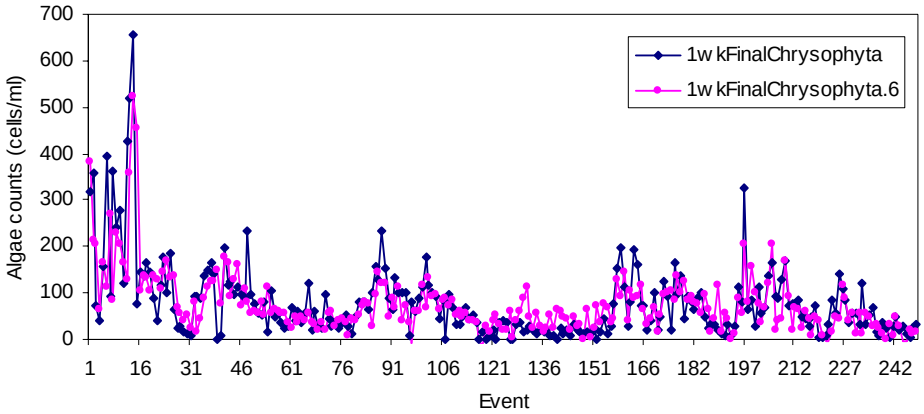

Figure 2.2. Time-series plot of measured chrysophytes counts from all three stations against ANN one-week ahead predicted values

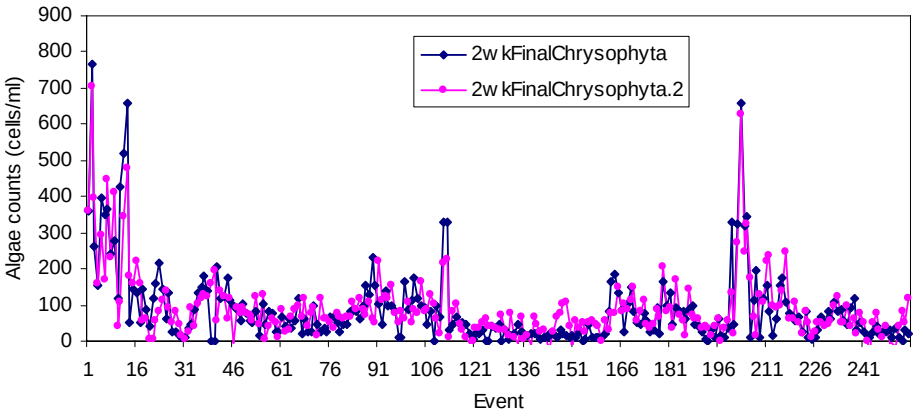

Figure 2.3. Time-series plot of measured chrysophytes counts from all three stations against ANN two-week ahead predicted values

3. CHLOROPHYTA

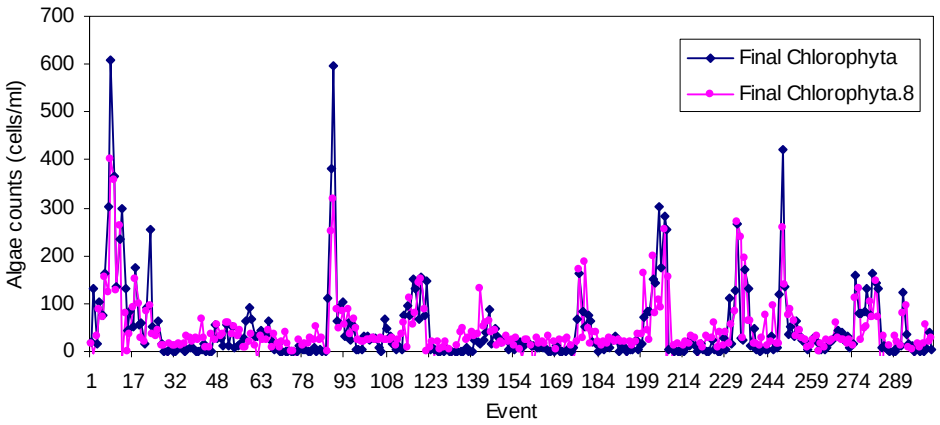

Figure 2.1. Time-series plot of measured chlorophyta counts from all three stations against ANN real-time predicted values

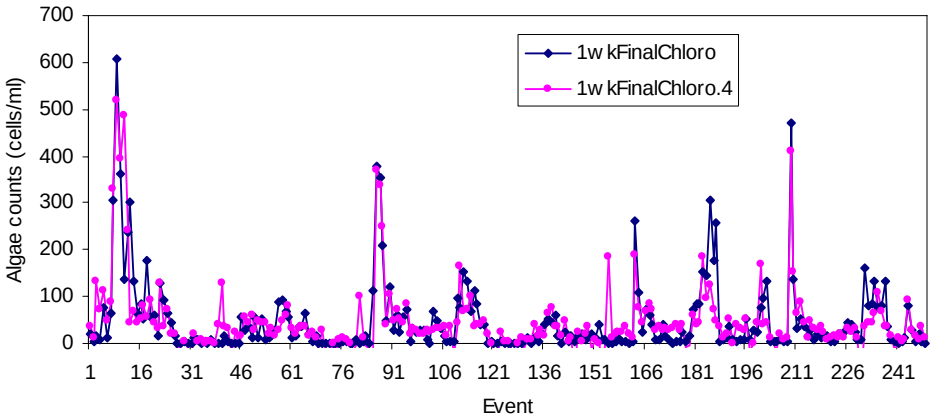

Figure 3.2. Time-series plot of measured chlorophyta counts from all three stations against ANN one-week ahead predicted values

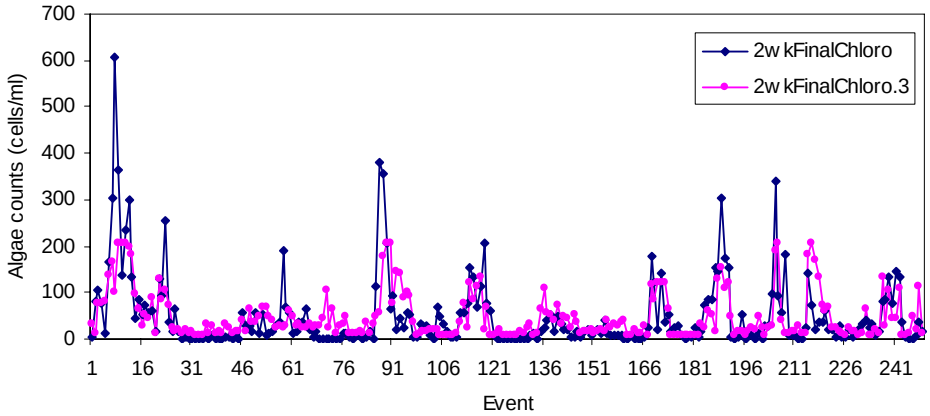

Figure 3.3. Time-series plot of measured chlorophyta counts from all three stations against ANN two-week ahead predicted values

APPENDIX B-1

WATER TREATMENT MODELING
Figures

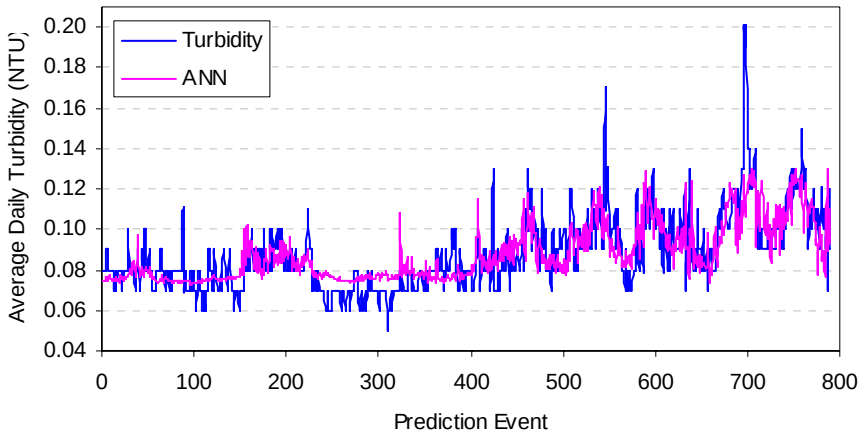

Figure 1.

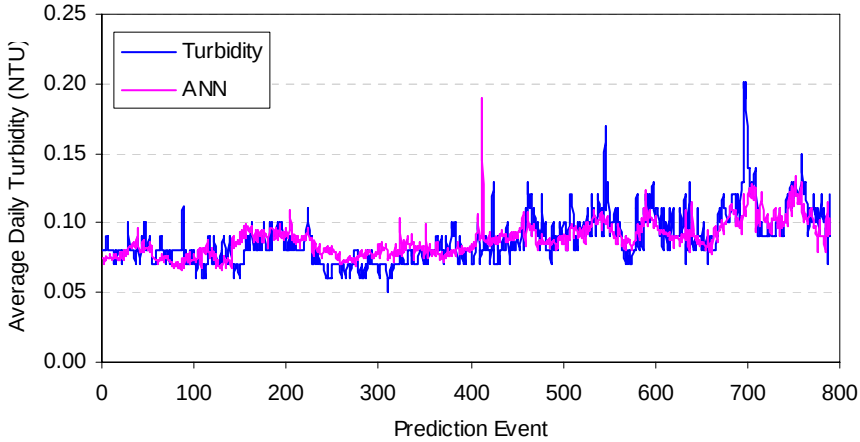

Figure 2.

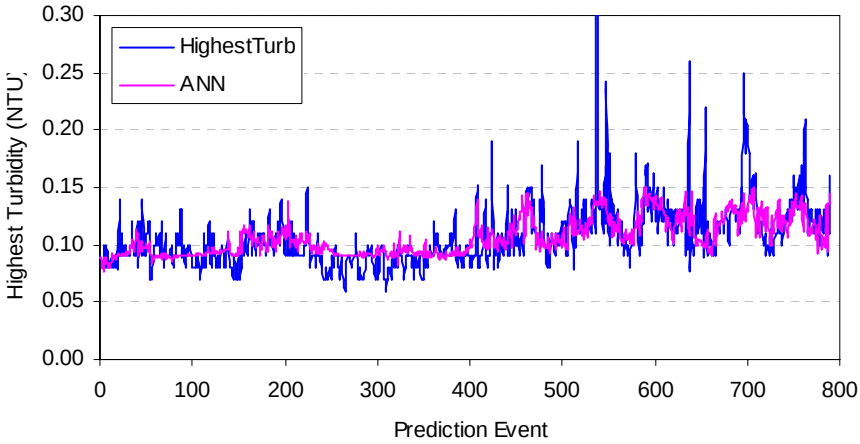

Figure 3.

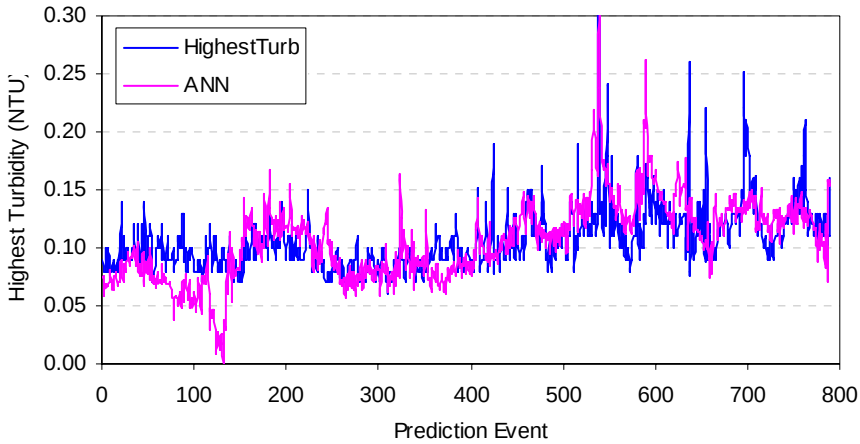

Figure 4.

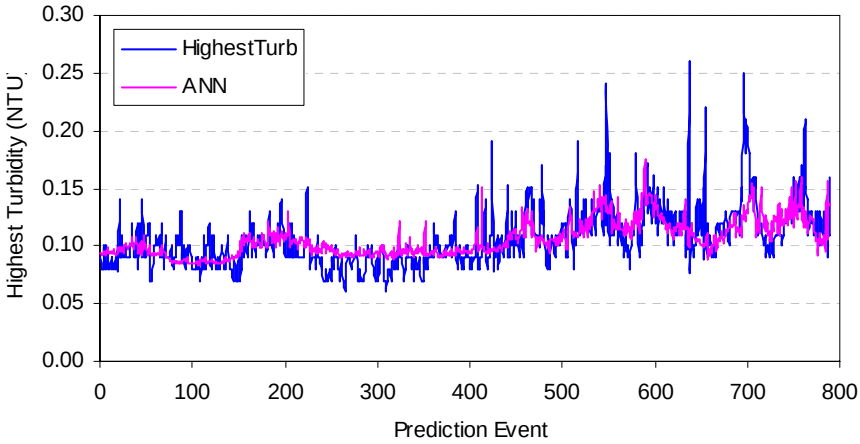

Figure 5.

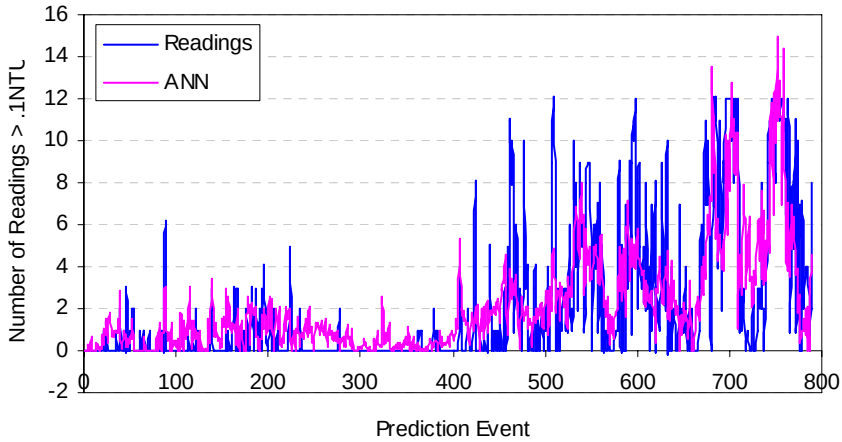

Figure 6.

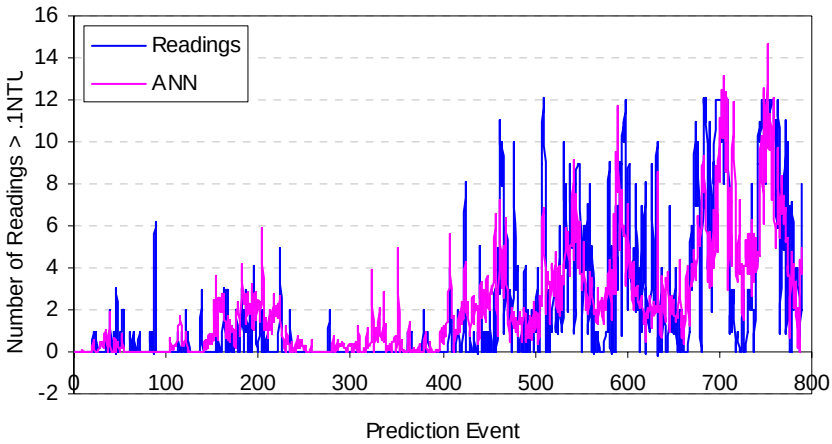

Figure 7. (from worksheet RegResults up to this point)

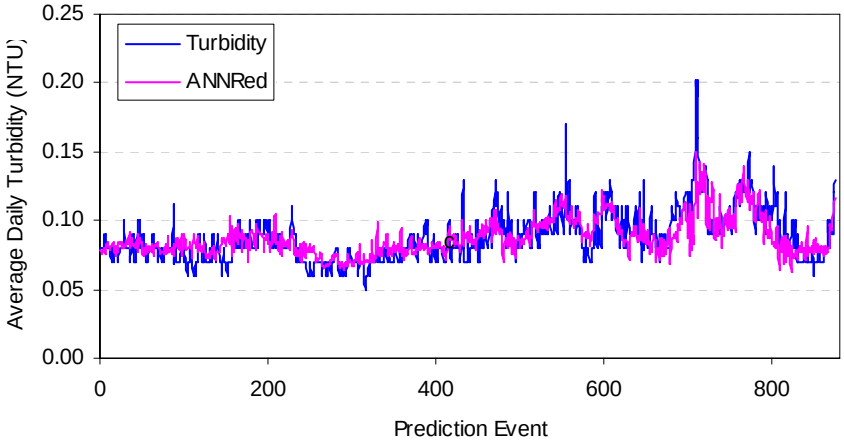

Figure 8. (from worksheet RegResFewer from this point onward)

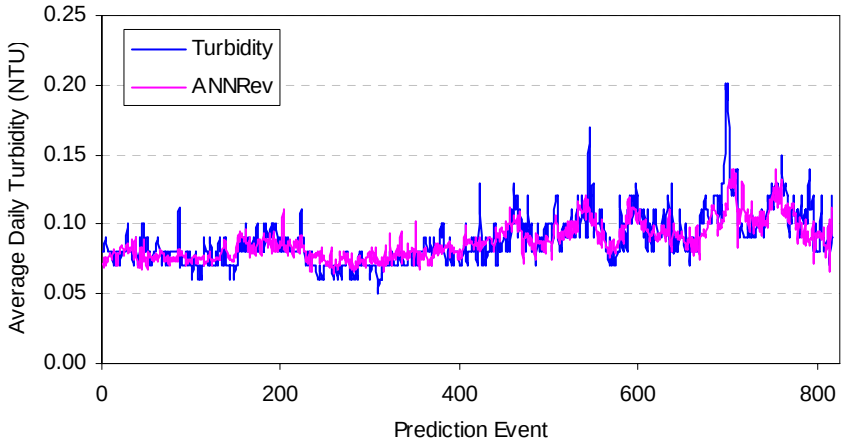

Figure 9.

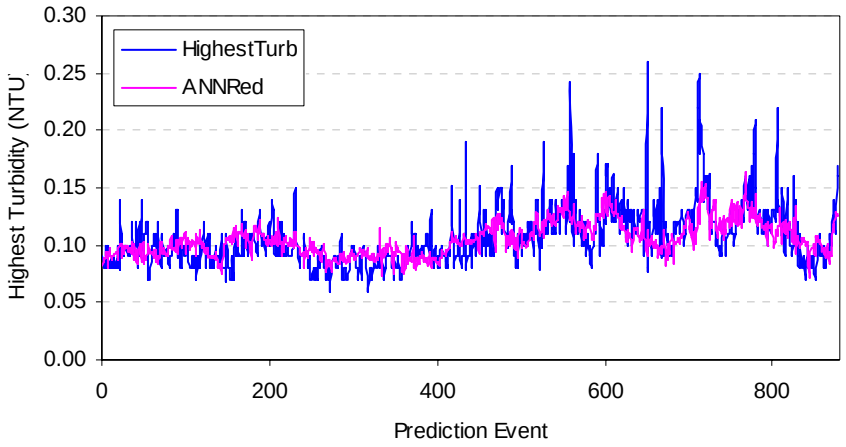

Figure 10.

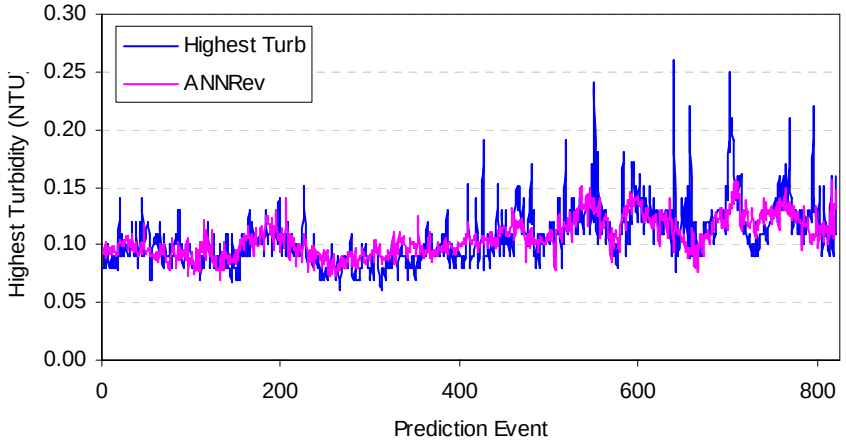

Figure 11.

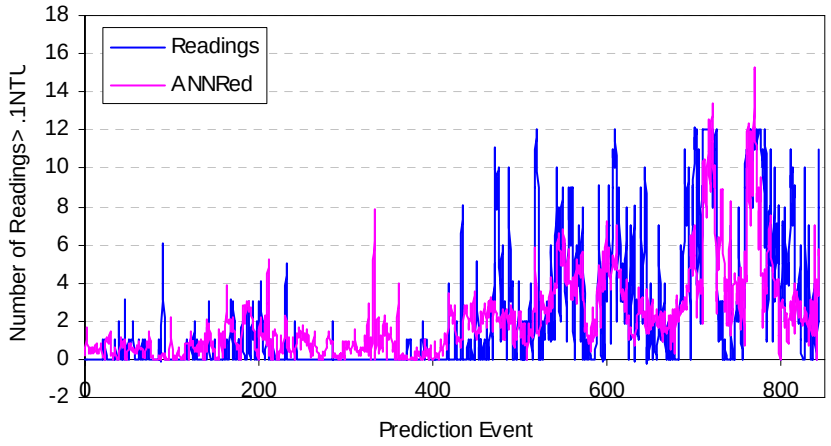

Figure 12.

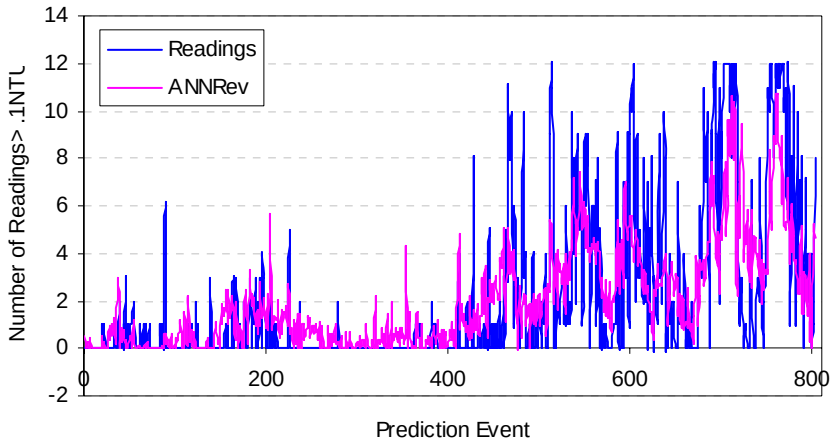

Figure 13. (end of RegResFewer figures)

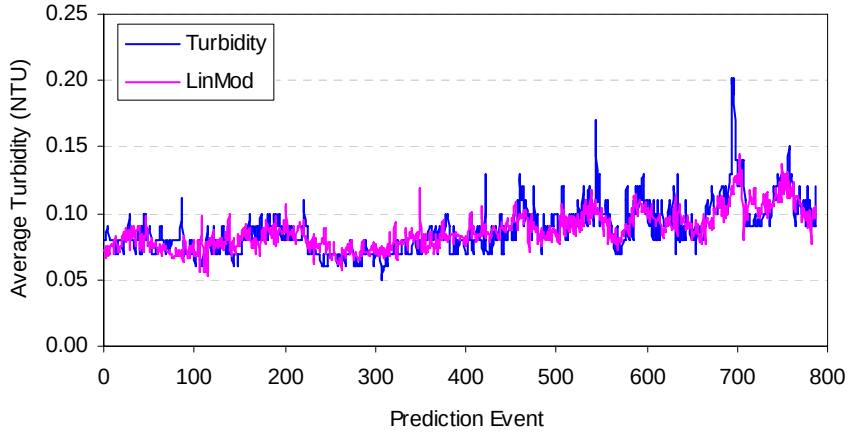

Figure 14. (start of figures from worksheet RegLinMod)

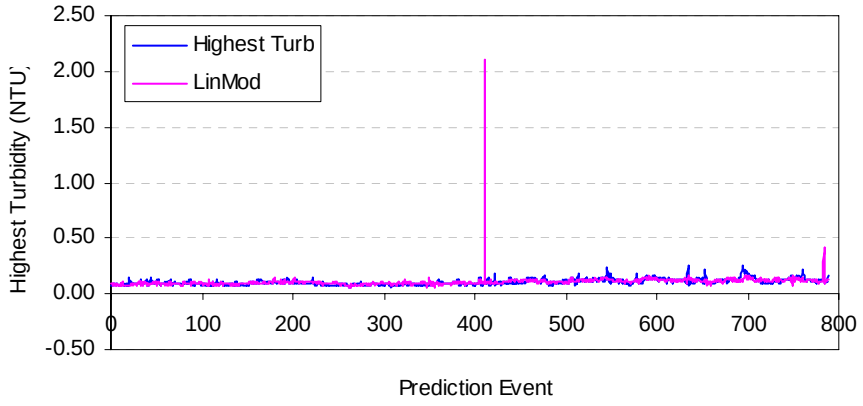

Figure 15.

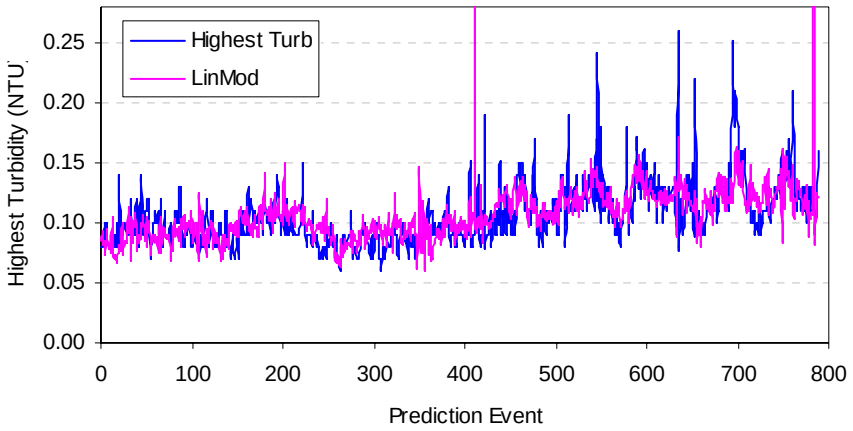

Figure 16.

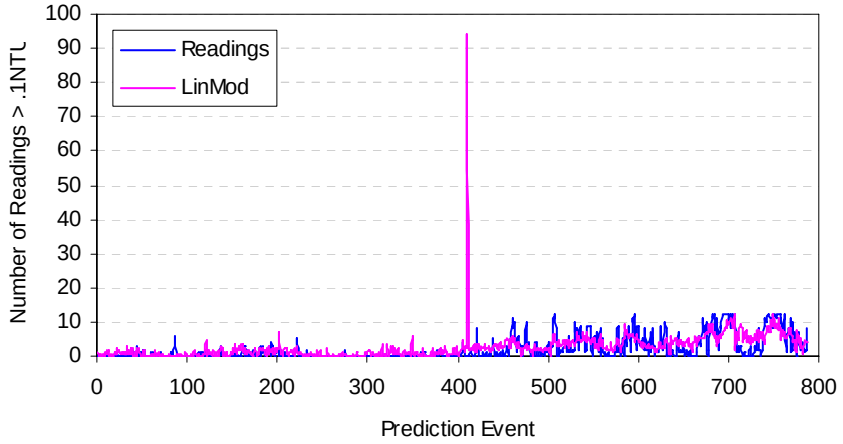

Figure 17.

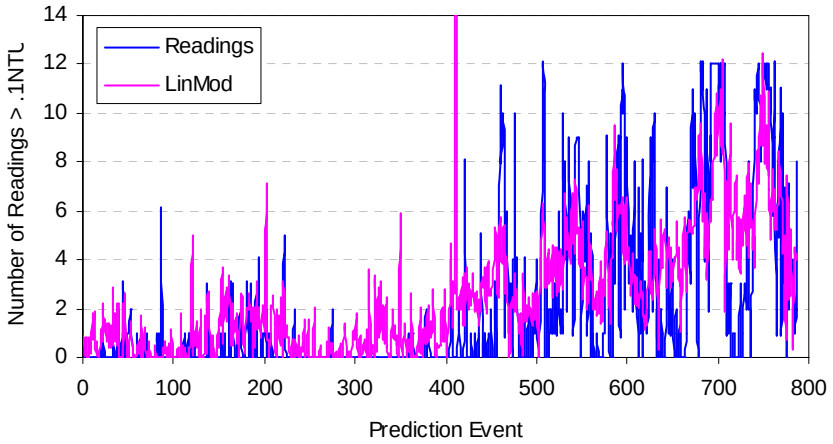

Figure 18. (end of RegLinMod)

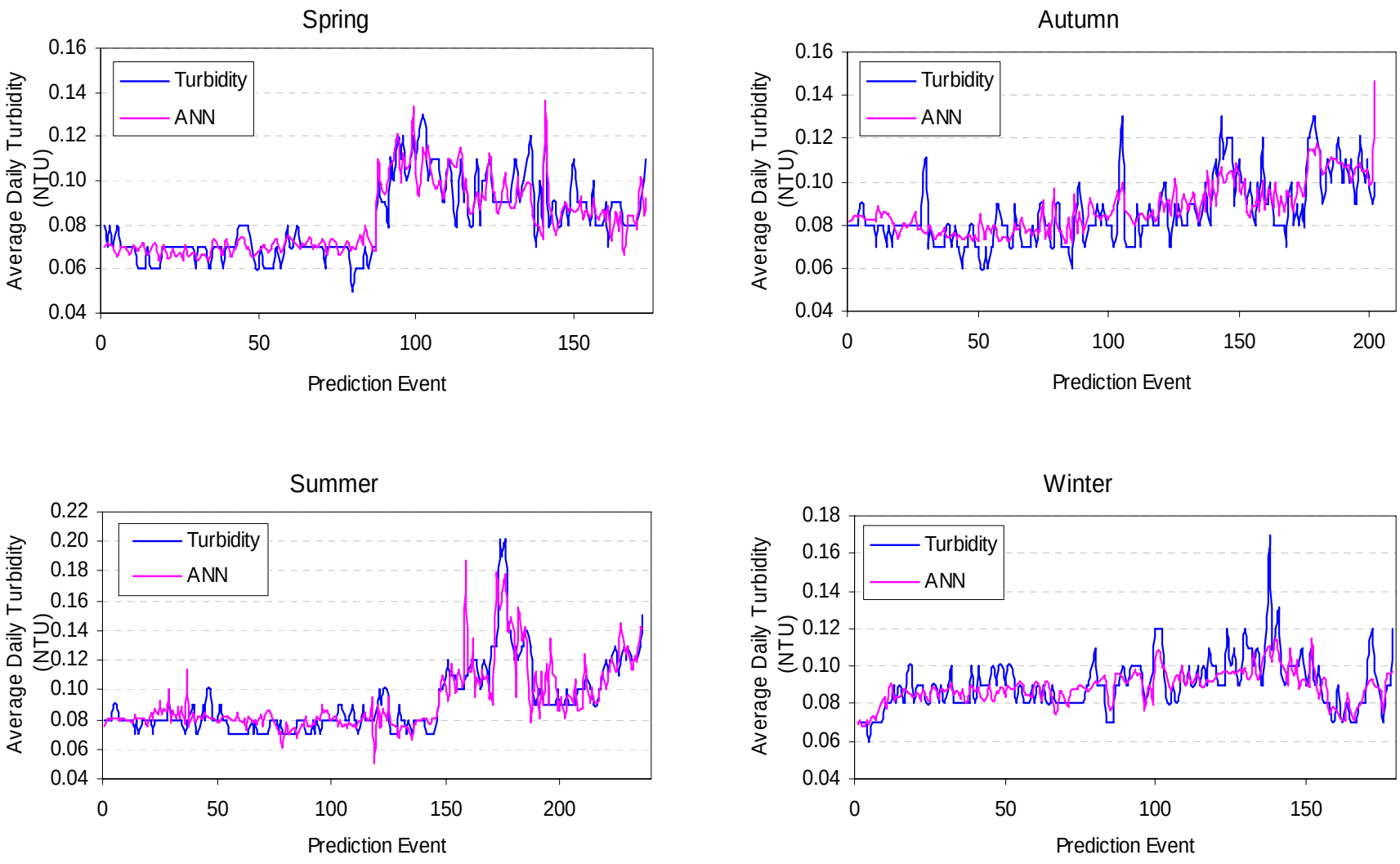

Figure 19. SeasonalRes

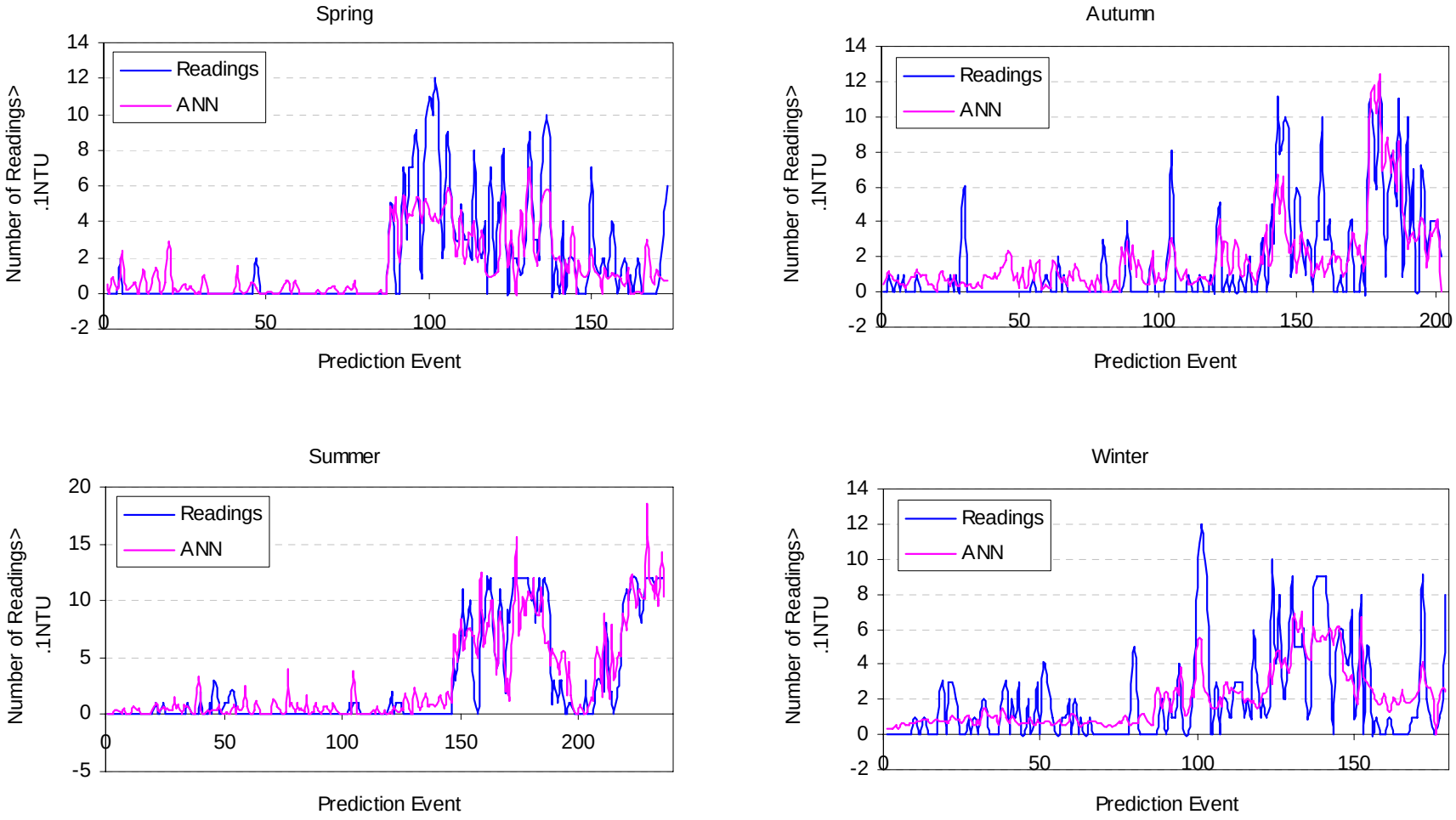

Figure 20. Seasonal

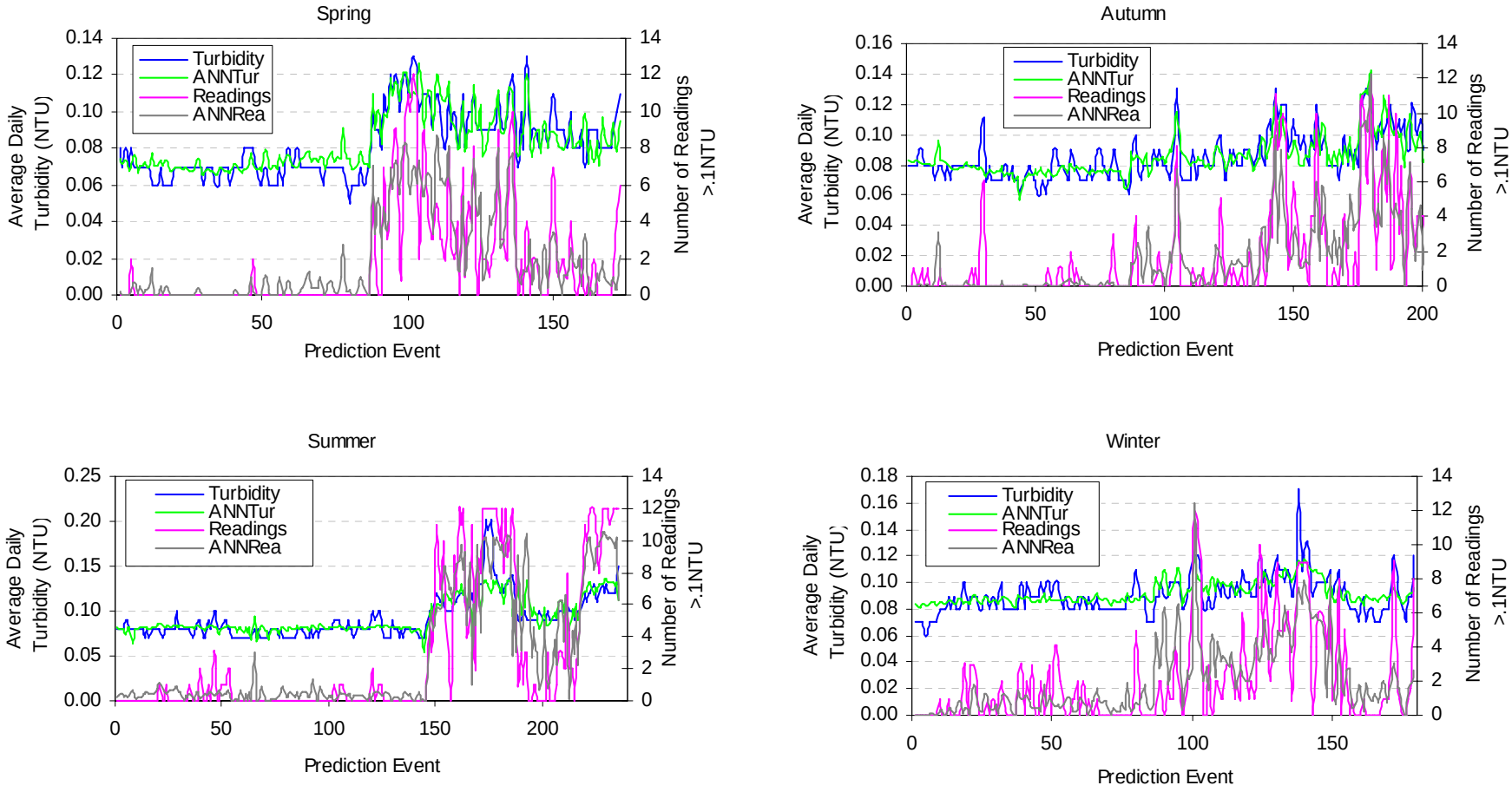

Figure 21. (end of SeasRes)

APPENDIX B-2

WATER TREATMENT MODELING
Sensitivity Analyses Tables

Table 1.

	A				B			
1	Temp Raw °C	Var45	1.087	1	Turbidity Settled NTU	Var35	1.0618	1
2	Turbidity Settled NTU	Var35	1.037	2	Chlorine mix mg/l	Var41	1.0213	2
3	Chlorine mix mg/l	Var41	1.0348	3	Filters Washed/24H	Var3	1.0156	3
4	Chlorine Eff mg/l	Var44	1.0286	4	Chlorine Eff mg/l	Var44	1.0143	4
5	Filters Washed/24H	Var3	1.0206	5	Chlorine PPM/24H	Var24	1.0127	5
6	Temp Eff °C	Var46	1.0203	6	Temp Raw °C	Var45	1.0115	6
7	Chlorine PPM/24H	Var24	1.0164	7	Polyaluminum chloride gals/24H	Var15	1.0114	7
8	Hydryfluosilicic acid PPM/24H	Var26	1.0151	8	Sysdel SR Midd MGD	Var31	1.011	8
9	Fluoride avg.mg/l/24H	Var47	1.0117	9	pH Settled	Var39	1.0106	9
10	Air temp °C min/24H	Var54	1.011	10	Fluoride avg.mg/l/24H	Var47	1.0105	10
11	CW Lowest level/24H	Var51	1.0092	11	Polyaluminum chloride PPM/24H	Var21	1.0087	11
12	Sodium hydroxide gals/24H	Var17	1.0076	12	Sysdel NS Midd MGD	Var33	1.007	12
13	Sysdel NS Midd MGD	Var33	1.0076	13	Chlorine lowest mg/l/24H	Var50	1.0057	13
14	Zinc orthophosphate lbs/24H	Var12	1.0069	14	Sysdel SR Main MGD	Var30	1.0052	14
15	Chlorine CW mg/l	Var43	1.0067	15	Zinc orthophosphate lbs/24H	Var12	1.0052	15
16	pH Settled	Var39	1.0062	16	NaOH PPM/24H	Var23	1.0049	16
17	Sysdel NS Main MGD	Var32	1.0061	17	pH Raw	Var37	1.0048	17
18	Raw MGD/24H	Var1	1.0059	18	Temp Eff °C	Var46	1.004	18
19	Polyaluminum chloride PPM/24H	Var21	1.0058	19	Hydryfluosilicic acid PPM/24H	Var26	1.0037	19
20	Polymer lbs/24H	Var7	1.0047	20	Polyaluminum chloride lbs/24H	Var6	1.003	20
21	System Delivery MGD	Var2	1.0045	21	Turbidity Raw NTU	Var34	1.0027	21
22	Average % solids/liter	Var14	1.0037	22	Average % solids/liter	Var14	1.0027	22
23	Hydrofluosilicic acid lbs/24H	Var11	1.0035	23	Zinc orthophosphate gals/24H	Var19	1.0024	23
24	Zinc orthophosphate PPM/24H	Var27	1.0026	24	Polymer PPM/24H	Var22	1.0024	24
25	pH Raw	Var37	1.0023	25	Sodium hydroxide gals/24H	Var17	1.0023	25
26	Turbidity Raw NTU	Var34	1.002	26	Peak flow eff MGD/24H	Var53	1.002	26
27	NaOH PPM/24H	Var23	1.002	27	Carbon lbs/24H	Var5	1.0017	27
28	Air temp °C max/24H	Var55	1.0015	28	Sodium hydroxide lbs/24H	Var10	1.0014	28
29	Polyaluminum chloride lbs/24H	Var6	1.0014	29	Ferric chloride PPM/24H	Var28	1.0014	29
30	Sodium Chlorite gals/24H	Var20	1.0013	30	Chlorine Settled mg/l	Var42	1.0013	30
31	Hydrofluosilicic acid gals/24H	Var18	1.0012	31	Sodium chlorite lbs/24H	Var9	1.001	31
32	Sodium chlorite lbs/24H	Var9	1.001	32	Sodium Chlorite gals/24H	Var20	1.0009	32
33	Ferric chloride PPM/24H	Var28	1.001	33	Sodium chlorite PPM/24H	Var29	1.0008	33
34	Ferric chloride lbs/24H	Var13	1.0008	34	Hydrofluosilicic acid gals/24H	Var18	1.0007	34
35	Peak flow eff MGD/24H	Var53	1.0008	35	Ferric chloride lbs/24H	Var13	1.0006	35
36	Sodium chlorite PPM/24H	Var29	1.0007	36	Chlorine CW mg/l	Var43	1.0006	36
37	Polyaluminum chloride gals/24H	Var15	1.0006	37	Sysdel NS Main MGD	Var32	1.0004	37
38	Chlorine Settled mg/l	Var42	1.0006	38	Settled readings >2,0 NTU/24H	Var57	1.0003	38
39	Sodium hydroxide lbs/24H	Var10	1.0005	39	Polymer lbs/24H	Var7	1.0003	39
40	Sysdel SR Main MGD	Var30	1.0003	40	Chlorine lbs/24H	Var8	1.0002	40
41	pH Effluent	Var40	1.0001	41	Polymer gals/24H	Var16	1.0001	41
42	Chlorine lbs/24H	Var8	1.0001	42	Carbon PPM/24H	Var25	1.0001	42
43	Sysdel SR Midd MGD	Var31	1	43	CW Lowest level/24H	Var51	1.0001	43
44	Carbon lbs/24H	Var5	1	44	Hydrofluosilicic acid lbs/24H	Var11	1	44
45	Turbidities measured/24H	Var49	1	45	Washwater MGD	Var4	1	45
46	Turbidities required/24H	Var48	1	46	Turbidities required/24H	Var48	1	46
47	NTU over limit	Var36	1	47	NTU over limit	Var36	1	47
48	Washwater MGD	Var4	1	48	Turbidities measured/24H	Var49	1	48
49	pH Mix	Var38	0.9998	49	pH Mix	Var38	1	49
50	Peak flow raw MGD/24H	Var52	0.9998	50	Zinc orthophosphate PPM/24H	Var27	0.9999	50
51	Air temp °C avg/24H	Var56	0.9998	51	Air temp °C min/24H	Var54	0.9998	51
52	Chlorine lowest mg/l/24H	Var50	0.9997	52	Raw MGD/24H	Var1	0.9997	52
53	Zinc orthophosphate gals/24H	Var19	0.9997	53	Air temp °C avg/24H	Var56	0.9994	53
54	Polymer PPM/24H	Var22	0.999	54	Air temp °C max/24H	Var55	0.9993	54
55	Settled readings >2,0 NTU/24H	Var57	0.9983	55	Peak flow raw MGD/24H	Var52	0.9992	55
56	Polymer gals/24H	Var16	0.9976	56	System Delivery MGD	Var2	0.9978	56
57	Carbon PPM/24H	Var25	0.9976	57	pH Effluent	Var40	0.9626	57

Table 2.

	A			B			C		
1	Turbidity Settled NTU	1.003	1	Settled readings >2,0 NTU/24H	1.0079	1	Turbidity Settled NTU	1.0283	1
2	Temp Raw °C	1.0013	2	Turbidity Settled NTU	1.0026	2	pH Raw	1.0151	2
3	Turbidity Raw NTU	1.001	3	Temp Raw °C	1.0012	3	NaOH PPM/24H	1.015	3
4	Air temp °C min/24H	1.0006	4	Turbidity Raw NTU	1.0009	4	Chlorine mix mg/l	1.0129	4
5	Sysdel SR Main MGD	1.0003	5	Temp Eff °C	1.0009	5	Temp Raw °C	1.012	5
6	Chlorine lbs/24H	1.0003	6	Chlorine lbs/24H	1.0004	6	Chlorine PPM/24H	1.0114	6
7	Zinc orthophosphate gals/24H	1.0003	7	Zinc orthophosphate PPM/24H	1.0004	7	Raw MGD/24H	1.0114	7
8	Hydryfluosilicic acid PPM/24H	1.0003	8	Chlorine CW mg/l	1.0003	8	Fluoride avg.mg/l/24H	1.0102	8
9	Fluoride avg.mg/l/24H	1.0002	9	Sysdel SR Main MGD	1.0002	9	Filters Washed/24H	1.007	9
10	Polymer lbs/24H	1.0002	10	Fluoride avg.mg/l/24H	1.0002	10	Polyaluminum chloride PPM/24H	1.007	10
11	Zinc orthophosphate PPM/24H	1.0002	11	Sysdel SR Midd MGD	1.0002	11	Temp Eff °C	1.0065	11
12	Air temp °C avg/24H	1.0001	12	pH Settled	1.0002	12	Sysdel NS Midd MGD	1.0062	12
13	Sysdel NS Main MGD	1.0001	13	Air temp °C min/24H	1.0002	13	Chlorine Eff mg/l	1.0057	13
14	Polymer PPM/24H	1.0001	14	Air temp °C avg/24H	1.0002	14	pH Settled	1.0054	14
15	Hydrofluosilicic acid lbs/24H	1.0001	15	Polymer gals/24H	1.0002	15	Hydryfluosilicic acid PPM/24H	1.0045	15
16	Sodium Chlorite gals/24H	1.0001	16	Air temp °C max/24H	1.0001	16	Polyaluminum chloride lbs/24H	1.0041	16
17	Sodium chlorite lbs/24H	1.0001	17	Polymer lbs/24H	1.0001	17	Sysdel SR Main MGD	1.004	17
18	pH Settled	1	18	Ferric chloride PPM/24H	1.0001	18	Chlorine CW mg/l	1.0035	18
19	Sodium hydroxide lbs/24H	1	19	Zinc orthophosphate gals/24H	1	19	Air temp °C min/24H	1.0025	19
20	Peak flow raw MGD/24H	1	20	Average % solids/liter	1	20	Chlorine lowest mg/l/24H	1.0023	20
21	Peak flow eff MGD/24H	1	21	System Delivery MGD	1	21	Sysdel NS Main MGD	1.002	21
22	System Delivery MGD	1	22	Polymer PPM/24H	1	22	Chlorine Settled mg/l	1.0019	22
23	Zinc orthophosphate lbs/24H	1	23	Sodium hydroxide gals/24H	1	23	Sodium hydroxide gals/24H	1.0016	23
24	Chlorine CW mg/l	1	24	Carbon PPM/24H	1	24	Hydrofluosilicic acid lbs/24H	1.0014	24
25	Sysdel SR Midd MGD	1	25	Zinc orthophosphate lbs/24H	1	25	Sodium chlorite lbs/24H	1.0014	25
26	Filters Washed/24H	1	26	Sodium hydroxide lbs/24H	1	26	Zinc orthophosphate gals/24H	1.0013	26
27	Chlorine Settled mg/l	1	27	Filters Washed/24H	1	27	Peak flow raw MGD/24H	1.001	27
28	pH Effluent	1	28	Peak flow raw MGD/24H	1	28	Sodium hydroxide lbs/24H	1.0007	28
29	CW Lowest level/24H	1	29	Sysdel NS Main MGD	1	29	Peak flow eff MGD/24H	1.0006	29
30	Raw MGD/24H	1	30	Peak flow eff MGD/24H	1	30	Polymer lbs/24H	1.0005	30
31	Hydrofluosilicic acid gals/24H	1	31	Turbidities required/24H	1	31	Average % solids/liter	1.0005	31
32	Turbidities required/24H	1	32	Turbidities measured/24H	1	32	Ferric chloride lbs/24H	1.0005	32
33	NTU over limit	1	33	NTU over limit	1	33	Carbon PPM/24H	1.0005	33
34	Turbidities measured/24H	1	34	Sodium chlorite PPM/24H	1	34	System Delivery MGD	1.0004	34
35	Ferric chloride lbs/24H	1	35	Ferric chloride lbs/24H	1	35	Sodium chlorite PPM/24H	1.0003	35
36	Polyaluminum chloride gals/24H	1	36	Hydrofluosilicic acid gals/24H	1	36	CW Lowest level/24H	1.0002	36
37	Ferric chloride PPM/24H	1	37	Chlorine lowest mg/l/24H	1	37	Polymer PPM/24H	1.0002	37
38	pH Mix	1	38	pH Effluent	1	38	Hydrofluosilicic acid gals/24H	1.0002	38
39	Sodium chlorite PPM/24H	1	39	pH Mix	1	39	Polyaluminum chloride gals/24H	1.0001	39
40	Chlorine lowest mg/l/24H	1	40	NaOH PPM/24H	0.9999	40	pH Mix	1.0001	40
41	Sodium hydroxide gals/24H	1	41	Chlorine Eff mg/l	0.9999	41	Sysdel SR Midd MGD	1	41
42	Sysdel NS Midd MGD	1	42	Raw MGD/24H	0.9999	42	Washwater MGD	1	42
43	Carbon lbs/24H	1	43	Hydryfluosilicic acid PPM/24H	0.9999	43	NTU over limit	1	43
44	pH Raw	0.9999	44	Chlorine mix mg/l	0.9999	44	Turbidities measured/24H	1	44
45	Washwater MGD	0.9999	45	Polyaluminum chloride lbs/24H	0.9999	45	Turbidities required/24H	1	45
46	Polyaluminum chloride PPM/24H	0.9999	46	Sysdel NS Midd MGD	0.9999	46	Sodium Chlorite gals/24H	1	46
47	Chlorine Eff mg/l	0.9999	47	Sodium chlorite lbs/24H	0.9999	47	Carbon lbs/24H	0.9998	47
48	Polyaluminum chloride lbs/24H	0.9999	48	CW Lowest level/24H	0.9999	48	Polymer gals/24H	0.9997	48
49	Carbon PPM/24H	0.9999	49	Sodium Chlorite gals/24H	0.9998	49	Zinc orthophosphate lbs/24H	0.9996	49
50	Polymer gals/24H	0.9998	50	Chlorine PPM/24H	0.9998	50	Turbidity Raw NTU	0.9996	50
51	Settled readings >2,0 NTU/24H	0.9998	51	Polyaluminum chloride PPM/24H	0.9998	51	Chlorine lbs/24H	0.9994	51
52	Average % solids/liter	0.9998	52	Polyaluminum chloride gals/24H	0.9998	52	Air temp °C avg/24H	0.9993	52
53	Chlorine PPM/24H	0.9998	53	Washwater MGD	0.9998	53	Settled readings >2,0 NTU/24H	0.9991	53
54	Temp Eff °C	0.9997	54	Carbon lbs/24H	0.9998	54	Zinc orthophosphate PPM/24H	0.9986	54
55	NaOH PPM/24H	0.9997	55	Hydrofluosilicic acid lbs/24H	0.9998	55	Ferric chloride PPM/24H	0.9981	55
56	Chlorine mix mg/l	0.9997	56	Chlorine Settled mg/l	0.9997	56	Air temp °C max/24H	0.9976	56
57	Air temp °C max/24H	0.9995	57	pH Raw	0.9997	57	pH Effluent	0.9961	57

Table 3.

	A				B			
1	Sodium chlorite lbs/24H	Var9	1.1478	1	Turbidity Settled NTU	Var35	1.0953	1
2	Chlorine mix mg/l	Var41	1.107	2	Temp Raw °C	Var45	1.0807	2
3	Air temp °C min/24H	Var54	1.0756	3	Chlorine mix mg/l	Var41	1.062	3
4	Temp Raw °C	Var45	1.0598	4	Fluoride avg.mg/l/24H	Var47	1.0214	4
5	Turbidity Settled NTU	Var35	1.0589	5	Hydrofluosilicic acid lbs/24H	Var11	1.018	5
6	Air temp °C max/24H	Var55	1.0567	6	CW Lowest level/24H	Var51	1.0111	6
7	Hydryfluosilicic acid PPM/24H	Var26	1.0371	7	Chlorine Settled mg/l	Var42	1.01	7
8	Chlorine lbs/24H	Var8	1.0368	8	Filters Washed/24H	Var3	1.0097	8
9	System Delivery MGD	Var2	1.0342	9	pH Raw	Var37	1.0083	9
10	Chlorine CW mg/l	Var43	1.0313	10	Sodium chlorite lbs/24H	Var9	1.0083	10
11	Temp Eff °C	Var46	1.0286	11	Chlorine PPM/24H	Var24	1.0081	11
12	pH Raw	Var37	1.0268	12	Chlorine CW mg/l	Var43	1.0075	12
13	CW Lowest level/24H	Var51	1.0264	13	Temp Eff °C	Var46	1.0067	13
14	Washwater MGD	Var4	1.0241	14	Hydryfluosilicic acid PPM/24H	Var26	1.0065	14
15	Polyaluminum chloride PPM/24H	Var21	1.0238	15	Polymer PPM/24H	Var22	1.0052	15
16	pH Settled	Var39	1.0216	16	NaOH PPM/24H	Var23	1.0051	16
17	Sodium Chlorite gals/24H	Var20	1.0199	17	System Delivery MGD	Var2	1.0044	17
18	Average % solids/liter	Var14	1.0186	18	Polyaluminum chloride lbs/24H	Var6	1.0025	18
19	Sysdel SR Main MGD	Var30	1.0183	19	Sodium hydroxide lbs/24H	Var10	1.0025	19
20	Filters Washed/24H	Var3	1.0181	20	Hydrofluosilicic acid gals/24H	Var18	1.0022	20
21	Zinc orthophosphate PPM/24H	Var27	1.0174	21	Washwater MGD	Var4	1.0021	21
22	Sodium hydroxide gals/24H	Var17	1.0145	22	Carbon PPM/24H	Var25	1.0016	22
23	pH Mix	Var38	1.0139	23	Polymer lbs/24H	Var7	1.0015	23
24	NaOH PPM/24H	Var23	1.0138	24	Chlorine lbs/24H	Var8	1.0013	24
25	Peak flow raw MGD/24H	Var52	1.0136	25	Carbon lbs/24H	Var5	1.0013	25
26	Chlorine PPM/24H	Var24	1.0123	26	Air temp °C max/24H	Var55	1.0013	26
27	Chlorine Settled mg/l	Var42	1.0108	27	Sysdel NS Main MGD	Var32	1.001	27
28	Zinc orthophosphate gals/24H	Var19	1.0106	28	Turbidity Raw NTU	Var34	1.0009	28
29	Raw MGD/24H	Var1	1.0105	29	Chlorine Eff mg/l	Var44	1.0009	29
30	Sodium hydroxide lbs/24H	Var10	1.009	30	Sodium hydroxide gals/24H	Var17	1.0008	30
31	Chlorine lowest mg/l/24H	Var50	1.0074	31	Ferric chloride PPM/24H	Var28	1.0005	31
32	Polymer lbs/24H	Var7	1.0058	32	Air temp °C min/24H	Var54	1.0005	32
33	Settled readings >2,0 NTU/24H	Var57	1.0051	33	Peak flow raw MGD/24H	Var52	1.0005	33
34	Polymer PPM/24H	Var22	1.004	34	Chlorine lowest mg/l/24H	Var50	1.0005	34
35	Fluoride avg.mg/l/24H	Var47	1.004	35	Air temp °C avg/24H	Var56	1.0003	35
36	Polymer gals/24H	Var16	1.0034	36	Sodium Chlorite gals/24H	Var20	1.0001	36
37	Chlorine Eff mg/l	Var44	1.0033	37	Sodium chlorite PPM/24H	Var29	1.0001	37
38	Turbidity Raw NTU	Var34	1.0031	38	Ferric chloride lbs/24H	Var13	1.0001	38
39	Peak flow eff MGD/24H	Var53	1.0031	39	Settled readings >2,0 NTU/24H	Var57	1.0001	39
40	Air temp °C avg/24H	Var56	1.0029	40	pH Mix	Var38	1	40
41	Sysdel NS Main MGD	Var32	1.0027	41	Turbidities required/24H	Var48	1	41
42	Carbon PPM/24H	Var25	1.0024	42	NTU over limit	Var36	1	42
43	Polyaluminum chloride gals/24H	Var15	1.0024	43	Turbidities measured/24H	Var49	1	43
44	Hydrofluosilicic acid gals/24H	Var18	1.0014	44	Polymer gals/24H	Var16	1	44
45	Polyaluminum chloride lbs/24H	Var6	1.0012	45	Zinc orthophosphate lbs/24H	Var12	0.9999	45
46	Sysdel NS Midd MGD	Var33	1.001	46	Zinc orthophosphate PPM/24H	Var27	0.9997	46
47	Hydrofluosilicic acid lbs/24H	Var11	1.0009	47	Peak flow eff MGD/24H	Var53	0.9996	47
48	Ferric chloride lbs/24H	Var13	1.0002	48	Polyaluminum chloride gals/24H	Var15	0.9996	48
49	Sodium chlorite PPM/24H	Var29	1.0002	49	Sysdel NS Midd MGD	Var33	0.9996	49
50	Turbidities required/24H	Var48	1	50	Raw MGD/24H	Var1	0.9993	50
51	NTU over limit	Var36	1	51	Sysdel SR Midd MGD	Var31	0.9992	51
52	Turbidities measured/24H	Var49	1	52	Sysdel SR Main MGD	Var30	0.999	52
53	pH Effluent	Var40	0.9998	53	Polyaluminum chloride PPM/24H	Var21	0.9983	53
54	Sysdel SR Midd MGD	Var31	0.9993	54	Average % solids/liter	Var14	0.9983	54
55	Carbon lbs/24H	Var5	0.9991	55	pH Settled	Var39	0.9983	55
56	Zinc orthophosphate lbs/24H	Var12	0.9989	56	Zinc orthophosphate gals/24H	Var19	0.9975	56
57	Ferric chloride PPM/24H	Var28	0.9951	57	pH Effluent	Var40	0.9941	57

Table 4.

WaterPhysical	WaterTreatment	WaterChem	Climate	Output
Raw MGD/24H	Carbon lbs/24H	Turbidity Raw NTU	Air temp °C min/24H	Turbidity Effluent NTU
System Delivery MGD	Polyaluminum chloride lbs/24H	Turbidity Settled NTU	Air temp °C max/24H	Eff Highest NTU/24H
Filters Washed/24H	Polymer lbs/24H	NTU over limit	Air temp °C avg/24H	Effluent readings >0,10 NTU/24H
Washwater MGD	Chlorine lbs/24H	pH Raw		
Sysdel SR Main MGD	Sodium chlorite lbs/24H	pH Mix		
Sysdel SR Midd MGD	Sodium hydroxide lbs/24H	pH Settled		
Sysdel NS Main MGD	Hydrofluosilicic acid lbs/24H	pH Effluent		
Sysdel NS Midd MGD	Zinc orthophosphate lbs/24H	Chlorine mix mg/l		
Temp Raw °C	Ferric chloride lbs/24H	Chlorine Settled mg/l		
Temp Eff °C	Average % solids/liter	Chlorine CW mg/l		
Peak flow raw MGD/24H	Polyaluminum chloride gals/24H	Chlorine Eff mg/l		
Peak flow eff MGD/24H	Polymer gals/24H	Fluoride avg.mg/l/24H		
	Sodium hydroxide gals/24H	Turbidities required/24H		
	Hydrofluosilicic acid gals/24H	Turbidities measured/24H		
	Zinc orthophosphate gals/24H	Chlorine lowest mg/l/24H		
	Sodium Chlorite gals/24H	CW Lowest level/24H		
	Polyaluminum chloride PPM/24H	Peak flow raw MGD/24H		
	Polymer PPM/24H	Peak flow eff MGD/24H		
	NaOH PPM/24H	Settled readings >2,0 NTU/24H		
	Chlorine PPM/24H			
	Carbon PPM/24H			
	Hydryfluosilicic acid PPM/24H			
	Zinc orthophosphate PPM/24H			
	Ferric chloride PPM/24H			
	Sodium chlorite PPM/24H			

Table 5.

ANN				Linear Model			
Temp Raw °C	Var45	1.087	1	Chlorine PPM/24H	Var24	1.44E+14	1
Turbidity Settled NTU	Var35	1.037	2	Polyaluminum chloride PPM/24H	Var21	1.44E+14	2
Chlorine mix mg/l	Var41	1.035	3	Hydrofluosilicic acid lbs/24H	Var11	1.40E+14	3
Chlorine Eff mg/l	Var44	1.029	4	Sodium Chlorite gals/24H	Var20	1.27E+14	4
Filters Washed/24H	Var3	1.021	5	Average % solids/liter	Var14	9.28E+13	5
Temp Eff °C	Var46	1.02	6	Zinc orthophosphate gals/24H	Var19	9.28E+13	6
Chlorine PPM/24H	Var24	1.016	7	Ferric chloride lbs/24H	Var13	6.24E+13	7
Hydryfluosilicic acid PPM/24H	Var26	1.015	8	Hydrofluosilicic acid gals/24H	Var18	6.24E+13	8
Fluoride avg.mg/l/24H	Var47	1.012	9	Polymer PPM/24H	Var22	4.79E+13	9
Air temp °C min/24H	Var54	1.011	10	Carbon PPM/24H	Var25	4.79E+13	10
CW Lowest level/24H	Var51	1.009	11	Hydryfluosilicic acid PPM/24H	Var26	2.61E+13	11
Sodium hydroxide gals/24H	Var17	1.008	12	NaOH PPM/24H	Var23	2.61E+13	12
Sysdel NS Midd MGD	Var33	1.008	13	Zinc orthophosphate lbs/24H	Var12	1.76E+13	13
Zinc orthophosphate lbs/24H	Var12	1.007	14	Sodium chlorite lbs/24H	Var9	1.34E+13	14
Chlorine CW mg/l	Var43	1.007	15	Sodium hydroxide lbs/24H	Var10	9.02E+12	15
pH Settled	Var39	1.006	16	Sodium hydroxide gals/24H	Var17	8.54E+12	16
Sysdel NS Main MGD	Var32	1.006	17	Polymer lbs/24H	Var7	5.05E+12	17
Raw MGD/24H	Var1	1.006	18	Polymer gals/24H	Var16	5.05E+12	18
Polyaluminum chloride PPM/24H	Var21	1.006	19	Temp Raw °C	Var45	1.47	19
Polymer lbs/24H	Var7	1.005	20	System Delivery MGD	Var2	1.208	20
System Delivery MGD	Var2	1.005	21	Sysdel NS Main MGD	Var32	1.202	21
Average % solids/liter	Var14	1.004	22	Raw MGD/24H	Var1	1.193	22
Hydrofluosilicic acid lbs/24H	Var11	1.003	23	Sysdel SR Midd MGD	Var31	1.134	23
Zinc orthophosphate PPM/24H	Var27	1.003	24	Sysdel SR Main MGD	Var30	1.088	24
pH Raw	Var37	1.002	25	Carbon lbs/24H	Var5	1.085	25
Turbidity Raw NTU	Var34	1.002	26	Zinc orthophosphate PPM/24H	Var27	1.083	26
NaOH PPM/24H	Var23	1.002	27	Polyaluminum chloride gals/24H	Var15	1.07	27
Air temp °C max/24H	Var55	1.002	28	Turbidity Settled NTU	Var35	1.065	28
Polyaluminum chloride lbs/24H	Var6	1.001	29	Ferric chloride PPM/24H	Var28	1.058	29
Sodium Chlorite gals/24H	Var20	1.001	30	Temp Eff °C	Var46	1.056	30
Hydrofluosilicic acid gals/24H	Var18	1.001	31	Air temp °C min/24H	Var54	1.04	31
Sodium chlorite lbs/24H	Var9	1.001	32	Chlorine lbs/24H	Var8	1.039	32
Ferric chloride PPM/24H	Var28	1.001	33	Chlorine mix mg/l	Var41	1.015	33
Ferric chloride lbs/24H	Var13	1.001	34	Fluoride avg.mg/l/24H	Var47	1.012	34
Peak flow eff MGD/24H	Var53	1.001	35	Polyaluminum chloride lbs/24H	Var6	1.011	35
Sodium chlorite PPM/24H	Var29	1.001	36	Air temp °C avg/24H	Var56	1.006	36
Polyaluminum chloride gals/24H	Var15	1.001	37	Filters Washed/24H	Var3	1.005	37
Chlorine Settled mg/l	Var42	1.001	38	Turbidity Raw NTU	Var34	1.005	38
Sodium hydroxide lbs/24H	Var10	1	39	Washwater MGD	Var4	1.004	39
Sysdel SR Main MGD	Var30	1	40	Peak flow eff MGD/24H	Var53	1.004	40
pH Effluent	Var40	1	41	pH Settled	Var39	1.003	41
Chlorine lbs/24H	Var8	1	42	Chlorine Settled mg/l	Var42	1.003	42
Sysdel SR Midd MGD	Var31	1	43	Peak flow raw MGD/24H	Var52	1.001	43
Carbon lbs/24H	Var5	1	44	pH Raw	Var37	1.001	44
Turbidities measured/24H	Var49	1	45	Chlorine Eff mg/l	Var44	1	45
Turbidities required/24H	Var48	1	46	NTU over limit	Var36	1	46
NTU over limit	Var36	1	47	Turbidities required/24H	Var48	1	47
Washwater MGD	Var4	1	48	Turbidities measured/24H	Var49	1	48
pH Mix	Var38	1	49	pH Mix	Var38	1	49
Peak flow raw MGD/24H	Var52	1	50	pH Effluent	Var40	1	50
Air temp °C avg/24H	Var56	1	51	Settled readings >2,0 NTU/24H	Var57	1	51
Chlorine lowest mg/l/24H	Var50	1	52	Chlorine lowest mg/l/24H	Var50	0.999	52
Zinc orthophosphate gals/24H	Var19	1	53	Air temp °C max/24H	Var55	0.997	53
Polymer PPM/24H	Var22	0.999	54	Sodium chlorite PPM/24H	Var29	0.997	54
Settled readings >2,0 NTU/24H	Var57	0.998	55	Sysdel NS Midd MGD	Var33	0.995	55
Polymer gals/24H	Var16	0.998	56	Chlorine CW mg/l	Var43	0.972	56
Carbon PPM/24H	Var25	0.998	57	CW Lowest level/24H	Var51	0.894	57

Table 6.

ANN				Linear Model			
Turbidity Settled NTU	Var35	1.028	1	Polyaluminum chloride PPM/24H	Var21	5.57E+13	1
pH Raw	Var37	1.015	2	Chlorine PPM/24H	Var24	5.57E+13	2
NaOH PPM/24H	Var23	1.015	3	Hydrofluosilicic acid gals/24H	Var18	3.85E+13	3
Chlorine mix mg/l	Var41	1.013	4	Ferric chloride lbs/24H	Var13	3.85E+13	4
Temp Raw °C	Var45	1.012	5	Hydrofluosilicic acid lbs/24H	Var11	3.77E+13	5
Chlorine PPM/24H	Var24	1.011	6	Zinc orthophosphate gals/24H	Var19	3.41E+13	6
Raw MGD/24H	Var1	1.011	7	Average % solids/liter	Var14	3.41E+13	7
Fluoride avg.mg/l/24H	Var47	1.01	8	Polymer gals/24H	Var16	2.40E+13	8
Filters Washed/24H	Var3	1.007	9	Polymer lbs/24H	Var7	2.40E+13	9
Polyaluminum chloride PPM/24H	Var21	1.007	10	Sodium hydroxide lbs/24H	Var10	2.40E+13	10
Temp Eff °C	Var46	1.006	11	Hydryfluosilicic acid PPM/24H	Var26	1.91E+13	11
Sysdel NS Midd MGD	Var33	1.006	12	NaOH PPM/24H	Var23	1.91E+13	12
Chlorine Eff mg/l	Var44	1.006	13	Sodium chlorite lbs/24H	Var9	1.91E+13	13
pH Settled	Var39	1.005	14	Sodium Chlorite gals/24H	Var20	1.86E+13	14
Hydryfluosilicic acid PPM/24H	Var26	1.004	15	Zinc orthophosphate lbs/24H	Var12	1.44E+13	15
Polyaluminum chloride lbs/24H	Var6	1.004	16	Polymer PPM/24H	Var22	1.29E+13	16
Sysdel SR Main MGD	Var30	1.004	17	Carbon PPM/24H	Var25	1.29E+13	17
Chlorine CW mg/l	Var43	1.004	18	Sodium hydroxide gals/24H	Var17	9.59E+12	18
Air temp °C min/24H	Var54	1.002	19	Polyaluminum chloride lbs/24H	Var6	1.06	19
Chlorine lowest mg/l/24H	Var50	1.002	20	Sysdel SR Main MGD	Var30	1.049	20
Sysdel NS Main MGD	Var32	1.002	21	Temp Raw °C	Var45	1.023	21
Chlorine Settled mg/l	Var42	1.002	22	Sysdel SR Midd MGD	Var31	1.019	22
Sodium hydroxide gals/24H	Var17	1.002	23	Sysdel NS Main MGD	Var32	1.017	23
Hydrofluosilicic acid lbs/24H	Var11	1.001	24	System Delivery MGD	Var2	1.012	24
Sodium chlorite lbs/24H	Var9	1.001	25	Turbidity Settled NTU	Var35	1.011	25
Zinc orthophosphate gals/24H	Var19	1.001	26	CW Lowest level/24H	Var51	1.011	26
Peak flow raw MGD/24H	Var52	1.001	27	Polyaluminum chloride gals/24H	Var15	1.01	27
Sodium hydroxide lbs/24H	Var10	1.001	28	Temp Eff °C	Var46	1.008	28
Peak flow eff MGD/24H	Var53	1.001	29	Zinc orthophosphate PPM/24H	Var27	1.005	29
Polymer lbs/24H	Var7	1.001	30	Carbon lbs/24H	Var5	1.004	30
Average % solids/liter	Var14	1.001	31	Air temp °C min/24H	Var54	1.002	31
Ferric chloride lbs/24H	Var13	1	32	Air temp °C avg/24H	Var56	1.002	32
Carbon PPM/24H	Var25	1	33	Raw MGD/24H	Var1	1.002	33
System Delivery MGD	Var2	1	34	Peak flow raw MGD/24H	Var52	1.002	34
Sodium chlorite PPM/24H	Var29	1	35	Chlorine Settled mg/l	Var42	1.002	35
CW Lowest level/24H	Var51	1	36	Sodium chlorite PPM/24H	Var29	1.002	36
Polymer PPM/24H	Var22	1	37	pH Mix	Var38	1.001	37
Hydrofluosilicic acid gals/24H	Var18	1	38	Chlorine Eff mg/l	Var44	1.001	38
Polyaluminum chloride gals/24H	Var15	1	39	Ferric chloride PPM/24H	Var28	1.001	39
pH Mix	Var38	1	40	Turbidity Raw NTU	Var34	1.001	40
Sysdel SR Midd MGD	Var31	1	41	Sysdel NS Midd MGD	Var33	1	41
Washwater MGD	Var4	1	42	Fluoride avg.mg/l/24H	Var47	1	42
NTU over limit	Var36	1	43	Washwater MGD	Var4	1	43
Turbidities measured/24H	Var49	1	44	Air temp °C max/24H	Var55	1	44
Turbidities required/24H	Var48	1	45	Chlorine lbs/24H	Var8	1	45
Sodium Chlorite gals/24H	Var20	1	46	Turbidities measured/24H	Var49	1	46
Carbon lbs/24H	Var5	1	47	Turbidities required/24H	Var48	1	47
Polymer gals/24H	Var16	1	48	NTU over limit	Var36	1	48
Zinc orthophosphate lbs/24H	Var12	1	49	Settled readings >2,0 NTU/24H	Var57	1	49
Turbidity Raw NTU	Var34	1	50	Chlorine mix mg/l	Var41	1	50
Chlorine lbs/24H	Var8	0.999	51	pH Settled	Var39	1	51
Air temp °C avg/24H	Var56	0.999	52	Chlorine lowest mg/l/24H	Var50	0.999	52
Settled readings >2,0 NTU/24H	Var57	0.999	53	pH Raw	Var37	0.999	53
Zinc orthophosphate PPM/24H	Var27	0.999	54	Chlorine CW mg/l	Var43	0.999	54
Ferric chloride PPM/24H	Var28	0.998	55	Filters Washed/24H	Var3	0.998	55
Air temp °C max/24H	Var55	0.998	56	Peak flow eff MGD/24H	Var53	0.997	56
pH Effluent	Var40	0.996	57	pH Effluent	Var40	0.313	57

Table 7.

ANN				Linear Model			
Sodium chlorite lbs/24H	Var9	1.148	1	Average % solids/liter	Var14	6.22E+13	1
Chlorine mix mg/l	Var41	1.107	2	Zinc orthophosphate gals/24H	Var19	6.22E+13	2
Air temp °C min/24H	Var54	1.076	3	Polymer gals/24H	Var16	5.72E+13	3
Temp Raw °C	Var45	1.06	4	Polymer lbs/24H	Var7	5.72E+13	4
Turbidity Settled NTU	Var35	1.059	5	Hydrofluosilicic acid lbs/24H	Var11	5.12E+13	5
Air temp °C max/24H	Var55	1.057	6	Sodium hydroxide gals/24H	Var17	4.85E+13	6
Hydryfluosilicic acid PPM/24H	Var26	1.037	7	Chlorine PPM/24H	Var24	3.32E+13	7
Chlorine lbs/24H	Var8	1.037	8	Polyaluminum chloride PPM/24H	Var21	3.32E+13	8
System Delivery MGD	Var2	1.034	9	Sodium chlorite lbs/24H	Var9	3.07E+13	9
Chlorine CW mg/l	Var43	1.031	10	Sodium hydroxide lbs/24H	Var10	2.52E+13	10
Temp Eff °C	Var46	1.029	11	Hydrofluosilicic acid gals/24H	Var18	2.35E+13	11
pH Raw	Var37	1.027	12	Ferric chloride lbs/24H	Var13	2.35E+13	12
CW Lowest level/24H	Var51	1.026	13	Zinc orthophosphate lbs/24H	Var12	2.33E+13	13
Washwater MGD	Var4	1.024	14	Sodium Chlorite gals/24H	Var20	2.05E+13	14
Polyaluminum chloride PPM/24H	Var21	1.024	15	Carbon PPM/24H	Var25	1.58E+13	15
pH Settled	Var39	1.022	16	Polymer PPM/24H	Var22	1.58E+13	16
Sodium Chlorite gals/24H	Var20	1.02	17	Hydryfluosilicic acid PPM/24H	Var26	9.60E+12	17
Average % solids/liter	Var14	1.019	18	NaOH PPM/24H	Var23	9.60E+12	18
Sysdel SR Main MGD	Var30	1.018	19	Temp Raw °C	Var45	1.313	19
Filters Washed/24H	Var3	1.018	20	Temp Eff °C	Var46	1.146	20
Zinc orthophosphate PPM/24H	Var27	1.017	21	System Delivery MGD	Var2	1.114	21
Sodium hydroxide gals/24H	Var17	1.014	22	Raw MGD/24H	Var1	1.052	22
pH Mix	Var38	1.014	23	Turbidity Settled NTU	Var35	1.051	23
NaOH PPM/24H	Var23	1.014	24	Sysdel SR Midd MGD	Var31	1.043	24
Peak flow raw MGD/24H	Var52	1.014	25	Chlorine lbs/24H	Var8	1.029	25
Chlorine PPM/24H	Var24	1.012	26	Polyaluminum chloride gals/24H	Var15	1.027	26
Chlorine Settled mg/l	Var42	1.011	27	Carbon lbs/24H	Var5	1.024	27
Zinc orthophosphate gals/24H	Var19	1.011	28	Peak flow eff MGD/24H	Var53	1.023	28
Raw MGD/24H	Var1	1.011	29	Chlorine mix mg/l	Var41	1.02	29
Sodium hydroxide lbs/24H	Var10	1.009	30	Air temp °C avg/24H	Var56	1.015	30
Chlorine lowest mg/l/24H	Var50	1.007	31	Air temp °C max/24H	Var55	1.012	31
Polymer lbs/24H	Var7	1.006	32	Polyaluminum chloride lbs/24H	Var6	1.008	32
Settled readings >2,0 NTU/24H	Var57	1.005	33	Fluoride avg.mg/l/24H	Var47	1.007	33
Polymer PPM/24H	Var22	1.004	34	Chlorine Settled mg/l	Var42	1.006	34
Fluoride avg.mg/l/24H	Var47	1.004	35	Sysdel SR Main MGD	Var30	1.003	35
Polymer gals/24H	Var16	1.003	36	Air temp °C min/24H	Var54	1.003	36
Chlorine Eff mg/l	Var44	1.003	37	Peak flow raw MGD/24H	Var52	1.002	37
Turbidity Raw NTU	Var34	1.003	38	Sodium chlorite PPM/24H	Var29	1.001	38
Peak flow eff MGD/24H	Var53	1.003	39	Sysdel NS Main MGD	Var32	1.001	39
Air temp °C avg/24H	Var56	1.003	40	pH Raw	Var37	1.001	40
Sysdel NS Main MGD	Var32	1.003	41	Ferric chloride PPM/24H	Var28	1.001	41
Carbon PPM/24H	Var25	1.002	42	pH Mix	Var38	1.001	42
Polyaluminum chloride gals/24H	Var15	1.002	43	Chlorine lowest mg/l/24H	Var50	1	43
Hydrofluosilicic acid gals/24H	Var18	1.001	44	Settled readings >2,0 NTU/24H	Var57	1	44
Polyaluminum chloride lbs/24H	Var6	1.001	45	NTU over limit	Var36	1	45
Sysdel NS Midd MGD	Var33	1.001	46	Turbidities measured/24H	Var49	1	46
Hydrofluosilicic acid lbs/24H	Var11	1.001	47	Turbidities required/24H	Var48	1	47
Ferric chloride lbs/24H	Var13	1	48	Sysdel NS Midd MGD	Var33	1	48
Sodium chlorite PPM/24H	Var29	1	49	Chlorine Eff mg/l	Var44	1	49
Turbidities required/24H	Var48	1	50	Filters Washed/24H	Var3	1	50
NTU over limit	Var36	1	51	Turbidity Raw NTU	Var34	1	51
Turbidities measured/24H	Var49	1	52	pH Settled	Var39	0.999	52
pH Effluent	Var40	1	53	Washwater MGD	Var4	0.998	53
Sysdel SR Midd MGD	Var31	0.999	54	Zinc orthophosphate PPM/24H	Var27	0.998	54
Carbon lbs/24H	Var5	0.999	55	Chlorine CW mg/l	Var43	0.989	55
Zinc orthophosphate lbs/24H	Var12	0.999	56	CW Lowest level/24H	Var51	0.974	56
Ferric chloride PPM/24H	Var28	0.995	57	pH Effluent	Var40	0.619	57

Table 8.

	A				B			
1	Temp Raw °C	Var45	1.087	1	Turbidity Settled NTU	Var35	1.0618	1
2	Turbidity Settled NTU	Var35	1.037	2	Chlorine mix mg/l	Var41	1.0213	2
3	Chlorine mix mg/l	Var41	1.0348	3	Filters Washed/24H	Var3	1.0156	3
4	Chlorine Eff mg/l	Var44	1.0286	4	Chlorine Eff mg/l	Var44	1.0143	4
5	Filters Washed/24H	Var3	1.0206	5	Chlorine PPM/24H	Var24	1.0127	5
6	Temp Eff °C	Var46	1.0203	6	Temp Raw °C	Var45	1.0115	6
7	Chlorine PPM/24H	Var24	1.0164	7	Polyaluminum chloride gals/24H	Var15	1.0114	7
8	Hydryfluosilicic acid PPM/24H	Var26	1.0151	8	Sysdel SR Midd MGD	Var31	1.011	8
9	Fluoride avg.mg/l/24H	Var47	1.0117	9	pH Settled	Var39	1.0106	9
10	Air temp °C min/24H	Var54	1.011	10	Fluoride avg.mg/l/24H	Var47	1.0105	10
11	CW Lowest level/24H	Var51	1.0092	11	Polyaluminum chloride PPM/24H	Var21	1.0087	11
12	Sodium hydroxide gals/24H	Var17	1.0076	12	Sysdel NS Midd MGD	Var33	1.007	12
13	Sysdel NS Midd MGD	Var33	1.0076	13	Chlorine lowest mg/l/24H	Var50	1.0057	13
14	Zinc orthophosphate lbs/24H	Var12	1.0069	14	Sysdel SR Main MGD	Var30	1.0052	14
15	Chlorine CW mg/l	Var43	1.0067	15	Zinc orthophosphate lbs/24H	Var12	1.0052	15
16	pH Settled	Var39	1.0062	16	NaOH PPM/24H	Var23	1.0049	16
17	Sysdel NS Main MGD	Var32	1.0061	17	pH Raw	Var37	1.0048	17
18	Raw MGD/24H	Var1	1.0059	18	Temp Eff °C	Var46	1.004	18
19	Polyaluminum chloride PPM/24H	Var21	1.0058	19	Hydryfluosilicic acid PPM/24H	Var26	1.0037	19
20	Polymer lbs/24H	Var7	1.0047	20	Polyaluminum chloride lbs/24H	Var6	1.003	20
21	System Delivery MGD	Var2	1.0045	21	Turbidity Raw NTU	Var34	1.0027	21
22	Average % solids/liter	Var14	1.0037	22	Average % solids/liter	Var14	1.0027	22
23	Hydrofluosilicic acid lbs/24H	Var11	1.0035	23	Zinc orthophosphate gals/24H	Var19	1.0024	23
24	Zinc orthophosphate PPM/24H	Var27	1.0026	24	Polymer PPM/24H	Var22	1.0024	24
25	pH Raw	Var37	1.0023	25	Sodium hydroxide gals/24H	Var17	1.0023	25
26	Turbidity Raw NTU	Var34	1.002	26	Peak flow eff MGD/24H	Var53	1.002	26
27	NaOH PPM/24H	Var23	1.002	27	Carbon lbs/24H	Var5	1.0017	27
28	Air temp °C max/24H	Var55	1.0015	28	Sodium hydroxide lbs/24H	Var10	1.0014	28
29	Polyaluminum chloride lbs/24H	Var6	1.0014	29	Ferric chloride PPM/24H	Var28	1.0014	29
30	Sodium Chlorite gals/24H	Var20	1.0013	30	Chlorine Settled mg/l	Var42	1.0013	30
31	Hydrofluosilicic acid gals/24H	Var18	1.0012	31	Sodium chlorite lbs/24H	Var9	1.001	31
32	Sodium chlorite lbs/24H	Var9	1.001	32	Sodium Chlorite gals/24H	Var20	1.0009	32
33	Ferric chloride PPM/24H	Var28	1.001	33	Sodium chlorite PPM/24H	Var29	1.0008	33
34	Ferric chloride lbs/24H	Var13	1.0008	34	Hydrofluosilicic acid gals/24H	Var18	1.0007	34
35	Peak flow eff MGD/24H	Var53	1.0008	35	Ferric chloride lbs/24H	Var13	1.0006	35
36	Sodium chlorite PPM/24H	Var29	1.0007	36	Chlorine CW mg/l	Var43	1.0006	36
37	Polyaluminum chloride gals/24H	Var15	1.0006	37	Sysdel NS Main MGD	Var32	1.0004	37
38	Chlorine Settled mg/l	Var42	1.0006	38	Settled readings >2,0 NTU/24H	Var57	1.0003	38
39	Sodium hydroxide lbs/24H	Var10	1.0005	39	Polymer lbs/24H	Var7	1.0003	39
40	Sysdel SR Main MGD	Var30	1.0003	40	Chlorine lbs/24H	Var8	1.0002	40
41	pH Effluent	Var40	1.0001	41	Polymer gals/24H	Var16	1.0001	41
42	Chlorine lbs/24H	Var8	1.0001	42	Carbon PPM/24H	Var25	1.0001	42
43	Sysdel SR Midd MGD	Var31	1	43	CW Lowest level/24H	Var51	1.0001	43
44	Carbon lbs/24H	Var5	1	44	Hydrofluosilicic acid lbs/24H	Var11	1	44
45	Turbidities measured/24H	Var49	1	45	Washwater MGD	Var4	1	45
46	Turbidities required/24H	Var48	1	46	Turbidities required/24H	Var48	1	46
47	NTU over limit	Var36	1	47	NTU over limit	Var36	1	47
48	Washwater MGD	Var4	1	48	Turbidities measured/24H	Var49	1	48
49	pH Mix	Var38	0.9998	49	pH Mix	Var38	1	49
50	Peak flow raw MGD/24H	Var52	0.9998	50	Zinc orthophosphate PPM/24H	Var27	0.9999	50
51	Air temp °C avg/24H	Var56	0.9998	51	Air temp °C min/24H	Var54	0.9998	51
52	Chlorine lowest mg/l/24H	Var50	0.9997	52	Raw MGD/24H	Var1	0.9997	52
53	Zinc orthophosphate gals/24H	Var19	0.9997	53	Air temp °C avg/24H	Var56	0.9994	53
54	Polymer PPM/24H	Var22	0.999	54	Air temp °C max/24H	Var55	0.9993	54
55	Settled readings >2,0 NTU/24H	Var57	0.9983	55	Peak flow raw MGD/24H	Var52	0.9992	55
56	Polymer gals/24H	Var16	0.9976	56	System Delivery MGD	Var2	0.9978	56
57	Carbon PPM/24H	Var25	0.9976	57	pH Effluent	Var40	0.9626	57

Table 9.

	A			B			C		
1	Turbidity Settled NTU	1.003	1	Settled readings >2,0 NTU/24H	1.0079	1	Turbidity Settled NTU	1.0283	1
2	Temp Raw °C	1.0013	2	Turbidity Settled NTU	1.0026	2	pH Raw	1.0151	2
3	Turbidity Raw NTU	1.001	3	Temp Raw °C	1.0012	3	NaOH PPM/24H	1.015	3
4	Air temp °C min/24H	1.0006	4	Turbidity Raw NTU	1.0009	4	Chlorine mix mg/l	1.0129	4
5	Sysdel SR Main MGD	1.0003	5	Temp Eff °C	1.0009	5	Temp Raw °C	1.012	5
6	Chlorine lbs/24H	1.0003	6	Chlorine lbs/24H	1.0004	6	Chlorine PPM/24H	1.0114	6
7	Zinc orthophosphate gals/24H	1.0003	7	Zinc orthophosphate PPM/24H	1.0004	7	Raw MGD/24H	1.0114	7
8	Hydryfluosilicic acid PPM/24H	1.0003	8	Chlorine CW mg/l	1.0003	8	Fluoride avg.mg/l/24H	1.0102	8
9	Fluoride avg.mg/l/24H	1.0002	9	Sysdel SR Main MGD	1.0002	9	Filters Washed/24H	1.007	9
10	Polymer lbs/24H	1.0002	10	Fluoride avg.mg/l/24H	1.0002	10	Polyaluminum chloride PPM/24H	1.007	10
11	Zinc orthophosphate PPM/24H	1.0002	11	Sysdel SR Midd MGD	1.0002	11	Temp Eff °C	1.0065	11
12	Air temp °C avg/24H	1.0001	12	pH Settled	1.0002	12	Sysdel NS Midd MGD	1.0062	12
13	Sysdel NS Main MGD	1.0001	13	Air temp °C min/24H	1.0002	13	Chlorine Eff mg/l	1.0057	13
14	Polymer PPM/24H	1.0001	14	Air temp °C avg/24H	1.0002	14	pH Settled	1.0054	14
15	Hydrofluosilicic acid lbs/24H	1.0001	15	Polymer gals/24H	1.0002	15	Hydryfluosilicic acid PPM/24H	1.0045	15
16	Sodium Chlorite gals/24H	1.0001	16	Air temp °C max/24H	1.0001	16	Polyaluminum chloride lbs/24H	1.0041	16
17	Sodium chlorite lbs/24H	1.0001	17	Polymer lbs/24H	1.0001	17	Sysdel SR Main MGD	1.004	17
18	pH Settled	1	18	Ferric chloride PPM/24H	1.0001	18	Chlorine CW mg/l	1.0035	18
19	Sodium hydroxide lbs/24H	1	19	Zinc orthophosphate gals/24H	1	19	Air temp °C min/24H	1.0025	19
20	Peak flow raw MGD/24H	1	20	Average % solids/liter	1	20	Chlorine lowest mg/l/24H	1.0023	20
21	Peak flow eff MGD/24H	1	21	System Delivery MGD	1	21	Sysdel NS Main MGD	1.002	21
22	System Delivery MGD	1	22	Polymer PPM/24H	1	22	Chlorine Settled mg/l	1.0019	22
23	Zinc orthophosphate lbs/24H	1	23	Sodium hydroxide gals/24H	1	23	Sodium hydroxide gals/24H	1.0016	23
24	Chlorine CW mg/l	1	24	Carbon PPM/24H	1	24	Hydrofluosilicic acid lbs/24H	1.0014	24
25	Sysdel SR Midd MGD	1	25	Zinc orthophosphate lbs/24H	1	25	Sodium chlorite lbs/24H	1.0014	25
26	Filters Washed/24H	1	26	Sodium hydroxide lbs/24H	1	26	Zinc orthophosphate gals/24H	1.0013	26
27	Chlorine Settled mg/l	1	27	Filters Washed/24H	1	27	Peak flow raw MGD/24H	1.001	27
28	pH Effluent	1	28	Peak flow raw MGD/24H	1	28	Sodium hydroxide lbs/24H	1.0007	28
29	CW Lowest level/24H	1	29	Sysdel NS Main MGD	1	29	Peak flow eff MGD/24H	1.0006	29
30	Raw MGD/24H	1	30	Peak flow eff MGD/24H	1	30	Polymer lbs/24H	1.0005	30
31	Hydrofluosilicic acid gals/24H	1	31	Turbidities required/24H	1	31	Average % solids/liter	1.0005	31
32	Turbidities required/24H	1	32	Turbidities measured/24H	1	32	Ferric chloride lbs/24H	1.0005	32
33	NTU over limit	1	33	NTU over limit	1	33	Carbon PPM/24H	1.0005	33
34	Turbidities measured/24H	1	34	Sodium chlorite PPM/24H	1	34	System Delivery MGD	1.0004	34
35	Ferric chloride lbs/24H	1	35	Ferric chloride lbs/24H	1	35	Sodium chlorite PPM/24H	1.0003	35
36	Polyaluminum chloride gals/24H	1	36	Hydrofluosilicic acid gals/24H	1	36	CW Lowest level/24H	1.0002	36
37	Ferric chloride PPM/24H	1	37	Chlorine lowest mg/l/24H	1	37	Polymer PPM/24H	1.0002	37
38	pH Mix	1	38	pH Effluent	1	38	Hydrofluosilicic acid gals/24H	1.0002	38
39	Sodium chlorite PPM/24H	1	39	pH Mix	1	39	Polyaluminum chloride gals/24H	1.0001	39
40	Chlorine lowest mg/l/24H	1	40	NaOH PPM/24H	0.9999	40	pH Mix	1.0001	40
41	Sodium hydroxide gals/24H	1	41	Chlorine Eff mg/l	0.9999	41	Sysdel SR Midd MGD	1	41
42	Sysdel NS Midd MGD	1	42	Raw MGD/24H	0.9999	42	Washwater MGD	1	42
43	Carbon lbs/24H	1	43	Hydryfluosilicic acid PPM/24H	0.9999	43	NTU over limit	1	43
44	pH Raw	0.9999	44	Chlorine mix mg/l	0.9999	44	Turbidities measured/24H	1	44
45	Washwater MGD	0.9999	45	Polyaluminum chloride lbs/24H	0.9999	45	Turbidities required/24H	1	45
46	Polyaluminum chloride PPM/24H	0.9999	46	Sysdel NS Midd MGD	0.9999	46	Sodium Chlorite gals/24H	1	46
47	Chlorine Eff mg/l	0.9999	47	Sodium chlorite lbs/24H	0.9999	47	Carbon lbs/24H	0.9998	47
48	Polyaluminum chloride lbs/24H	0.9999	48	CW Lowest level/24H	0.9999	48	Polymer gals/24H	0.9997	48
49	Carbon PPM/24H	0.9999	49	Sodium Chlorite gals/24H	0.9998	49	Zinc orthophosphate lbs/24H	0.9996	49
50	Polymer gals/24H	0.9998	50	Chlorine PPM/24H	0.9998	50	Turbidity Raw NTU	0.9996	50
51	Settled readings >2,0 NTU/24H	0.9998	51	Polyaluminum chloride PPM/24H	0.9998	51	Chlorine lbs/24H	0.9994	51
52	Average % solids/liter	0.9998	52	Polyaluminum chloride gals/24H	0.9998	52	Air temp °C avg/24H	0.9993	52
53	Chlorine PPM/24H	0.9998	53	Washwater MGD	0.9998	53	Settled readings >2,0 NTU/24H	0.9991	53
54	Temp Eff °C	0.9997	54	Carbon lbs/24H	0.9998	54	Zinc orthophosphate PPM/24H	0.9986	54
55	NaOH PPM/24H	0.9997	55	Hydrofluosilicic acid lbs/24H	0.9998	55	Ferric chloride PPM/24H	0.9981	55
56	Chlorine mix mg/l	0.9997	56	Chlorine Settled mg/l	0.9997	56	Air temp °C max/24H	0.9976	56
57	Air temp °C max/24H	0.9995	57	pH Raw	0.9997	57	pH Effluent	0.9961	57

Table 10.

	A				B			
1	Sodium chlorite lbs/24H	Var9	1.1478	1	Turbidity Settled NTU	Var35	1.0953	1
2	Chlorine mix mg/l	Var41	1.107	2	Temp Raw °C	Var45	1.0807	2
3	Air temp °C min/24H	Var54	1.0756	3	Chlorine mix mg/l	Var41	1.062	3
4	Temp Raw °C	Var45	1.0598	4	Fluoride avg.mg/l/24H	Var47	1.0214	4
5	Turbidity Settled NTU	Var35	1.0589	5	Hydrofluosilicic acid lbs/24H	Var11	1.018	5
6	Air temp °C max/24H	Var55	1.0567	6	CW Lowest level/24H	Var51	1.0111	6
7	Hydryfluosilicic acid PPM/24H	Var26	1.0371	7	Chlorine Settled mg/l	Var42	1.01	7
8	Chlorine lbs/24H	Var8	1.0368	8	Filters Washed/24H	Var3	1.0097	8
9	System Delivery MGD	Var2	1.0342	9	pH Raw	Var37	1.0083	9
10	Chlorine CW mg/l	Var43	1.0313	10	Sodium chlorite lbs/24H	Var9	1.0083	10
11	Temp Eff °C	Var46	1.0286	11	Chlorine PPM/24H	Var24	1.0081	11
12	pH Raw	Var37	1.0268	12	Chlorine CW mg/l	Var43	1.0075	12
13	CW Lowest level/24H	Var51	1.0264	13	Temp Eff °C	Var46	1.0067	13
14	Washwater MGD	Var4	1.0241	14	Hydryfluosilicic acid PPM/24H	Var26	1.0065	14
15	Polyaluminum chloride PPM/24H	Var21	1.0238	15	Polymer PPM/24H	Var22	1.0052	15
16	pH Settled	Var39	1.0216	16	NaOH PPM/24H	Var23	1.0051	16
17	Sodium Chlorite gals/24H	Var20	1.0199	17	System Delivery MGD	Var2	1.0044	17
18	Average % solids/liter	Var14	1.0186	18	Polyaluminum chloride lbs/24H	Var6	1.0025	18
19	Sysdel SR Main MGD	Var30	1.0183	19	Sodium hydroxide lbs/24H	Var10	1.0025	19
20	Filters Washed/24H	Var3	1.0181	20	Hydrofluosilicic acid gals/24H	Var18	1.0022	20
21	Zinc orthophosphate PPM/24H	Var27	1.0174	21	Washwater MGD	Var4	1.0021	21
22	Sodium hydroxide gals/24H	Var17	1.0145	22	Carbon PPM/24H	Var25	1.0016	22
23	pH Mix	Var38	1.0139	23	Polymer lbs/24H	Var7	1.0015	23
24	NaOH PPM/24H	Var23	1.0138	24	Chlorine lbs/24H	Var8	1.0013	24
25	Peak flow raw MGD/24H	Var52	1.0136	25	Carbon lbs/24H	Var5	1.0013	25
26	Chlorine PPM/24H	Var24	1.0123	26	Air temp °C max/24H	Var55	1.0013	26
27	Chlorine Settled mg/l	Var42	1.0108	27	Sysdel NS Main MGD	Var32	1.001	27
28	Zinc orthophosphate gals/24H	Var19	1.0106	28	Turbidity Raw NTU	Var34	1.0009	28
29	Raw MGD/24H	Var1	1.0105	29	Chlorine Eff mg/l	Var44	1.0009	29
30	Sodium hydroxide lbs/24H	Var10	1.009	30	Sodium hydroxide gals/24H	Var17	1.0008	30
31	Chlorine lowest mg/l/24H	Var50	1.0074	31	Ferric chloride PPM/24H	Var28	1.0005	31
32	Polymer lbs/24H	Var7	1.0058	32	Air temp °C min/24H	Var54	1.0005	32
33	Settled readings >2,0 NTU/24H	Var57	1.0051	33	Peak flow raw MGD/24H	Var52	1.0005	33
34	Polymer PPM/24H	Var22	1.004	34	Chlorine lowest mg/l/24H	Var50	1.0005	34
35	Fluoride avg.mg/l/24H	Var47	1.004	35	Air temp °C avg/24H	Var56	1.0003	35
36	Polymer gals/24H	Var16	1.0034	36	Sodium Chlorite gals/24H	Var20	1.0001	36
37	Chlorine Eff mg/l	Var44	1.0033	37	Sodium chlorite PPM/24H	Var29	1.0001	37
38	Turbidity Raw NTU	Var34	1.0031	38	Ferric chloride lbs/24H	Var13	1.0001	38
39	Peak flow eff MGD/24H	Var53	1.0031	39	Settled readings >2,0 NTU/24H	Var57	1.0001	39
40	Air temp °C avg/24H	Var56	1.0029	40	pH Mix	Var38	1	40
41	Sysdel NS Main MGD	Var32	1.0027	41	Turbidities required/24H	Var48	1	41
42	Carbon PPM/24H	Var25	1.0024	42	NTU over limit	Var36	1	42
43	Polyaluminum chloride gals/24H	Var15	1.0024	43	Turbidities measured/24H	Var49	1	43
44	Hydrofluosilicic acid gals/24H	Var18	1.0014	44	Polymer gals/24H	Var16	1	44
45	Polyaluminum chloride lbs/24H	Var6	1.0012	45	Zinc orthophosphate lbs/24H	Var12	0.9999	45
46	Sysdel NS Midd MGD	Var33	1.001	46	Zinc orthophosphate PPM/24H	Var27	0.9997	46
47	Hydrofluosilicic acid lbs/24H	Var11	1.0009	47	Peak flow eff MGD/24H	Var53	0.9996	47
48	Ferric chloride lbs/24H	Var13	1.0002	48	Polyaluminum chloride gals/24H	Var15	0.9996	48
49	Sodium chlorite PPM/24H	Var29	1.0002	49	Sysdel NS Midd MGD	Var33	0.9996	49
50	Turbidities required/24H	Var48	1	50	Raw MGD/24H	Var1	0.9993	50
51	NTU over limit	Var36	1	51	Sysdel SR Midd MGD	Var31	0.9992	51
52	Turbidities measured/24H	Var49	1	52	Sysdel SR Main MGD	Var30	0.999	52
53	pH Effluent	Var40	0.9998	53	Polyaluminum chloride PPM/24H	Var21	0.9983	53
54	Sysdel SR Midd MGD	Var31	0.9993	54	Average % solids/liter	Var14	0.9983	54
55	Carbon lbs/24H	Var5	0.9991	55	pH Settled	Var39	0.9983	55
56	Zinc orthophosphate lbs/24H	Var12	0.9989	56	Zinc orthophosphate gals/24H	Var19	0.9975	56
57	Ferric chloride PPM/24H	Var28	0.9951	57	pH Effluent	Var40	0.9941	57

Table 11.

WaterPhysical	WaterTreatment	WaterChem	Climate	Output
Raw MGD/24H	Carbon lbs/24H	Turbidity Raw NTU	Air temp °C min/24H	Turbidity Effluent NTU
System Delivery MGD	Polyaluminum chloride lbs/24H	Turbidity Settled NTU	Air temp °C max/24H	Eff Highest NTU/24H
Filters Washed/24H	Polymer lbs/24H	NTU over limit	Air temp °C avg/24H	Effluent readings >0,10 NTU/24H
Washwater MGD	Chlorine lbs/24H	pH Raw		
Sysdel SR Main MGD	Sodium chlorite lbs/24H	pH Mix		
Sysdel SR Midd MGD	Sodium hydroxide lbs/24H	pH Settled		
Sysdel NS Main MGD	Hydrofluosilicic acid lbs/24H	pH Effluent		
Sysdel NS Midd MGD	Zinc orthophosphate lbs/24H	Chlorine mix mg/l		
Temp Raw °C	Ferric chloride lbs/24H	Chlorine Settled mg/l		
Temp Eff °C	Average % solids/liter	Chlorine CW mg/l		
Peak flow raw MGD/24H	Polyaluminum chloride gals/24H	Chlorine Eff mg/l		
Peak flow eff MGD/24H	Polymer gals/24H	Fluoride avg.mg/l/24H		
	Sodium hydroxide gals/24H	Turbidities required/24H		
	Hydrofluosilicic acid gals/24H	Turbidities measured/24H		
	Zinc orthophosphate gals/24H	Chlorine lowest mg/l/24H		
	Sodium Chlorite gals/24H	CW Lowest level/24H		
	Polyaluminum chloride PPM/24H	Peak flow raw MGD/24H		
	Polymer PPM/24H	Peak flow eff MGD/24H		
	NaOH PPM/24H	Settled readings >2,0 NTU/24H		
	Chlorine PPM/24H			
	Carbon PPM/24H			
	Hydryfluosilicic acid PPM/24H			
	Zinc orthophosphate PPM/24H			
	Ferric chloride PPM/24H			
	Sodium chlorite PPM/24H			

Table 12.

ANN				Linear Model			
Temp Raw °C	Var45	1.087	1	Chlorine PPM/24H	Var24	1.44E+14	1
Turbidity Settled NTU	Var35	1.037	2	Polyaluminum chloride PPM/24H	Var21	1.44E+14	2
Chlorine mix mg/l	Var41	1.035	3	Hydrofluosilicic acid lbs/24H	Var11	1.4E+14	3
Chlorine Eff mg/l	Var44	1.029	4	Sodium Chlorite gals/24H	Var20	1.27E+14	4
Filters Washed/24H	Var3	1.021	5	Average % solids/liter	Var14	9.28E+13	5
Temp Eff °C	Var46	1.02	6	Zinc orthophosphate gals/24H	Var19	9.28E+13	6
Chlorine PPM/24H	Var24	1.016	7	Ferric chloride lbs/24H	Var13	6.24E+13	7
Hydryfluosilicic acid PPM/24H	Var26	1.015	8	Hydrofluosilicic acid gals/24H	Var18	6.24E+13	8
Fluoride avg.mg/l/24H	Var47	1.012	9	Polymer PPM/24H	Var22	4.79E+13	9
Air temp °C min/24H	Var54	1.011	10	Carbon PPM/24H	Var25	4.79E+13	10
CW Lowest level/24H	Var51	1.009	11	Hydryfluosilicic acid PPM/24H	Var26	2.61E+13	11
Sodium hydroxide gals/24H	Var17	1.008	12	NaOH PPM/24H	Var23	2.61E+13	12
Sysdel NS Midd MGD	Var33	1.008	13	Zinc orthophosphate lbs/24H	Var12	1.76E+13	13
Zinc orthophosphate lbs/24H	Var12	1.007	14	Sodium chlorite lbs/24H	Var9	1.34E+13	14
Chlorine CW mg/l	Var43	1.007	15	Sodium hydroxide lbs/24H	Var10	9.02E+12	15
pH Settled	Var39	1.006	16	Sodium hydroxide gals/24H	Var17	8.54E+12	16
Sysdel NS Main MGD	Var32	1.006	17	Polymer lbs/24H	Var7	5.05E+12	17
Raw MGD/24H	Var1	1.006	18	Polymer gals/24H	Var16	5.05E+12	18
Polyaluminum chloride PPM/24H	Var21	1.006	19	Temp Raw °C	Var45	1.47	19
Polymer lbs/24H	Var7	1.005	20	System Delivery MGD	Var2	1.208	20
System Delivery MGD	Var2	1.005	21	Sysdel NS Main MGD	Var32	1.202	21
Average % solids/liter	Var14	1.004	22	Raw MGD/24H	Var1	1.193	22
Hydrofluosilicic acid lbs/24H	Var11	1.003	23	Sysdel SR Midd MGD	Var31	1.134	23
Zinc orthophosphate PPM/24H	Var27	1.003	24	Sysdel SR Main MGD	Var30	1.088	24
pH Raw	Var37	1.002	25	Carbon lbs/24H	Var5	1.085	25
Turbidity Raw NTU	Var34	1.002	26	Zinc orthophosphate PPM/24H	Var27	1.083	26
NaOH PPM/24H	Var23	1.002	27	Polyaluminum chloride gals/24H	Var15	1.07	27
Air temp °C max/24H	Var55	1.002	28	Turbidity Settled NTU	Var35	1.065	28
Polyaluminum chloride lbs/24H	Var6	1.001	29	Ferric chloride PPM/24H	Var28	1.058	29
Sodium Chlorite gals/24H	Var20	1.001	30	Temp Eff °C	Var46	1.056	30
Hydrofluosilicic acid gals/24H	Var18	1.001	31	Air temp °C min/24H	Var54	1.04	31
Sodium chlorite lbs/24H	Var9	1.001	32	Chlorine lbs/24H	Var8	1.039	32
Ferric chloride PPM/24H	Var28	1.001	33	Chlorine mix mg/l	Var41	1.015	33
Ferric chloride lbs/24H	Var13	1.001	34	Fluoride avg.mg/l/24H	Var47	1.012	34
Peak flow eff MGD/24H	Var53	1.001	35	Polyaluminum chloride lbs/24H	Var6	1.011	35
Sodium chlorite PPM/24H	Var29	1.001	36	Air temp °C avg/24H	Var56	1.006	36
Polyaluminum chloride gals/24H	Var15	1.001	37	Filters Washed/24H	Var3	1.005	37
Chlorine Settled mg/l	Var42	1.001	38	Turbidity Raw NTU	Var34	1.005	38
Sodium hydroxide lbs/24H	Var10	1	39	Washwater MGD	Var4	1.004	39
Sysdel SR Main MGD	Var30	1	40	Peak flow eff MGD/24H	Var53	1.004	40
pH Effluent	Var40	1	41	pH Settled	Var39	1.003	41
Chlorine lbs/24H	Var8	1	42	Chlorine Settled mg/l	Var42	1.003	42
Sysdel SR Midd MGD	Var31	1	43	Peak flow raw MGD/24H	Var52	1.001	43
Carbon lbs/24H	Var5	1	44	pH Raw	Var37	1.001	44
Turbidities measured/24H	Var49	1	45	Chlorine Eff mg/l	Var44	1	45
Turbidities required/24H	Var48	1	46	NTU over limit	Var36	1	46
NTU over limit	Var36	1	47	Turbidities required/24H	Var48	1	47
Washwater MGD	Var4	1	48	Turbidities measured/24H	Var49	1	48
pH Mix	Var38	1	49	pH Mix	Var38	1	49
Peak flow raw MGD/24H	Var52	1	50	pH Effluent	Var40	1	50
Air temp °C avg/24H	Var56	1	51	Settled readings >2,0 NTU/24H	Var57	1	51
Chlorine lowest mg/l/24H	Var50	1	52	Chlorine lowest mg/l/24H	Var50	0.999	52
Zinc orthophosphate gals/24H	Var19	1	53	Air temp °C max/24H	Var55	0.997	53
Polymer PPM/24H	Var22	0.999	54	Sodium chlorite PPM/24H	Var29	0.997	54
Settled readings >2,0 NTU/24H	Var57	0.998	55	Sysdel NS Midd MGD	Var33	0.995	55
Polymer gals/24H	Var16	0.998	56	Chlorine CW mg/l	Var43	0.972	56
Carbon PPM/24H	Var25	0.998	57	CW Lowest level/24H	Var51	0.894	57

Table 13

ANN				Linear Model			
Turbidity Settled NTU	Var35	1.028	1	Polyaluminum chloride PPM/24H	Var21	5.57469E+13	1
pH Raw	Var37	1.015	2	Chlorine PPM/24H	Var24	5.57469E+13	2
NaOH PPM/24H	Var23	1.015	3	Hydrofluosilicic acid gals/24H	Var18	3.85179E+13	3
Chlorine mix mg/l	Var41	1.013	4	Ferric chloride lbs/24H	Var13	3.85179E+13	4
Temp Raw °C	Var45	1.012	5	Hydrofluosilicic acid lbs/24H	Var11	3.76786E+13	5
Chlorine PPM/24H	Var24	1.011	6	Zinc orthophosphate gals/24H	Var19	3.41211E+13	6
Raw MGD/24H	Var1	1.011	7	Average % solids/liter	Var14	3.41211E+13	7
Fluoride avg.mg/l/24H	Var47	1.01	8	Polymer gals/24H	Var16	2.40457E+13	8
Filters Washed/24H	Var3	1.007	9	Polymer lbs/24H	Var7	2.40457E+13	9
Polyaluminum chloride PPM/24H	Var21	1.007	10	Sodium hydroxide lbs/24H	Var10	2.39978E+13	10
Temp Eff °C	Var46	1.006	11	Hydryfluosilicic acid PPM/24H	Var26	1.90768E+13	11
Sysdel NS Midd MGD	Var33	1.006	12	NaOH PPM/24H	Var23	1.90768E+13	12
Chlorine Eff mg/l	Var44	1.006	13	Sodium chlorite lbs/24H	Var9	1.90596E+13	13
pH Settled	Var39	1.005	14	Sodium Chlorite gals/24H	Var20	1.86191E+13	14
Hydryfluosilicic acid PPM/24H	Var26	1.004	15	Zinc orthophosphate lbs/24H	Var12	1.44122E+13	15
Polyaluminum chloride lbs/24H	Var6	1.004	16	Polymer PPM/24H	Var22	1.28786E+13	16
Sysdel SR Main MGD	Var30	1.004	17	Carbon PPM/24H	Var25	1.28786E+13	17
Chlorine CW mg/l	Var43	1.004	18	Sodium hydroxide gals/24H	Var17	9.58553E+12	18
Air temp °C min/24H	Var54	1.002	19	Polyaluminum chloride lbs/24H	Var6	1.06	19
Chlorine lowest mg/l/24H	Var50	1.002	20	Sysdel SR Main MGD	Var30	1.049	20
Sysdel NS Main MGD	Var32	1.002	21	Temp Raw °C	Var45	1.023	21
Chlorine Settled mg/l	Var42	1.002	22	Sysdel SR Midd MGD	Var31	1.019	22
Sodium hydroxide gals/24H	Var17	1.002	23	Sysdel NS Main MGD	Var32	1.017	23
Hydrofluosilicic acid lbs/24H	Var11	1.001	24	System Delivery MGD	Var2	1.012	24
Sodium chlorite lbs/24H	Var9	1.001	25	Turbidity Settled NTU	Var35	1.011	25
Zinc orthophosphate gals/24H	Var19	1.001	26	CW Lowest level/24H	Var51	1.011	26
Peak flow raw MGD/24H	Var52	1.001	27	Polyaluminum chloride gals/24H	Var15	1.01	27
Sodium hydroxide lbs/24H	Var10	1.001	28	Temp Eff °C	Var46	1.008	28
Peak flow eff MGD/24H	Var53	1.001	29	Zinc orthophosphate PPM/24H	Var27	1.005	29
Polymer lbs/24H	Var7	1.001	30	Carbon lbs/24H	Var5	1.004	30
Average % solids/liter	Var14	1.001	31	Air temp °C min/24H	Var54	1.002	31
Ferric chloride lbs/24H	Var13	1	32	Air temp °C avg/24H	Var56	1.002	32
Carbon PPM/24H	Var25	1	33	Raw MGD/24H	Var1	1.002	33
System Delivery MGD	Var2	1	34	Peak flow raw MGD/24H	Var52	1.002	34
Sodium chlorite PPM/24H	Var29	1	35	Chlorine Settled mg/l	Var42	1.002	35
CW Lowest level/24H	Var51	1	36	Sodium chlorite PPM/24H	Var29	1.002	36
Polymer PPM/24H	Var22	1	37	pH Mix	Var38	1.001	37
Hydrofluosilicic acid gals/24H	Var18	1	38	Chlorine Eff mg/l	Var44	1.001	38
Polyaluminum chloride gals/24H	Var15	1	39	Ferric chloride PPM/24H	Var28	1.001	39
pH Mix	Var38	1	40	Turbidity Raw NTU	Var34	1.001	40
Sysdel SR Midd MGD	Var31	1	41	Sysdel NS Midd MGD	Var33	1	41
Washwater MGD	Var4	1	42	Fluoride avg.mg/l/24H	Var47	1	42
NTU over limit	Var36	1	43	Washwater MGD	Var4	1	43
Turbidities measured/24H	Var49	1	44	Air temp °C max/24H	Var55	1	44
Turbidities required/24H	Var48	1	45	Chlorine lbs/24H	Var8	1	45
Sodium Chlorite gals/24H	Var20	1	46	Turbidities measured/24H	Var49	1	46
Carbon lbs/24H	Var5	1	47	Turbidities required/24H	Var48	1	47
Polymer gals/24H	Var16	1	48	NTU over limit	Var36	1	48
Zinc orthophosphate lbs/24H	Var12	1	49	Settled readings >2,0 NTU/24H	Var57	1	49
Turbidity Raw NTU	Var34	1	50	Chlorine mix mg/l	Var41	1	50
Chlorine lbs/24H	Var8	0.999	51	pH Settled	Var39	1	51
Air temp °C avg/24H	Var56	0.999	52	Chlorine lowest mg/l/24H	Var50	0.999	52
Settled readings >2,0 NTU/24H	Var57	0.999	53	pH Raw	Var37	0.999	53
Zinc orthophosphate PPM/24H	Var27	0.999	54	Chlorine CW mg/l	Var43	0.999	54
Ferric chloride PPM/24H	Var28	0.998	55	Filters Washed/24H	Var3	0.998	55
Air temp °C max/24H	Var55	0.998	56	Peak flow eff MGD/24H	Var53	0.997	56
pH Effluent	Var40	0.996	57	pH Effluent	Var40	0.313	57

Table 14.

ANN				Linear Model			
Sodium chlorite lbs/24H	Var9	1.148	1	Average % solids/liter	Var14	6.22E+13	1
Chlorine mix mg/l	Var41	1.107	2	Zinc orthophosphate gals/24H	Var19	6.22E+13	2
Air temp °C min/24H	Var54	1.076	3	Polymer gals/24H	Var16	5.72E+13	3
Temp Raw °C	Var45	1.06	4	Polymer lbs/24H	Var7	5.72E+13	4
Turbidity Settled NTU	Var35	1.059	5	Hydrofluosilicic acid lbs/24H	Var11	5.12E+13	5
Air temp °C max/24H	Var55	1.057	6	Sodium hydroxide gals/24H	Var17	4.85E+13	6
Hydryfluosilicic acid PPM/24H	Var26	1.037	7	Chlorine PPM/24H	Var24	3.32E+13	7
Chlorine lbs/24H	Var8	1.037	8	Polyaluminum chloride PPM/24H	Var21	3.32E+13	8
System Delivery MGD	Var2	1.034	9	Sodium chlorite lbs/24H	Var9	3.07E+13	9
Chlorine CW mg/l	Var43	1.031	10	Sodium hydroxide lbs/24H	Var10	2.52E+13	10
Temp Eff °C	Var46	1.029	11	Hydrofluosilicic acid gals/24H	Var18	2.35E+13	11
pH Raw	Var37	1.027	12	Ferric chloride lbs/24H	Var13	2.35E+13	12
CW Lowest level/24H	Var51	1.026	13	Zinc orthophosphate lbs/24H	Var12	2.33E+13	13
Washwater MGD	Var4	1.024	14	Sodium Chlorite gals/24H	Var20	2.05E+13	14
Polyaluminum chloride PPM/24H	Var21	1.024	15	Carbon PPM/24H	Var25	1.58E+13	15
pH Settled	Var39	1.022	16	Polymer PPM/24H	Var22	1.58E+13	16
Sodium Chlorite gals/24H	Var20	1.02	17	Hydryfluosilicic acid PPM/24H	Var26	9.60E+12	17
Average % solids/liter	Var14	1.019	18	NaOH PPM/24H	Var23	9.60E+12	18
Sysdel SR Main MGD	Var30	1.018	19	Temp Raw °C	Var45	1.313	19
Filters Washed/24H	Var3	1.018	20	Temp Eff °C	Var46	1.146	20
Zinc orthophosphate PPM/24H	Var27	1.017	21	System Delivery MGD	Var2	1.114	21
Sodium hydroxide gals/24H	Var17	1.014	22	Raw MGD/24H	Var1	1.052	22
pH Mix	Var38	1.014	23	Turbidity Settled NTU	Var35	1.051	23
NaOH PPM/24H	Var23	1.014	24	Sysdel SR Midd MGD	Var31	1.043	24
Peak flow raw MGD/24H	Var52	1.014	25	Chlorine lbs/24H	Var8	1.029	25
Chlorine PPM/24H	Var24	1.012	26	Polyaluminum chloride gals/24H	Var15	1.027	26
Chlorine Settled mg/l	Var42	1.011	27	Carbon lbs/24H	Var5	1.024	27
Zinc orthophosphate gals/24H	Var19	1.011	28	Peak flow eff MGD/24H	Var53	1.023	28
Raw MGD/24H	Var1	1.011	29	Chlorine mix mg/l	Var41	1.02	29
Sodium hydroxide lbs/24H	Var10	1.009	30	Air temp °C avg/24H	Var56	1.015	30
Chlorine lowest mg/l/24H	Var50	1.007	31	Air temp °C max/24H	Var55	1.012	31
Polymer lbs/24H	Var7	1.006	32	Polyaluminum chloride lbs/24H	Var6	1.008	32
Settled readings >2,0 NTU/24H	Var57	1.005	33	Fluoride avg.mg/l/24H	Var47	1.007	33
Polymer PPM/24H	Var22	1.004	34	Chlorine Settled mg/l	Var42	1.006	34
Fluoride avg.mg/l/24H	Var47	1.004	35	Sysdel SR Main MGD	Var30	1.003	35
Polymer gals/24H	Var16	1.003	36	Air temp °C min/24H	Var54	1.003	36
Chlorine Eff mg/l	Var44	1.003	37	Peak flow raw MGD/24H	Var52	1.002	37
Turbidity Raw NTU	Var34	1.003	38	Sodium chlorite PPM/24H	Var29	1.001	38
Peak flow eff MGD/24H	Var53	1.003	39	Sysdel NS Main MGD	Var32	1.001	39
Air temp °C avg/24H	Var56	1.003	40	pH Raw	Var37	1.001	40
Sysdel NS Main MGD	Var32	1.003	41	Ferric chloride PPM/24H	Var28	1.001	41
Carbon PPM/24H	Var25	1.002	42	pH Mix	Var38	1.001	42
Polyaluminum chloride gals/24H	Var15	1.002	43	Chlorine lowest mg/l/24H	Var50	1	43
Hydrofluosilicic acid gals/24H	Var18	1.001	44	Settled readings >2,0 NTU/24H	Var57	1	44
Polyaluminum chloride lbs/24H	Var6	1.001	45	NTU over limit	Var36	1	45
Sysdel NS Midd MGD	Var33	1.001	46	Turbidities measured/24H	Var49	1	46
Hydrofluosilicic acid lbs/24H	Var11	1.001	47	Turbidities required/24H	Var48	1	47
Ferric chloride lbs/24H	Var13	1	48	Sysdel NS Midd MGD	Var33	1	48
Sodium chlorite PPM/24H	Var29	1	49	Chlorine Eff mg/l	Var44	1	49
Turbidities required/24H	Var48	1	50	Filters Washed/24H	Var3	1	50
NTU over limit	Var36	1	51	Turbidity Raw NTU	Var34	1	51
Turbidities measured/24H	Var49	1	52	pH Settled	Var39	0.999	52
pH Effluent	Var40	1	53	Washwater MGD	Var4	0.998	53
Sysdel SR Midd MGD	Var31	0.999	54	Zinc orthophosphate PPM/24H	Var27	0.998	54
Carbon lbs/24H	Var5	0.999	55	Chlorine CW mg/l	Var43	0.989	55
Zinc orthophosphate lbs/24H	Var12	0.999	56	CW Lowest level/24H	Var51	0.974	56
Ferric chloride PPM/24H	Var28	0.995	57	pH Effluent	Var40	0.619	57

Table 15.

Turbidity			TurbidityReduced		
Temp Raw °C	1.087	1	Temp Raw °C	2.059332	1
Turbidity Settled NTU	1.03699	2	Temp Eff °C	1.620327	2
Chlorine mix mg/l	1.03483	3	Turbidity Settled NTU	1.126475	3
Chlorine Eff mg/l	1.02858	4	Hydryfluosilicic acid PPM/24H	1.062644	4
Filters Washed/24H	1.020621	5	Filters Washed/24H	1.059522	5
Temp Eff °C	1.02025	6	Chlorine PPM/24H	1.056567	6
Chlorine PPM/24H	1.01637	7	Chlorine mix mg/l	1.051521	7
Hydryfluosilicic acid PPM/24H	1.01506	8	Fluoride avg.mg/l/24H	1.047177	8
Fluoride avg.mg/l/24H	1.01173	9	Air temp °C min/24H	1.035181	9
Air temp °C min/24H	1.01104	10	Chlorine Eff mg/l	0.99799	10

Highest Turbidity			Highest Turbidity Reduced		
Turbidity Settled NTU	1.02825	1	Temp Raw °C	1.172367	1
pH Raw	1.01506	2	Turbidity Settled NTU	1.070007	2
NaOH PPM/24H	1.01502	3	Chlorine PPM/24H	1.038624	3
Chlorine mix mg/l	1.01294	4	NaOH PPM/24H	1.035102	4
Temp Raw °C	1.01199	5	Chlorine mix mg/l	1.033076	5
Chlorine PPM/24H	1.01144	6	Filters Washed/24H	1.018472	6
Raw MGD/24H	1.011406	7	Raw MGD/24H	1.01644	7
Fluoride avg.mg/l/24H	1.01024	8	Fluoride avg.mg/l/24H	1.009059	8
Filters Washed/24H	1.006998	9	pH Raw	1.003328	9

Readings			Readings Reduced		
Sodium chlorite lbs/24H	1.147799	1	Temp Raw °C	1.257054	1
Chlorine mix mg/l	1.107004	2	Hydryfluosilicic acid PPM/24H	1.182786	2
Air temp °C min/24H	1.075601	3	Turbidity Settled NTU	1.11108	3
Temp Raw °C	1.059846	4	Chlorine mix mg/l	1.107227	4
Turbidity Settled NTU	1.058936	5	Air temp °C min/24H	1.084027	5
Air temp °C max/24H	1.056682	6	System Delivery MGD	1.053657	6
Hydryfluosilicic acid PPM/24H	1.037087	7	Chlorine lbs/24H	1.038624	7
Chlorine lbs/24H	1.036777	8	Sodium chlorite lbs/24H	1.036901	8
System Delivery MGD	1.034205	9	Air temp °C max/24H	1.009533	9
Chlorine CW mg/l	1.031279	10	Chlorine CW mg/l	0.99912	10

Table 16.

Turbidity				FewerTurbidity			
Temp Raw °C	Var45	1.087	1	Temp Raw °C	Var45	1.177	1
Turbidity Settled NTU	Var35	1.037	2	Temp Eff °C	Var46	1.118	2
Chlorine mix mg/l	Var41	1.035	3	Turbidity Settled NTU	Var35	1.101	3
Chlorine Eff mg/l	Var44	1.029	4	Hydryfluosilicic acid PPM/24H	Var26	1.095	4
Filters Washed/24H	Var3	1.021	5	System Delivery MGD	Var2	1.077	5
Temp Eff °C	Var46	1.02	6	Sodium hydroxide gals/24H	Var17	1.046	6
Chlorine PPM/24H	Var24	1.016	7	Chlorine mix mg/l	Var41	1.041	7
Hydryfluosilicic acid PPM/24H	Var26	1.015	8	Filters Washed/24H	Var3	1.04	8
Fluoride avg.mg/l/24H	Var47	1.012	9	Sysdel NS Main MGD	Var32	1.031	9
Air temp °C min/24H	Var54	1.011	10	Fluoride avg.mg/l/24H	Var47	1.025	10
CW Lowest level/24H	Var51	1.009	11	Polyaluminum chloride PPM/24H	Var21	1.025	11
Sodium hydroxide gals/24H	Var17	1.008	12	Turbidity Raw NTU	Var34	1.024	12
Sysdel NS Midd MGD	Var33	1.008	13	pH Settled	Var39	1.022	13
Zinc orthophosphate lbs/24H	Var12	1.007	14	Sysdel NS Midd MGD	Var33	1.022	14
Chlorine CW mg/l	Var43	1.007	15	Zinc orthophosphate PPM/24H	Var27	1.021	15
pH Settled	Var39	1.006	16	Air temp °C min/24H	Var54	1.019	16
Sysdel NS Main MGD	Var32	1.006	17	Chlorine PPM/24H	Var24	1.018	17
Raw MGD/24H	Var1	1.006	18	Polymer lbs/24H	Var7	1.017	18
Polyaluminum chloride PPM/24H	Var21	1.006	19	NaOH PPM/24H	Var23	1.016	19
Polymer lbs/24H	Var7	1.005	20	Raw MGD/24H	Var1	1.015	20
System Delivery MGD	Var2	1.005	21	Zinc orthophosphate lbs/24H	Var12	1.014	21
Average % solids/liter	Var14	1.004	22	pH Raw	Var37	1.011	22
Hydrofluosilicic acid lbs/24H	Var11	1.003	23	Sodium chlorite lbs/24H	Var9	1.01	23
Zinc orthophosphate PPM/24H	Var27	1.003	24	Hydrofluosilicic acid lbs/24H	Var11	1.009	24
pH Raw	Var37	1.002	25	CW Lowest level/24H	Var51	1.007	25
Turbidity Raw NTU	Var34	1.002	26	Polyaluminum chloride lbs/24H	Var6	1.007	26
NaOH PPM/24H	Var23	1.002	27	Chlorine Eff mg/l	Var44	1.005	27
Air temp °C max/24H	Var55	1.002	28	Hydrofluosilicic acid gals/24H	Var18	1.004	28
Polyaluminum chloride lbs/24H	Var6	1.001	29	Average % solids/liter	Var14	1.001	29
Sodium Chlorite gals/24H	Var20	1.001	30	Sodium Chlorite gals/24H	Var20	1.001	30
Hydrofluosilicic acid gals/24H	Var18	1.001	31	Air temp °C max/24H	Var55	1	31
Sodium chlorite lbs/24H	Var9	1.001	32	Chlorine CW mg/l	Var43	0.999	32

Table 17.

EffHighest				EffHighest Fewer			
Turbidity Settled NTU	Var35	1.028	1	Temp Raw °C	Var45	1.123	1
pH Raw	Var37	1.015	2	Turbidity Settled NTU	Var35	1.049	2
NaOH PPM/24H	Var23	1.015	3	Hydrofluosilicic acid lbs/24H	Var11	1.045	3
Chlorine mix mg/l	Var41	1.013	4	Hydryfluosilicic acid PPM/24H	Var26	1.044	4
Temp Raw °C	Var45	1.012	5	Polyaluminum chloride PPM/24H	Var21	1.044	5
Chlorine PPM/24H	Var24	1.011	6	Raw MGD/24H	Var1	1.028	6
Raw MGD/24H	Var1	1.011	7	Temp Eff °C	Var46	1.024	7
Fluoride avg.mg/l/24H	Var47	1.01	8	Chlorine mix mg/l	Var41	1.02	8
Filters Washed/24H	Var3	1.007	9	Chlorine CW mg/l	Var43	1.017	9
Polyaluminum chloride PPM/24H	Var21	1.007	10	Sodium hydroxide lbs/24H	Var10	1.016	10
Temp Eff °C	Var46	1.006	11	Peak flow raw MGD/24H	Var52	1.015	11
Sysdel NS Midd MGD	Var33	1.006	12	Filters Washed/24H	Var3	1.014	12
Chlorine Eff mg/l	Var44	1.006	13	Air temp °C min/24H	Var54	1.01	13
pH Settled	Var39	1.005	14	pH Raw	Var37	1.009	14
Hydryfluosilicic acid PPM/24H	Var26	1.004	15	Sysdel NS Main MGD	Var32	1.009	15
Polyaluminum chloride lbs/24H	Var6	1.004	16	Sysdel NS Midd MGD	Var33	1.008	16
Sysdel SR Main MGD	Var30	1.004	17	Chlorine PPM/24H	Var24	1.007	17
Chlorine CW mg/l	Var43	1.004	18	Fluoride avg.mg/l/24H	Var47	1.007	18
Air temp °C min/24H	Var54	1.002	19	NaOH PPM/24H	Var23	1.006	19
Chlorine lowest mg/l/24H	Var50	1.002	20	Sodium chlorite lbs/24H	Var9	1.005	20
Sysdel NS Main MGD	Var32	1.002	21	Chlorine Eff mg/l	Var44	1.005	21
Chlorine Settled mg/l	Var42	1.002	22	Chlorine Settled mg/l	Var42	1.004	22
Sodium hydroxide gals/24H	Var17	1.002	23	Sodium hydroxide gals/24H	Var17	1.004	23
Hydrofluosilicic acid lbs/24H	Var11	1.001	24	Sysdel SR Main MGD	Var30	1.003	24
Sodium chlorite lbs/24H	Var9	1.001	25	pH Settled	Var39	1.002	25
Zinc orthophosphate gals/24H	Var19	1.001	26	Polyaluminum chloride lbs/24H	Var6	1.001	26
Peak flow raw MGD/24H	Var52	1.001	27	Chlorine lowest mg/l/24H	Var50	1	27
Sodium hydroxide lbs/24H	Var10	1.001	28	Zinc orthophosphate gals/24H	Var19	0.994	28

Table 18.

Readings				Readings Fewer			
Sodium chlorite lbs/24H	Var9	1.148	1	Temp Raw °C	Var45	1.164	1
Chlorine mix mg/l	Var41	1.107	2	Turbidity Settled NTU	Var35	1.131	2
Air temp °C min/24H	Var54	1.076	3	Sodium hydroxide lbs/24H	Var10	1.093	3
Temp Raw °C	Var45	1.06	4	Temp Eff °C	Var46	1.087	4
Turbidity Settled NTU	Var35	1.059	5	Polyaluminum chloride PPM/24H	Var21	1.084	5
Air temp °C max/24H	Var55	1.057	6	Chlorine mix mg/l	Var41	1.079	6
Hydryfluosilicic acid PPM/24H	Var26	1.037	7	NaOH PPM/24H	Var23	1.052	7
Chlorine lbs/24H	Var8	1.037	8	Sodium hydroxide gals/24H	Var17	1.049	8
System Delivery MGD	Var2	1.034	9	Air temp °C min/24H	Var54	1.041	9
Chlorine CW mg/l	Var43	1.031	10	Raw MGD/24H	Var1	1.026	10
Temp Eff °C	Var46	1.029	11	Chlorine Settled mg/l	Var42	1.017	11
pH Raw	Var37	1.027	12	Zinc orthophosphate PPM/24H	Var27	1.017	12
CW Lowest level/24H	Var51	1.026	13	Average % solids/liter	Var14	1.014	13
Washwater MGD	Var4	1.024	14	Chlorine lbs/24H	Var8	1.01	14
Polyaluminum chloride PPM/24H	Var21	1.024	15	Hydryfluosilicic acid PPM/24H	Var26	1.01	15
pH Settled	Var39	1.022	16	pH Raw	Var37	1.009	16
Sodium Chlorite gals/24H	Var20	1.02	17	Chlorine CW mg/l	Var43	1.008	17
Average % solids/liter	Var14	1.019	18	Sodium chlorite lbs/24H	Var9	1.008	18
Sysdel SR Main MGD	Var30	1.018	19	Zinc orthophosphate gals/24H	Var19	1.007	19
Filters Washed/24H	Var3	1.018	20	Sodium Chlorite gals/24H	Var20	1.003	20
Zinc orthophosphate PPM/24H	Var27	1.017	21	Peak flow raw MGD/24H	Var52	1.003	21
Sodium hydroxide gals/24H	Var17	1.014	22	pH Mix	Var38	1.002	22
pH Mix	Var38	1.014	23	Chlorine PPM/24H	Var24	1.002	23
NaOH PPM/24H	Var23	1.014	24	Air temp °C max/24H	Var55	1.002	24
Peak flow raw MGD/24H	Var52	1.014	25	Settled readings >2,0 NTU/24H	Var57	1.001	25
Chlorine PPM/24H	Var24	1.012	26	Polymer lbs/24H	Var7	1.001	26
Chlorine Settled mg/l	Var42	1.011	27	System Delivery MGD	Var2	1.001	27
Zinc orthophosphate gals/24H	Var19	1.011	28	CW Lowest level/24H	Var51	1	28
Raw MGD/24H	Var1	1.011	29	pH Settled	Var39	1	29
Sodium hydroxide lbs/24H	Var10	1.009	30	Filters Washed/24H	Var3	1	30
Chlorine lowest mg/l/24H	Var50	1.007	31	Chlorine lowest mg/l/24H	Var50	0.998	31
Polymer lbs/24H	Var7	1.006	32	Sysdel SR Main MGD	Var30	0.997	32
Settled readings >2,0 NTU/24H	Var57	1.005	33	Washwater MGD	Var4	0.994	33

Table 19.

Spring		
Raw MGD/24H	1.002306	25
System Delivery MGD	1.006145	17
Filters Washed/24H	0.99928	44
Washwater MGD	1.013835	7
Carbon lbs/24H	0.998833	46
Polyaluminum chloride lbs/24H	0.99572	52
Polymer lbs/24H	1.026545	4
Chlorine lbs/24H	1.003496	23
Sodium chlorite lbs/24H	1	36
Sodium hydroxide lbs/24H	0.990162	56
Hydrofluosilicic acid lbs/24H	1	37
Zinc orthophosphate lbs/24H	1.004501	21
Ferric chloride lbs/24H	1.000053	34
Average % solids/liter	0.995073	53
Polyaluminum chloride gals/24H	1	38
Polymer gals/24H	0.998863	45
Sodium hydroxide gals/24H	0.990264	55
Hydrofluosilicic acid gals/24H	1.006313	16
Zinc orthophosphate gals/24H	1.001197	31
Sodium Chlorite gals/24H	1	41
Polyaluminum chloride PPM/24H	1.001919	27
Polymer PPM/24H	1.005408	19
NaOH PPM/24H	1.002202	26
Chlorine PPM/24H	1.001224	29
Carbon PPM/24H	1.000763	32
Hydryfluosilicic acid PPM/24H	1.007461	14
Zinc orthophosphate PPM/24H	1.009778	10
Ferric chloride PPM/24H	0.996537	49
Sodium chlorite PPM/24H	1.001249	28
Sysdel SR Main MGD	1.005316	20
Sysdel SR Midd MGD	1	42
Sysdel NS Main MGD	1	40
Sysdel NS Midd MGD	1.016572	6
Turbidity Raw NTU	1.007114	15
Turbidity Settled NTU	1.008022	13
NTU over limit	1	35
pH Raw	0.983731	57
pH Mix	1.0081	12
pH Settled	1.013116	8
pH Effluent	1.045771	2
Chlorine mix mg/l	1.000377	33
Chlorine Settled mg/l	0.997358	48
Chlorine CW mg/l	1.00432	22
Chlorine Eff mg/l	1.002306	24
Temp Raw °C	1.110257	1
Temp Eff °C	1.01039	9
Fluoride avg.mg/l/24H	0.993047	54
Turbidities required/24H	1	43
Turbidities measured/24H	1	39
Chlorine lowest mg/l/24H	1.001211	30
CW Lowest level/24H	0.998405	47
Peak flow raw MGD/24H	0.995774	51
Peak flow eff MGD/24H	1.005988	18
Air temp °C min/24H	0.995844	50
Air temp °C max/24H	1.040954	3
Air temp °C avg/24H	1.00867	11
Settled readings >2,0 NTU/24H	1.024493	5

Summer		
Raw MGD/24H	0.999027	45
System Delivery MGD	1.047182	4
Filters Washed/24H	0.989807	51
Washwater MGD	0.969856	57
Carbon lbs/24H	0.991074	50
Polyaluminum chloride lbs/24H	0.994011	49
Polymer lbs/24H	0.996817	46
Chlorine lbs/24H	1.004011	28
Sodium chlorite lbs/24H	1	34
Sodium hydroxide lbs/24H	0.995966	48
Hydrofluosilicic acid lbs/24H	1	42
Zinc orthophosphate lbs/24H	1.006269	24
Ferric chloride lbs/24H	0.996493	47
Average % solids/liter	0.985673	55
Polyaluminum chloride gals/24H	1	41
Polymer gals/24H	1.002142	30
Sodium hydroxide gals/24H	0.989799	52
Hydrofluosilicic acid gals/24H	1.010261	21
Zinc orthophosphate gals/24H	1.01433	16
Sodium Chlorite gals/24H	1	36
Polyaluminum chloride PPM/24H	0.988726	54
Polymer PPM/24H	1.004398	26
NaOH PPM/24H	1.010266	20
Chlorine PPM/24H	1.03376	8
Carbon PPM/24H	1.012253	17
Hydryfluosilicic acid PPM/24H	1.00121	32
Zinc orthophosphate PPM/24H	1.002666	29
Ferric chloride PPM/24H	1.036687	6
Sodium chlorite PPM/24H	0.999645	44
Sysdel SR Main MGD	0.989037	53
Sysdel SR Midd MGD	1	39
Sysdel NS Main MGD	1	37
Sysdel NS Midd MGD	1.008351	22
Turbidity Raw NTU	1.045224	5
Turbidity Settled NTU	1.022947	10
NTU over limit	1	35
pH Raw	1.023091	9
pH Mix	1.011478	18
pH Settled	1.021624	12
pH Effluent	1.004095	27
Chlorine mix mg/l	1.053566	3
Chlorine Settled mg/l	1.035029	7
Chlorine CW mg/l	1.001795	31
Chlorine Eff mg/l	1.017503	13
Temp Raw °C	1.09897	1
Temp Eff °C	1.077648	2
Fluoride avg.mg/l/24H	1.011292	19
Turbidities required/24H	1	40
Turbidities measured/24H	1	38
Chlorine lowest mg/l/24H	0.999812	43
CW Lowest level/24H	1.000888	33
Peak flow raw MGD/24H	1.016943	14
Peak flow eff MGD/24H	1.004897	25
Air temp °C min/24H	1.0223	11
Air temp °C max/24H	0.975053	56
Air temp °C avg/24H	1.007559	23
Settled readings >2,0 NTU/24H	1.014751	15

Table 20.

Fall		
Raw MGD/24H	1.026485	9
System Delivery MGD	1.003694	34
Filters Washed/24H	1.051514	4
Washwater MGD	1.00817	27
Carbon lbs/24H	1.000578	42
Polyaluminum chloride lbs/24H	0.999179	49
Polymer lbs/24H	1.004173	33
Chlorine lbs/24H	1.011919	19
Sodium chlorite lbs/24H	1.010045	23
Sodium hydroxide lbs/24H	1.008144	28
Hydrofluosilicic acid lbs/24H	0.998326	50
Zinc orthophosphate lbs/24H	0.999758	48
Ferric chloride lbs/24H	1.021616	13
Average % solids/liter	1.009951	24
Polyaluminum chloride gals/24H	1.002943	37
Polymer gals/24H	1.022617	12
Sodium hydroxide gals/24H	1.001408	41
Hydrofluosilicic acid gals/24H	1.004396	32
Zinc orthophosphate gals/24H	0.991714	57
Sodium Chlorite gals/24H	1.002578	39
Polyaluminum chloride PPM/24H	1.022848	11
Polymer PPM/24H	1.011611	20
NaOH PPM/24H	1.014686	16
Chlorine PPM/24H	1.007826	29
Carbon PPM/24H	1.008228	26
Hydryfluosilicic acid PPM/24H	1.048858	5
Zinc orthophosphate PPM/24H	1.012671	18
Ferric chloride PPM/24H	1.001455	40
Sodium chlorite PPM/24H	0.997837	53
Sysdel SR Main MGD	0.997627	54
Sysdel SR Midd MGD	1.008305	25
Sysdel NS Main MGD	1.077267	3
Sysdel NS Midd MGD	1.003635	35
Turbidity Raw NTU	1.030981	7
Turbidity Settled NTU	0.997885	52
NTU over limit	1	44
pH Raw	1.039871	6
pH Mix	1.005546	31
pH Settled	0.996641	56
pH Effluent	1.030239	8
Chlorine mix mg/l	1.018322	15
Chlorine Settled mg/l	1.026049	10
Chlorine CW mg/l	1.000391	43
Chlorine Eff mg/l	1.010704	22
Temp Raw °C	0.997307	55
Temp Eff °C	1.00296	36
Fluoride avg.mg/l/24H	1.090768	2
Turbidities required/24H	1	46
Turbidities measured/24H	1	45
Chlorine lowest mg/l/24H	1.014471	17
CW Lowest level/24H	1.010755	21
Peak flow raw MGD/24H	0.998231	51
Peak flow eff MGD/24H	1.021165	14
Air temp °C min/24H	0.9998	47
Air temp °C max/24H	1.006389	30
Air temp °C avg/24H	1.097822	1
Settled readings >2,0 NTU/24H	1.002811	38

Winter		
Raw MGD/24H	1.009727	8
System Delivery MGD	0.998755	45
Filters Washed/24H	0.996912	51
Washwater MGD	1.017212	5
Carbon lbs/24H	0.989615	57
Polyaluminum chloride lbs/24H	0.993328	54
Polymer lbs/24H	1.001831	23
Chlorine lbs/24H	1.000554	33
Sodium chlorite lbs/24H	1.000801	30
Sodium hydroxide lbs/24H	1.003299	20
Hydrofluosilicic acid lbs/24H	1.001048	28
Zinc orthophosphate lbs/24H	0.999595	43
Ferric chloride lbs/24H	1.005235	16
Average % solids/liter	1.010599	7
Polyaluminum chloride gals/24H	1	39
Polymer gals/24H	1.000485	34
Sodium hydroxide gals/24H	1.001852	22
Hydrofluosilicic acid gals/24H	1.000324	35
Zinc orthophosphate gals/24H	0.998477	47
Sodium Chlorite gals/24H	1.002221	21
Polyaluminum chloride PPM/24H	0.990371	56
Polymer PPM/24H	1.000655	31
NaOH PPM/24H	1.001579	25
Chlorine PPM/24H	0.995315	52
Carbon PPM/24H	1.001469	26
Hydryfluosilicic acid PPM/24H	1.000963	29
Zinc orthophosphate PPM/24H	1.009474	9
Ferric chloride PPM/24H	0.994165	53
Sodium chlorite PPM/24H	1.001716	24
Sysdel SR Main MGD	1.011355	6
Sysdel SR Midd MGD	1	42
Sysdel NS Main MGD	0.997409	48
Sysdel NS Midd MGD	0.997226	50
Turbidity Raw NTU	1.003757	19
Turbidity Settled NTU	1.043882	1
NTU over limit	1	41
pH Raw	1.004953	17
pH Mix	1.005659	15
pH Settled	1.006482	14
pH Effluent	1.001146	27
Chlorine mix mg/l	1.007065	13
Chlorine Settled mg/l	1.007726	11
Chlorine CW mg/l	1.004432	18
Chlorine Eff mg/l	1.000154	37
Temp Raw °C	0.99889	44
Temp Eff °C	1.021741	4
Fluoride avg.mg/l/24H	1.00059	32
Turbidities required/24H	1	38
Turbidities measured/24H	1	40
Chlorine lowest mg/l/24H	1.027784	3
CW Lowest level/24H	1.007278	12
Peak flow raw MGD/24H	0.998678	46
Peak flow eff MGD/24H	1.040706	2
Air temp °C min/24H	0.992514	55
Air temp °C max/24H	1.000185	36
Air temp °C avg/24H	0.997279	49
Settled readings >2,0 NTU/24H	1.008538	10

APPENDIX C-1

PVWC MODELING
Classification Modeling Results

Table 1. Comparison of measured Chlorophytes counts against ANN One-week Ahead Class-predicted values at Station 101 without Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1	368	>200	Correct	49	8	0-10	Correct
2	28	11-50	Correct	50	16	11-50	Correct
3	64	51-200	Correct	51	8	0-10	Correct
4	204	>200	Correct	52	4	0-10	Correct
5	124	51-200	Correct	53	24	11-50	Correct
6	420	>200	Correct	54	4	0-10	Correct
7	252	>200	Correct	55	16	11-50	Correct
8	32	0-10	Incorrect	56	72	51-200	Correct
9	8	0-10	Correct	57	84	51-200	Correct
10	0	0-10	Correct	58	84	51-200	Correct
11	12	11-50	Correct	59	304	>200	Correct
12	4	0-10	Correct	60	4	0-10	Correct
13	0	0-10	Correct	61	0	0-10	Correct
14	12	11-50	Correct	62	8	0-10	Correct
15	0	0-10	Correct	63	16	11-50	Correct
16	4	0-10	Correct	64	8	0-10	Correct
17	0	0-10	Correct	65	28	11-50	Correct
18	4	0-10	Correct	66	28	11-50	Correct
19	0	0-10	Correct	67	36	11-50	Correct
20	4	0-10	Correct	68	52	51-200	Correct
21	0	0-10	Correct	69	52	51-200	Correct
22	0	0-10	Correct	70	12	11-50	Correct
23	0	0-10	Correct	71	8	0-10	Correct
24	0	0-10	Correct	72	0	0-10	Correct
25	0	0-10	Correct	73	4	0-10	Correct
26	0	0-10	Correct	74	0	0-10	Correct
27	20	11-50	Correct	75	16	11-50	Correct
28	0	0-10	Correct	76	16	11-50	Correct
29	68	51-200	Correct	77	8	0-10	Correct
30	260	>200	Correct	78	12	11-50	Correct
31	180	51-200	Correct	79	4	0-10	Correct
32	164	51-200	Correct	80	4	0-10	Correct
33	108	51-200	Correct	81	0	0-10	Correct
34	120	51-200	Correct	82	0	0-10	Correct
35	32	11-50	Correct	83	0	0-10	Correct
36	24	11-50	Correct	84	0	0-10	Correct
37	20	11-50	Correct	85	0	0-10	Correct
38	32	11-50	Correct	86	8	0-10	Correct
39	52	51-200	Correct	87	24	11-50	Correct
40	72	51-200	Correct	88	52	51-200	Correct
41	140	51-200	Correct	89	12	11-50	Correct
42	320	>200	Correct	90	12	11-50	Correct
43	148	51-200	Correct	91	8	0-10	Correct
44	76	51-200	Correct	92	0	0-10	Correct
45	60	51-200	Correct	93	4	0-10	Correct
46	36	11-50	Correct	94	0	0-10	Correct
47	20	11-50	Correct	95	0	0-10	Correct
48	8	0-10	Correct	96	4	0-10	Correct

Table 2. Comparison of measured Chlorophytes counts against ANN One-week Ahead Class-predicted values at Station 101 with Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1	4	0-10	Correct	25	24	11-50	Correct
2	0	0-10	Correct	26	4	0-10	Correct
3	12	11-50	Correct	27	16	11-50	Correct
4	0	0-10	Correct	28	72	51-200	Correct
5	0	0-10	Correct	29	84	51-200	Correct
6	0	0-10	Correct	30	84	51-200	Correct
7	68	51-200	Correct	31	152	51-200	Correct
8	164	51-200	Correct	32	144	51-200	Correct
9	84	51-200	Correct	33	304	>200	Correct
10	52	51-200	Correct	34	176	51-200	Correct
11	76	51-200	Correct	35	92	51-200	Correct
12	64	51-200	Correct	36	284	>200	Correct
13	20	11-50	Correct	37	284	>200	Correct
14	0	0-10	Correct	38	0	0-10	Correct
15	8	0-10	Correct	39	8	0-10	Correct
16	8	0-10	Correct	40	28	11-50	Correct
17	40	11-50	Correct	41	12	11-50	Correct
18	28	11-50	Correct	42	0	0-10	Correct
19	32	11-50	Correct	43	16	11-50	Correct
20	16	11-50	Correct	44	4	0-10	Correct
21	8	0-10	Correct	45	0	0-10	Correct
22	0	0-10	Correct	46	24	11-50	Correct
23	4	0-10	Correct	47	0	0-10	Correct
24	4	0-10	Correct				

Table 3. Comparison of measured Chrysophytes counts against ANN One-week Ahead class-predicted values Station at 612 without Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1	324	>200	Correct	45	12	11-50	Correct
2	300	>200	Correct	46	28	11-50	Correct
3*	232	51-200	Incorrect	47	32	11-50	Correct
4	64	51-200	Correct	48	44	11-50	Correct
5	60	51-200	Correct	49	20	11-50	Correct
6	320	>200	Correct	50	40	11-50	Correct
7	500	>200	Correct	51	60	51-200	Correct
8	280	>200	Correct	52	92	51-200	Correct
9	84	51-200	Correct	53	16	11-50	Correct
10	44	51-200	Incorrect	54	20	11-50	Correct
11	344	>200	Correct	55	68	51-200	Correct
12	236	>200	Correct	56	100	51-200	Correct
13	212	>200	Correct	57	88	51-200	Correct
14*	84	>200	Incorrect	58	60	51-200	Correct
15	28	51-200	Incorrect	59	64	51-200	Correct
16	112	51-200	Correct	60	80	51-200	Correct
17	64	51-200	Correct	61	88	51-200	Correct
18*	4	51-200	Incorrect	62	128	51-200	Correct
19	112	51-200	Correct	63	152	51-200	Correct
20	152	51-200	Correct	64*	212	51-200	Incorrect
21	152	51-200	Correct	65	168	51-200	Correct
22	108	51-200	Correct	66	176	51-200	Correct
23	56	51-200	Correct	67	108	51-200	Correct
24	12	11-50	Correct	68	168	51-200	Correct
25	40	11-50	Correct	69	92	>200	Incorrect
26	72	51-200	Incorrect	70	72	51-200	Correct
27	24	11-50	Correct	71	108	51-200	Correct
28	80	51-200	Correct	72	100	51-200	Correct
29	56	51-200	Correct	73	56	51-200	Correct
30	152	51-200	Correct	74	76	51-200	Correct
31	68	51-200	Correct	75	76	51-200	Correct
32	120	51-200	Correct	76	68	51-200	Correct
33	136	51-200	Correct	77	84	51-200	Correct
34	192	51-200	Correct	78	88	51-200	Correct
35	136	51-200	Correct	79	84	51-200	Correct
36	152	51-200	Correct	80	56	51-200	Correct
37	208	>200	Correct	81	48	51-200	Correct
38	320	>200	Correct	82	68	51-200	Correct
39	164	51-200	Correct	83	200	51-200	Incorrect
40	80	51-200	Correct	84	100	51-200	Correct
41*	156	>200	Incorrect	85*	44	51-200	Incorrect
42	116	51-200	Correct	86	44	11-50	Correct
43	52	51-200	Correct	87	28	11-50	Correct
44	128	51-200	Correct	88	40	11-50	Correct

Table 3. Comparison of measured Chrysophytes counts against ANN One-week Ahead class-predicted values Station at 612 without Chemical Inputs (continuation)

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
89	28	11-50	Correct	132	28	11-50	Correct
90	48	11-50	Correct	133	40	11-50	Correct
91	80	51-200	Correct	134	48	11-50	Correct
92	72	51-200	Correct	135	24	11-50	Correct
93	4	51-200	Incorrect	136	24	11-50	Correct
94*	4	11-50	Incorrect	137	20	11-50	Correct
95	8	11-50	Incorrect	138	12	11-50	Correct
96	32	11-50	Correct	139	20	11-50	Correct
97	68	51-200	Correct	140*	28	51-200	Incorrect
98	84	51-200	Correct	141	16	11-50	Correct
99	84	51-200	Correct	142	8	11-50	Incorrect
100	56	51-200	Correct	143	20	11-50	Correct
101	108	51-200	Correct	144	16	11-50	Correct
102	140	51-200	Correct	145	8	11-50	Incorrect
103	108	51-200	Correct	146	28	11-50	Correct
104	84	51-200	Correct	147	32	11-50	Correct
105	76	51-200	Correct	148*	8	11-50	Incorrect
106	56	51-200	Correct	149	24	11-50	Correct
107	44	11-50	Correct	150	12	11-50	Correct
108	56	51-200	Correct	151	8	11-50	Incorrect
109	32	51-200	Incorrect	152	12	11-50	Correct
110	120	51-200	Correct	153	8	11-50	Incorrect
111	32	51-200	Incorrect	154	4	11-50	Incorrect
112	52	51-200	Correct	155	36	11-50	Correct
113	68	51-200	Correct	156	28	11-50	Correct
114*	16	51-200	Incorrect	157	8	11-50	Incorrect
115	8	51-200	Incorrect	158	32	11-50	Correct
116	36	11-50	Correct	159	24	11-50	Correct
117	24	11-50	Correct	160*	0	11-50	Incorrect
118	24	11-50	Correct	161	36	11-50	Correct
119	40	11-50	Correct	162	36	11-50	Correct
120	24	11-50	Correct	163	28	11-50	Correct
121	32	11-50	Correct	164	32	11-50	Correct
122	32	11-50	Correct	165	32	11-50	Correct
123	4	11-50	Incorrect	166	32	11-50	Correct
124	0	11-50	Incorrect	167	364	>200	Correct
125	28	11-50	Correct	168	108	51-200	Correct
126	20	11-50	Correct	169	76	51-200	Correct
127	32	11-50	Correct	170*	304	51-200	Incorrect
128	24	11-50	Correct	171	280	>200	Correct
129	20	11-50	Correct	172	24	11-50	Correct
130	48	11-50	Correct	173	84	51-200	Correct
131	24	11-50	Correct	174	16	11-50	Correct
89	28	11-50	Correct	132	28	11-50	Correct

Table 4. Comparison of measured Chrysophytes counts against ANN One-week Ahead class-predicted values Station at 612 with Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1	232	>200	Correct	27	56	51-200	Correct
2	280	>200	Correct	28	108	51-200	Correct
3	112	51-200	Correct	29	140	51-200	Correct
4	108	51-200	Correct	30	108	51-200	Correct
5	72	51-200	Correct	31	84	51-200	Correct
6	152	51-200	Correct	32	76	51-200	Correct
7	192	51-200	Correct	33	44	11-50	Correct
8	320	>200	Correct	34	56	51-200	Correct
9	128	51-200	Correct	35	32	11-50	Correct
10	60	51-200	Correct	36	120	51-200	Correct
11	100	51-200	Correct	37	32	11-50	Correct
12	88	51-200	Correct	38	52	51-200	Correct
13	212	>200	Correct	39	68	51-200	Correct
14	92	51-200	Correct	40	16	11-50	Correct
15	56	51-200	Correct	41	32	11-50	Correct
16	76	51-200	Correct	42	0	0-10	Correct
17	88	51-200	Correct	43	20	11-50	Correct
18	44	11-50	Correct	44	20	11-50	Correct
19	40	11-50	Correct	45	24	11-50	Correct
20	80	51-200	Correct	46	8	0-10	Correct
21	72	51-200	Correct	47	8	0-10	Correct
22	4	0-10	Correct	48	32	11-50	Correct
23	4	0-10	Correct	49	32	11-50	Correct
24	8	0-10	Correct	50	108	51-200	Correct
25	68	51-200	Correct	51	84	51-200	Correct
26	84	51-200	Correct				

Table 5. Comparison of measured Chlorophytes counts against ANN Two-week Ahead class-predicted values Station at 612 without Chemical Inputs

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
1	108	11-50	Incorrect	36	0	0-10	Correct
2	16	11-50	Correct	37	8	0-10	Correct
3	24	11-50	Correct	38	4	0-10	Correct
4	96	51-200	Correct	39	4	0-10	Correct
5	72	51-200	Correct	40	0	0-10	Correct
6	140	51-200	Correct	41	0	0-10	Correct
7	72	51-200	Correct	42	4	0-10	Correct
8	340	>200	Correct	43	8	0-10	Correct
9	268	>200	Correct	44	4	0-10	Correct
10	324	>200	Correct	45	24	11-50	Correct
11	56	51-200	Correct	46	8	0-10	Correct
12	56	51-200	Correct	47	0	0-10	Correct
13	24	11-50	Correct	48	120	51-200	Correct
14	48	11-50	Correct	49	472	>200	Correct
15	4	0-10	Correct	50	140	51-200	Correct
16	8	0-10	Correct	51	420	51-200	Incorrect
17	4	0-10	Correct	52	136	>200	Incorrect
18	4	0-10	Correct	53	72	51-200	Correct
19	4	0-10	Correct	54	136	51-200	Correct
20	4	0-10	Correct	55	80	51-200	Correct
21	0	0-10	Correct	56	136	51-200	Correct
22	4	0-10	Correct	57	32	11-50	Correct
23	8	0-10	Correct	58	20	11-50	Correct
24	16	11-50	Correct	59	44	11-50	Correct
25	4	0-10	Correct	60	36	11-50	Correct
26	4	0-10	Correct	61	52	51-200	Correct
27	8	0-10	Correct	62	36	51-200	Incorrect
28	16	0-10	Incorrect	63	36	11-50	Correct
29	4	51-200	Incorrect	64	32	11-50	Correct
30	8	0-10	Correct	65	32	11-50	Correct
31	0	11-50	Incorrect	66	16	11-50	Correct
32	16	11-50	Correct	67	60	11-50	Incorrect
33	4	0-10	Correct	68	20	11-50	Correct
34	32	11-50	Correct	69	52	51-200	Correct
35	4	0-10	Correct	70	44	11-50	Correct

Table 5. Comparison of measured Chlorophytes counts against ANN Two-week Ahead class-predicted values Station at 612 without Chemical Inputs (continuation)

Event	Measured	Bin	Accuracy	Event	Measured	Bin	Accuracy
71	32	11-50	Correct	106	12	0-10	Incorrect
72	8	11-50	Incorrect	107	8	0-10	Correct
73	20	11-50	Correct	108	0	11-50	Incorrect
74	24	11-50	Correct	109	12	11-50	Correct
75	20	11-50	Correct	110	24	11-50	Correct
76	4	0-10	Correct	111	12	11-50	Correct
77	20	0-10	Incorrect	112	36	11-50	Correct
78	5	0-10	Correct	113	36	11-50	Correct
79	4	0-10	Correct	114	40	11-50	Correct
80	20	11-50	Correct	115	24	11-50	Correct
81	4	0-10	Correct	116	20	11-50	Correct
82	20	11-50	Correct	117	20	11-50	Correct
83	24	11-50	Correct	118	16	11-50	Correct
84	44	11-50	Correct	119	32	11-50	Correct
85	40	11-50	Correct	120	16	11-50	Correct
86	24	11-50	Correct	121	4	0-10	Correct
87	8	0-10	Correct	122	24	11-50	Correct
88	16	11-50	Correct	123	24	11-50	Correct
89	160	51-200	Correct	124	12	11-50	Correct
90	84	51-200	Correct	125	20	11-50	Correct
91	132	51-200	Correct	126	8	0-10	Correct
92	76	51-200	Correct	127	8	0-10	Correct
93	132	51-200	Correct	128	4	0-10	Correct
94	36	11-50	Correct	129	0	0-10	Correct
95	4	0-10	Correct	130	0	0-10	Correct
96	0	0-10	Correct	131	4	0-10	Correct
97	4	0-10	Correct	132	0	0-10	Correct
98	0	0-10	Correct	133	8	0-10	Correct
99	0	0-10	Correct	134	0	11-50	Incorrect
100	0	0-10	Correct	135	0	0-10	Correct
101	4	0-10	Correct	136	40	11-50	Correct
102	0	0-10	Correct	137	122	51-200	Correct
103	0	0-10	Correct	138	12	11-50	Correct
104	0	0-10	Correct	139	20	11-50	Correct
105	12	0-10	Incorrect	140	4	11-50	Incorrect

Table 6. Comparison of measured Chlorophytes counts against ANN Two-week Ahead class-predicted values Station at 612 with Chemical Inputs

Event	Measured	Bin	Accuracy
1	16	11-50	Correct
2	140	51-200	Correct
3	48	11-50	Correct
4	0	0-10	Correct
5	4	0-10	Correct
6*	4	11-50	Incorrect
7	32	11-50	Correct
8	4	0-10	Correct
9	8	0-10	Correct
10	120	0-10	Incorrect
11	420	>200	Correct
12	136	11-50	Incorrect
13	36	51-200	Incorrect
14	52	11-50	Correct
15	32	11-50	Correct
16	32	11-50	Correct
17	4	0-10	Correct
18	20	11-50	Correct
19	5	0-10	Correct
20	4	0-10	Correct
21	4	0-10	Correct
22	20	11-50	Correct
23	24	11-50	Correct
24	44	11-50	Correct
25	40	11-50	Correct
26	24	11-50	Correct
27	16	11-50	Correct
28	160	51-200	Correct
29	84	51-200	Correct
30	132	51-200	Correct
31	76	51-200	Correct
32	132	51-200	Correct
33	12	11-50	Correct
34	24	11-50	Correct
35	16	11-50	Correct
36	12	11-50	Correct
37	8	0-10	Correct
38	8	11-50	Incorrect
39	40	11-50	Correct
40	4	11-50	Incorrect

APPENDIX C-2

PVWC LINEAR MODELING
Figures, Statistics and Sensitivity Analyses Tables

A. FIGURES

5. Original Models with Complete Input Sets

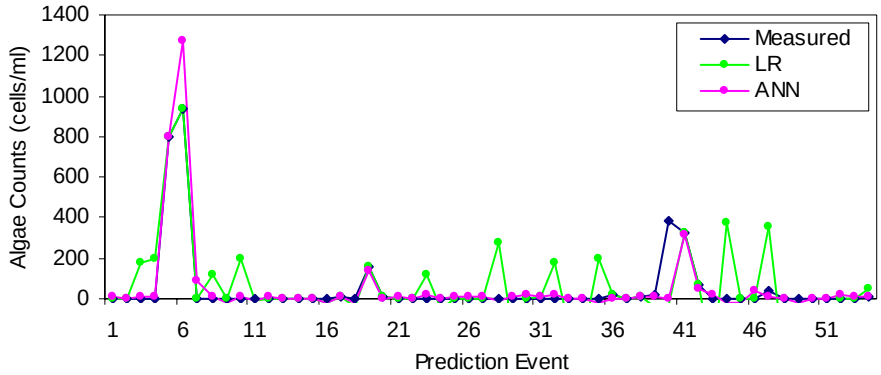

Figure 3.1 Comparison of Original ANN and LM performance for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

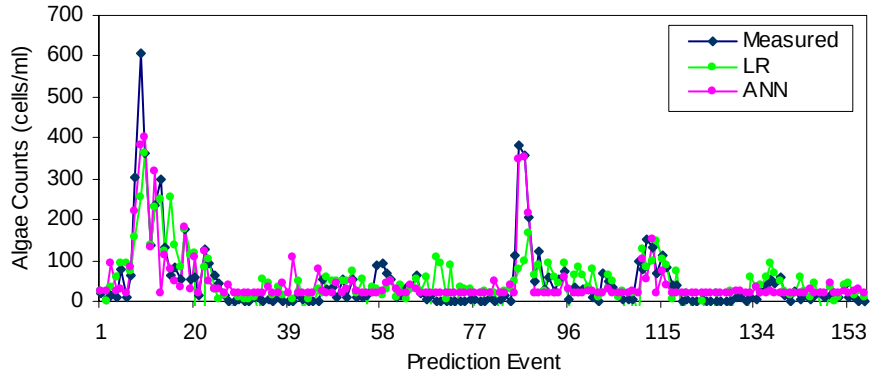

Figure 4.2 Comparison of Original ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

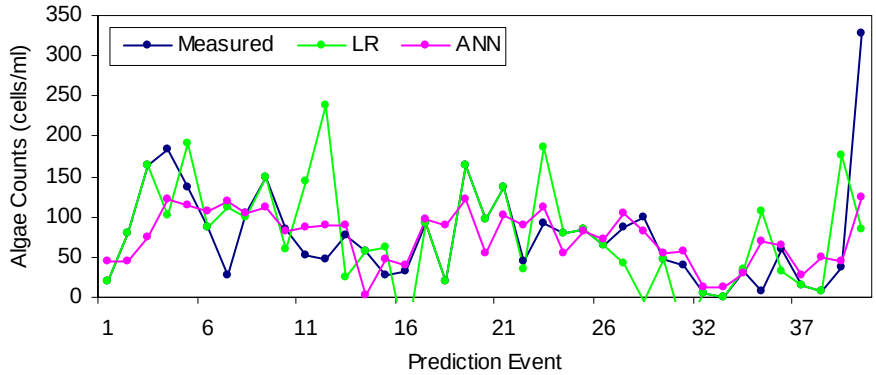

Figure 5.3 Comparison of Original ANN and LM performance for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

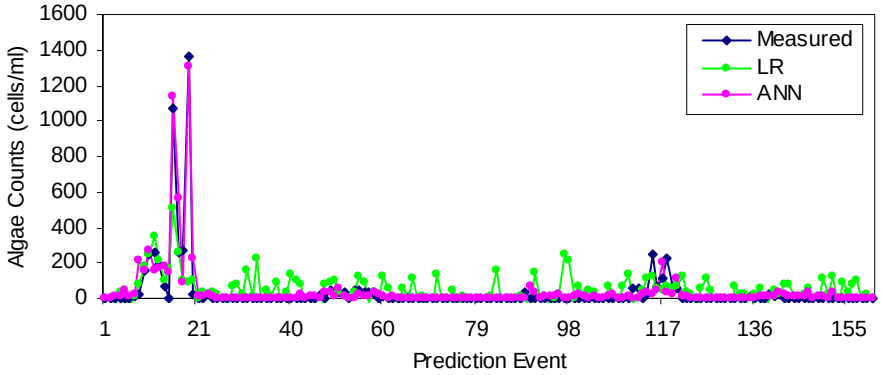

Figure 6.4 Comparison of Original ANN and LM performance for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

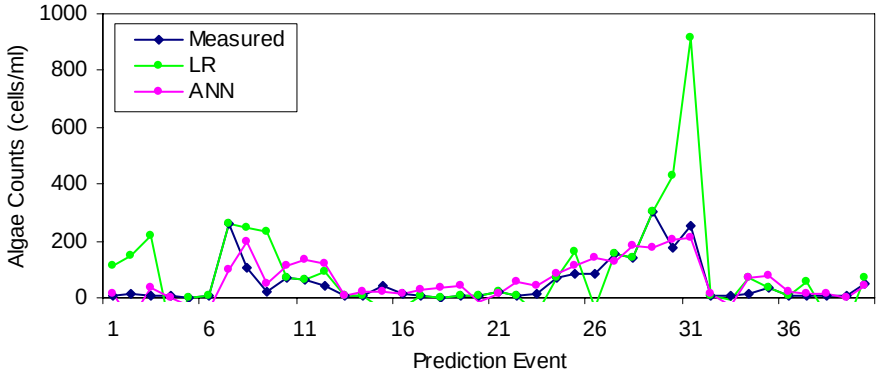

Figure 7.5 Comparison of Original ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

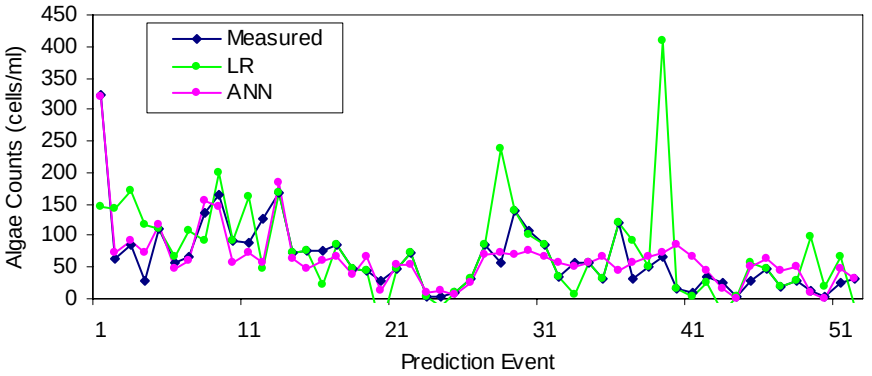

Figure 8.6 Comparison of Original ANN and LM performance for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

6. Original Models with Reduced Input Sets

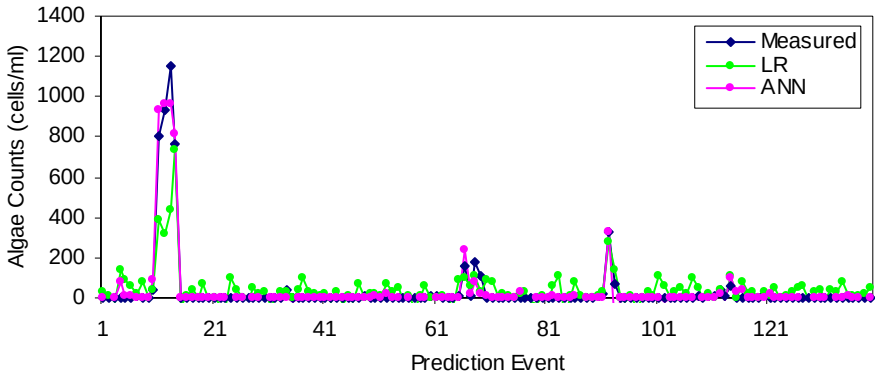

Figure 2.1 Comparison of Original ANN and LM performance for two week-ahead predictions of cyanobacteria at Station 612 excluding five water quality inputs

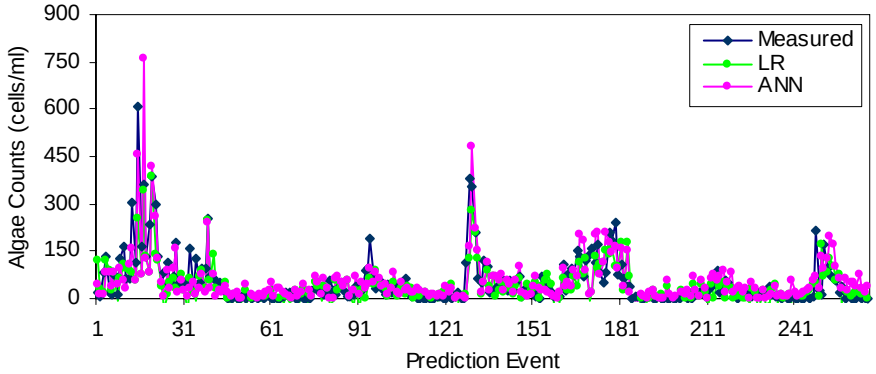

Figure 2.2 Comparison of Original ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 100 excluding five water quality inputs

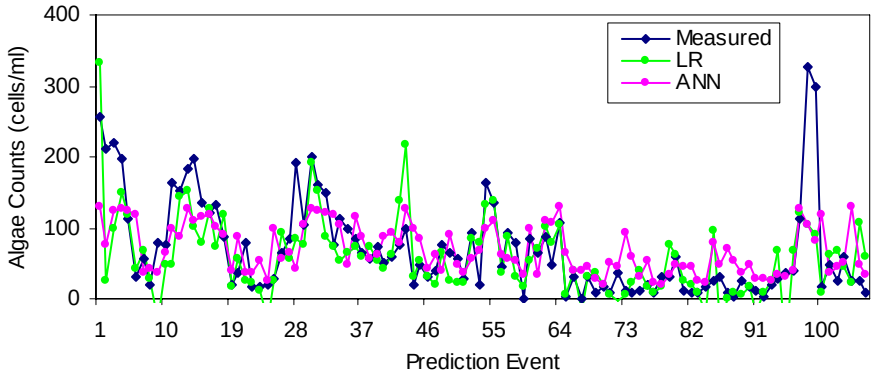

Figure 2.3 Comparison of Original ANN and LM performance for two week-ahead predictions of chrysophytes counts at Station 101 excluding five water quality inputs

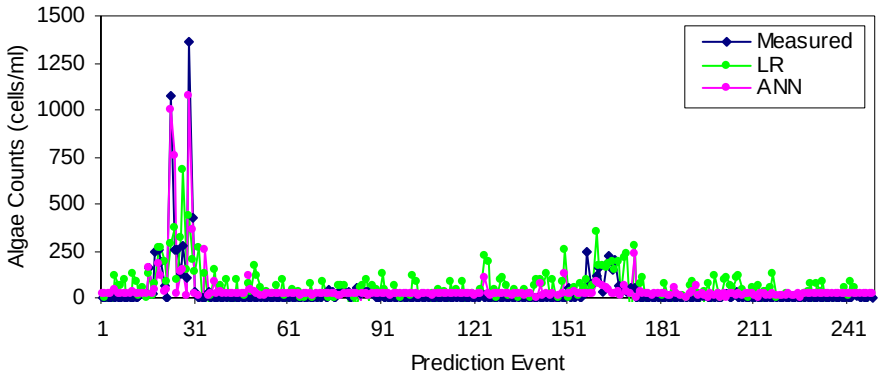

Figure 2.4 Comparison of Original ANN and LM performance for two week-ahead predictions of cyanobacteria counts at Station 100 excluding five water quality inputs

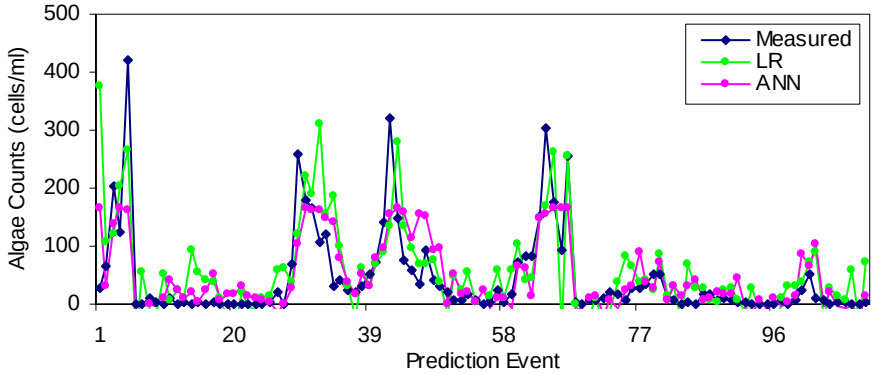

Figure 2.5 Comparison of Original ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 101 excluding five water quality inputs

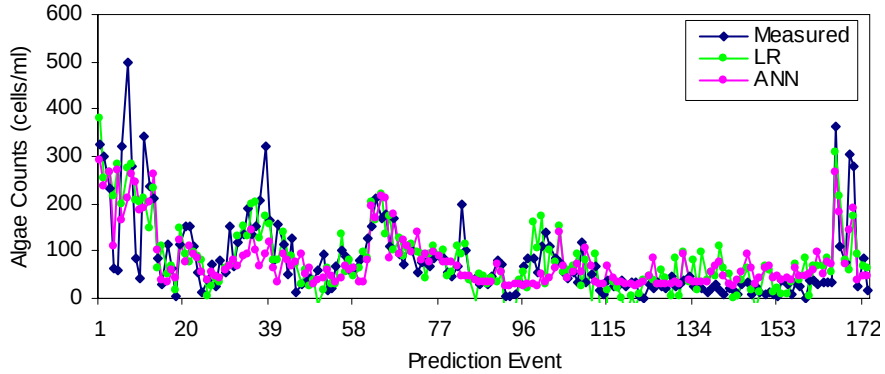

Figure 2.6 Comparison of Original ANN and LM performance for one week-ahead predictions of chrysophytes counts at Station 612 excluding five water quality inputs

7. Revised Models with Complete Input Sets

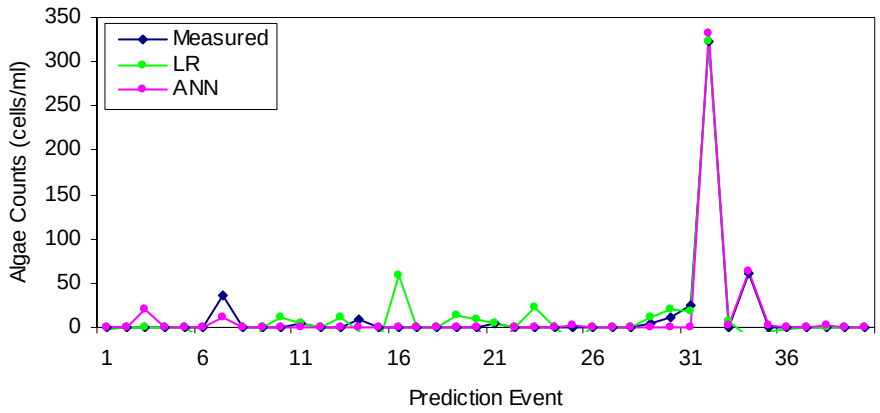

Figure 3.1 Comparison of Revised ANN and LM performance for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

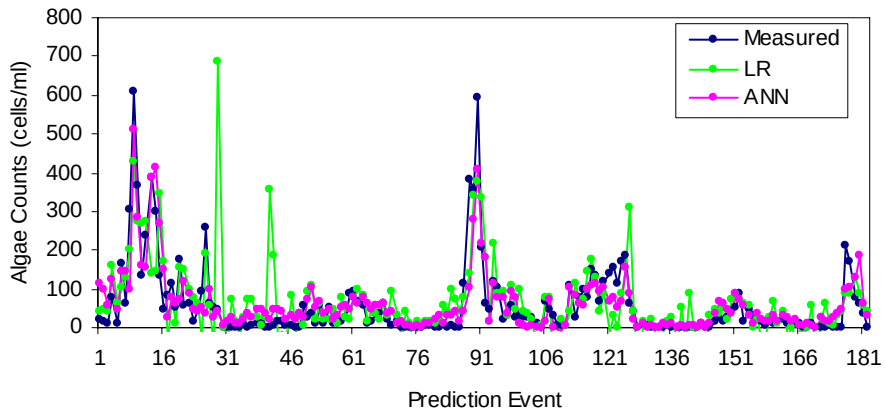

Figure 3.2 Comparison of Revised ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

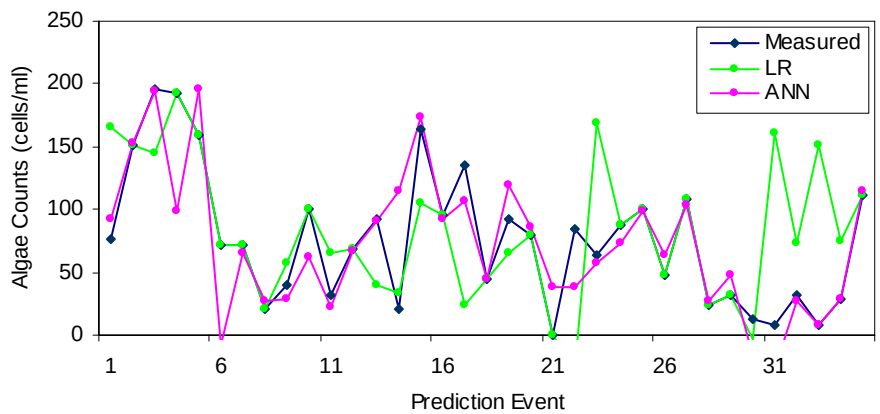

Figure 3.3 Comparison of Revised ANN and LM performance for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

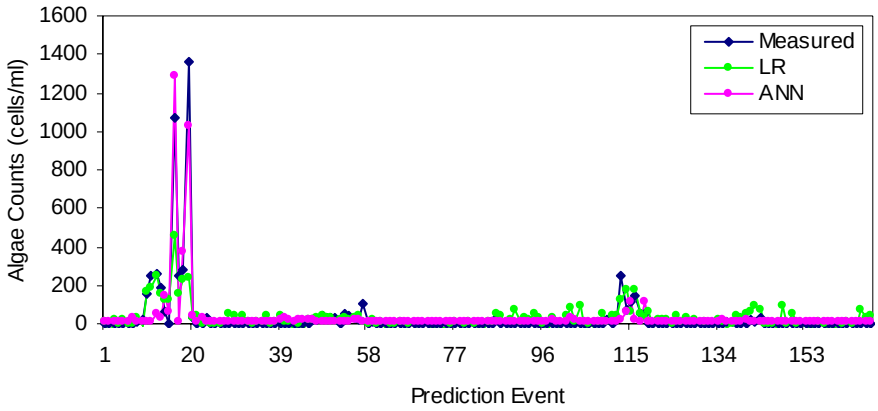

Figure 3.4 Comparison of Revised ANN and LM performance for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

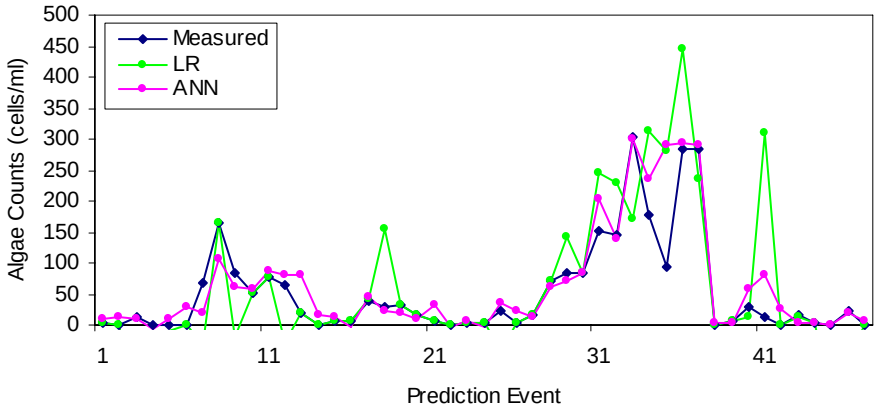

Figure 3.5 Comparison of Revised ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

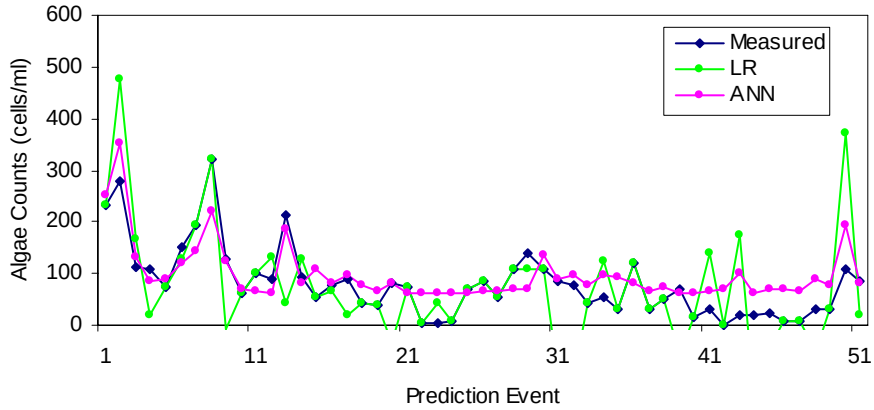

Figure 3.6 Comparison of Revised ANN and LM performance for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

8. Revised Models with Reduced Input Sets

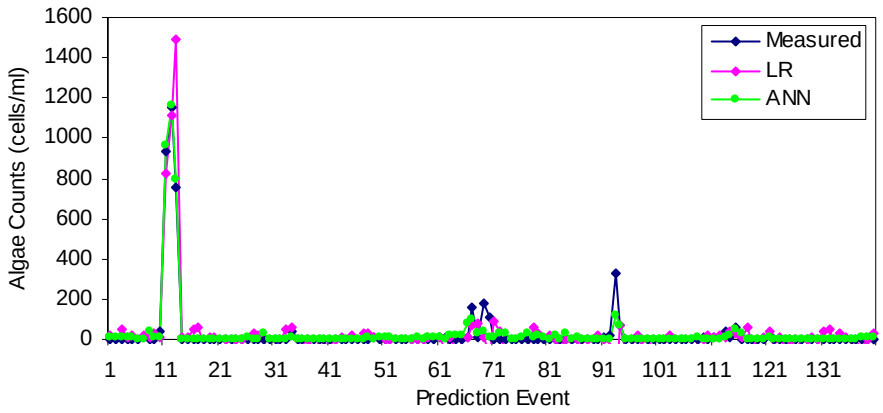

Figure 4.1 Comparison of Revised ANN and LM performance for two week-ahead predictions of cyanobacteria at Station 612 with reduced input sets

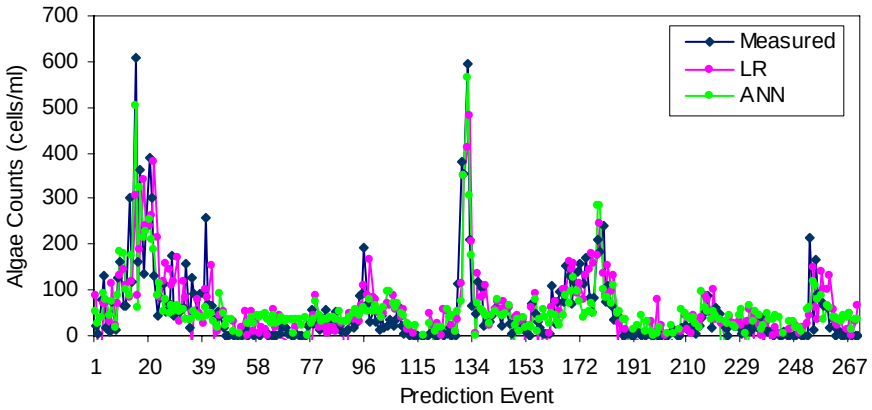

Figure 4.2 Comparison of Revised ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 100 with reduced input sets

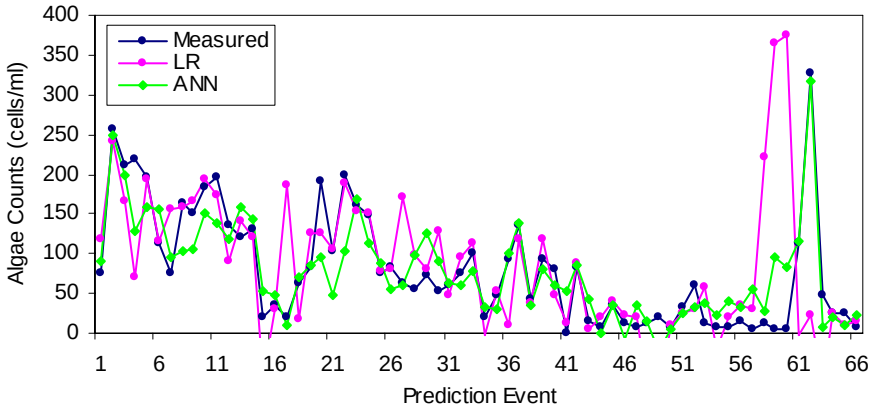

Figure 4.3 Comparison of Revised ANN and LM performance for two week-ahead predictions of chrysophytes counts at Station 101 with reduced input sets

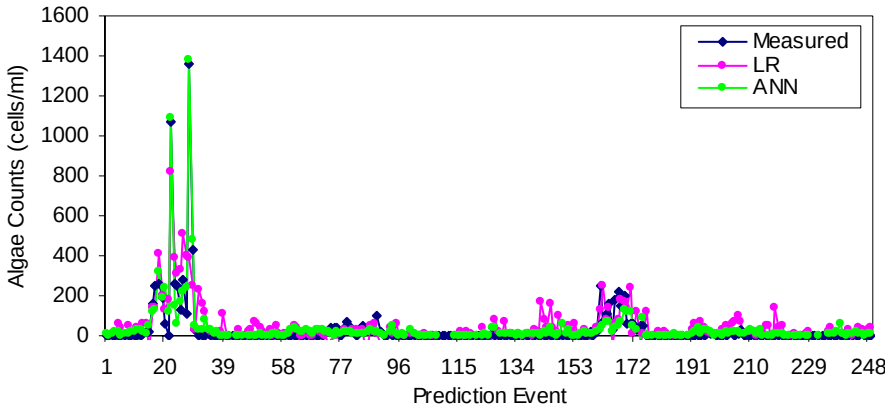

Figure 4.4 Comparison of Revised ANN and LM performance for two week-ahead predictions of cyanobacteria counts at Station 100 with reduced input sets

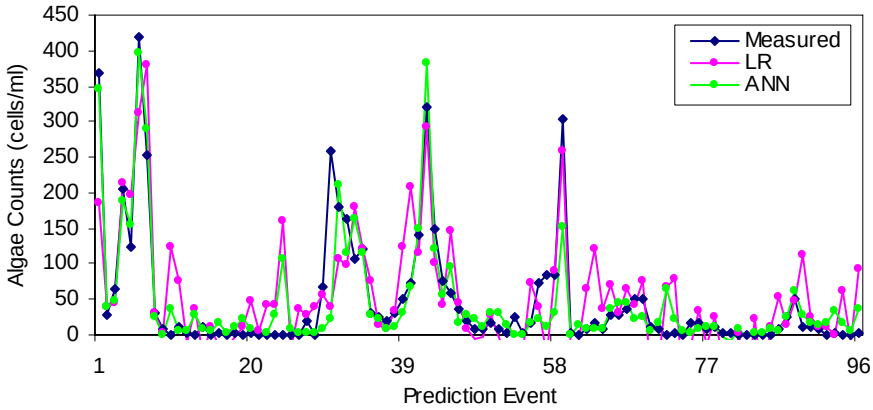

Figure 4.5 Comparison of Revised ANN and LM performance for one week-ahead predictions of chlorophytes counts at Station 101 with reduced input sets

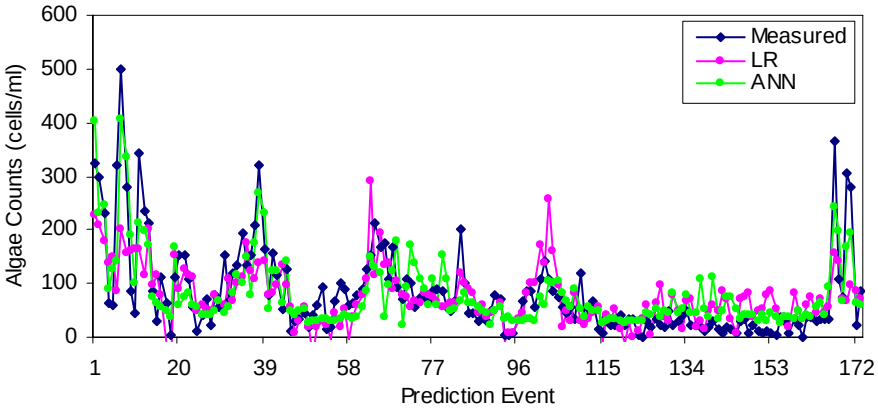

Figure 4.6 Comparison of Revised ANN and LM performance for one week-ahead predictions of chrysophytes counts at Station 612 with reduced input sets

B. DESCRIPTIVE STATISTICS

1. Original Models with Complete Input Sets

Table 9.1. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

	Overall	Training	Selection	Test
Data Mean	52.000	83.714	33.231	2.462
Data S.D.	174.835	227.352	103.077	6.571
Error Mean	-29.291	0.000	-84.599	-37.070
Error S.D.	228.608	0.000	411.308	207.233
Abs E. Mean	110.536	0.000	292.297	166.854
S.D. Ratio	1.308	0.000	3.990	31.540
Correlation	0.592	1.000	0.052	0.033

Table 1.2. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

	Overall	Training	Selection	Test
Data Mean	45.455	43.026	37.282	58.487
Data S.D.	82.410	69.978	68.410	111.549
Error Mean	-34.048	-2.429	1.546	-132.880
Error S.D.	393.485	30.785	67.125	774.523
Abs E. Mean	67.271	22.001	44.183	180.902
S.D. Ratio	4.775	0.440	0.981	6.943
Correlation	0.139	0.898	0.424	0.117

Table 1.3. Overall, Training and Validation Statistics for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

	Overall	Training	Selection	Test
Data Mean	75.400	70.800	97.200	62.800
Data S.D.	61.635	51.086	89.336	36.312
Error Mean	0.708	0.000	-38.860	41.691
Error S.D.	69.458	0.000	104.424	71.743
Abs E. Mean	38.995	0.000	92.724	63.256
S.D. Ratio	1.127	0.000	1.169	1.976
Correlation	0.404	1.000	0.232	0.153

Table 1.4. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

	Overall	Training	Selection	Test
Data Mean	34.152	32.550	16.205	55.385
Data S.D.	144.995	128.566	54.920	217.881
Error Mean	1.826	0.000	26.360	-18.961
Error S.D.	133.030	83.999	87.000	220.483
Abs E. Mean	66.790	49.965	74.244	93.850
S.D. Ratio	0.917	0.653	1.584	1.012
Correlation	0.435	0.757	0.123	0.159

Table 1.5. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

	Overall	Training	Selection	Test
Data Mean	52.293	56.381	54.000	42.000
Data S.D.	76.158	85.451	75.710	50.699
Error Mean	32.820	0.000	62.914	71.650
Error S.D.	128.299	0.000	217.576	124.392
Abs E. Mean	64.086	0.000	140.156	122.596
S.D. Ratio	1.685	0.000	2.874	2.454
Correlation	0.734	1.000	0.917	0.665

Table 1.6. Overall, Training and Validation Statistics for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

	Overall	Training	Selection	Test
Data Mean	63.769	60.769	67.692	65.846
Data S.D.	55.032	41.183	82.596	43.156
Error Mean	10.706	0.000	-0.281	43.105
Error S.D.	68.225	0.000	113.323	66.159
Abs E. Mean	34.317	0.000	70.976	66.291
S.D. Ratio	1.240	0.000	1.372	1.533
Correlation	0.485	1.000	0.356	0.393

2. Original Models with Reduced Input Sets

Table 2.1. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria at Station 612 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	34.849	22.535	34.824	60.588
Data S.D.	157.155	98.693	194.497	204.505
Error Mean	3.905	4.790	12.938	-6.976
Error S.D.	97.188	25.788	136.167	135.954
Abs E. Mean	44.180	19.217	70.992	69.494
S.D. Ratio	0.618	0.261	0.700	0.665
Correlation	0.823	0.965	0.809	0.879

Table 2.2. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 100 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	49.455	52.209	53.561	39.758
Data S.D.	77.028	77.728	92.378	54.650
Error Mean	-14.533	-8.120	-30.826	-11.259
Error S.D.	53.676	43.664	68.023	52.481
Abs E. Mean	34.756	27.455	46.965	37.369
S.D. Ratio	0.697	0.562	0.736	0.960
Correlation	0.720	0.827	0.683	0.530

Table 2.3. Overall, Training and Validation Statistics for two week-ahead predictions of chrysophytes counts at Station 101 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	69.736	66.963	76.000	69.231
Data S.D.	67.014	53.329	94.397	58.618
Error Mean	-12.705	-7.472	-24.077	-12.200
Error S.D.	51.512	21.268	79.402	58.202
Abs E. Mean	32.792	16.336	58.649	41.113
S.D. Ratio	0.769	0.399	0.841	0.993
Correlation	0.662	0.917	0.572	0.458

Table 2.4. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria counts at Station 100 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	30.297	40.864	21.161	18.129
Data S.D.	121.847	160.462	67.119	52.468
Error Mean	8.902	0.000	6.442	29.309
Error S.D.	114.290	129.744	90.516	98.720
Abs E. Mean	69.781	65.742	69.897	77.809
S.D. Ratio	0.938	0.809	1.349	1.882
Correlation	0.492	0.588	0.436	0.599

Table 2.5. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 101 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	44.367	52.218	53.926	18.815
Data S.D.	75.159	82.356	83.858	32.964
Error Mean	9.921	0.000	7.800	32.253
Error S.D.	64.239	41.833	82.547	74.680
Abs E. Mean	42.364	29.756	60.619	49.792
S.D. Ratio	0.855	0.508	0.984	2.266
Correlation	0.662	0.861	0.557	0.540

Table 2.6. Overall, Training and Validation Statistics for one week-ahead predictions of chrysophytes counts at Station 612 excluding five water quality inputs

	Overall	Training	Selection	Test
Data Mean	80.231	90.851	63.256	75.721
Data S.D.	82.210	92.573	55.145	79.212
Error Mean	0.354	0.000	-1.443	2.867
Error S.D.	59.266	52.532	56.667	72.988
Abs E. Mean	42.832	37.441	40.228	56.347
S.D. Ratio	0.721	0.567	1.028	0.921
Correlation	0.715	0.823	0.607	0.512

3. Revised Models with Complete Input Sets

Table 3.1. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

	Overall	Training	Selection	Test
Data Mean	11.900	16.600	6.800	7.600
Data S.D.	51.244	70.533	17.893	12.060
Error Mean	-2.072	0.000	-5.715	-2.575
Error S.D.	19.111	0.000	25.084	28.453
Abs E. Mean	9.622	0.000	16.837	21.652
S.D. Ratio	0.373	0.000	1.402	2.359
Correlation	0.932	1.000	-0.387	-0.061

Table 3.2. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

	Overall	Training	Selection	Test
Data Mean	55.582	71.500	52.756	25.867
Data S.D.	95.147	117.832	74.561	35.494
Error Mean	5.849	0.000	8.911	14.744
Error S.D.	88.009	67.331	121.928	83.864
Abs E. Mean	53.680	46.879	66.885	54.380
S.D. Ratio	0.925	0.571	1.635	2.363
Correlation	0.596	0.821	0.260	0.239

Table 3.3. Overall, Training and Validation Statistics for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

	Overall	Training	Selection	Test
Data Mean	75.771	82.526	62.500	73.000
Data S.D.	52.424	48.648	51.456	58.847
Error Mean	6.104	0.000	12.527	14.178
Error S.D.	53.857	0.000	89.262	67.284
Abs E. Mean	30.568	0.000	75.080	58.657
S.D. Ratio	1.027	0.000	1.735	1.143
Correlation	0.491	1.000	-0.308	0.372

Table 3.4. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

	Overall	Training	Selection	Test
Data Mean	31.760	24.894	64.195	13.561
Data S.D.	140.813	62.042	263.587	42.716
Error Mean	-5.875	0.000	-23.451	-0.479
Error S.D.	104.614	28.675	203.633	31.566
Abs E. Mean	34.471	19.733	76.052	23.444
S.D. Ratio	0.743	0.462	0.773	0.739
Correlation	0.728	0.887	0.772	0.697

Table 3.5. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

	Overall	Training	Selection	Test
Data Mean	53.277	23.360	114.545	60.000
Data S.D.	77.348	38.077	102.354	77.187
Error Mean	2.731	0.000	23.264	-11.595
Error S.D.	81.302	0.000	104.266	129.335
Abs E. Mean	46.146	0.000	91.510	105.658
S.D. Ratio	1.051	0.000	1.019	1.676
Correlation	0.736	1.000	0.657	0.702

Table 3.6. Overall, Training and Validation Statistics for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

	Overall	Training	Selection	Test
Data Mean	81.020	72.889	92.333	88.000
Data S.D.	67.909	72.266	56.414	65.889
Error Mean	-10.331	0.000	-40.112	-3.792
Error S.D.	81.767	0.000	94.897	135.053
Abs E. Mean	47.958	0.000	87.387	116.436
S.D. Ratio	1.204	0.000	1.682	2.050
Correlation	0.661	1.000	0.175	0.720

4. Revised Models with Reduced Input Sets

Table 4.1. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria at Station 612 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	28.886	22.114	54.400	16.914
Data S.D.	142.553	137.668	196.986	60.754
Error Mean	-7.425	0.000	1.170	-30.870
Error S.D.	88.662	29.812	131.789	107.537
Abs E. Mean	35.487	21.477	53.371	45.623
S.D. Ratio	0.622	0.217	0.669	1.770
Correlation	0.863	0.976	0.912	-0.664

Table 4.2. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 100 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	51.167	52.368	62.343	37.552
Data S.D.	83.488	87.849	100.595	44.624
Error Mean	1.502	0.000	-2.244	8.296
Error S.D.	62.262	49.419	87.591	54.108
Abs E. Mean	40.959	33.463	56.354	40.779
S.D. Ratio	0.746	0.563	0.871	1.213
Correlation	0.702	0.827	0.618	0.454

Table 4.3. Overall, Training and Validation Statistics for two week-ahead predictions of chrysophytes counts at Station 101 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	80.606	84.353	92.500	60.750
Data S.D.	72.390	65.406	93.636	56.502
Error Mean	4.454	0.000	-11.547	29.921
Error S.D.	92.150	18.386	146.807	108.677
Abs E. Mean	49.810	12.885	103.867	74.218
S.D. Ratio	1.273	0.281	1.568	1.923
Correlation	0.361	0.960	-0.025	0.264

Table 4.4. Overall, Training and Validation Statistics for two week-ahead predictions of cyanobacteria counts at Station 100 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	29.921	28.730	40.190	22.032
Data S.D.	121.225	110.387	175.514	58.614
Error Mean	1.265	0.000	-12.313	17.374
Error S.D.	88.743	55.497	143.128	66.398
Abs E. Mean	47.504	38.859	65.742	46.557
S.D. Ratio	0.732	0.503	0.815	1.133
Correlation	0.693	0.864	0.581	0.881

Table 4.5. Overall, Training and Validation Statistics for one week-ahead predictions of chlorophytes counts at Station 101 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	47.542	54.417	48.667	32.667
Data S.D.	83.662	88.418	92.978	58.306
Error Mean	2.771	0.000	1.905	9.178
Error S.D.	59.361	33.415	80.764	72.677
Abs E. Mean	42.271	24.074	60.378	60.558
S.D. Ratio	0.710	0.378	0.869	1.246
Correlation	0.745	0.926	0.525	0.670

Table 4.6. Overall, Training and Validation Statistics for one week-ahead predictions of chrysophytes counts at Station 612 with reduced input sets

	Overall	Training	Selection	Test
Data Mean	79.885	67.682	94.233	90.512
Data S.D.	82.099	59.967	102.991	93.192
Error Mean	-6.096	0.000	-18.175	-6.492
Error S.D.	63.627	36.427	84.363	79.541
Abs E. Mean	43.212	27.435	59.827	58.882
S.D. Ratio	0.775	0.607	0.819	0.854
Correlation	0.632	0.794	0.581	0.546

C. SENSITIVITY ANALYSES

1. Original Models with Complete Input Sets

Table 10.1 Sensitivity Analysis for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Conductivity	1.1705	1	Prediction Period's Precipitation Total	0.9988	18
Dissolved Oxygen	1.1599	2	Heating Degree Days	0.9984	19
Initial Chlorophytes counts	1.0620	3	Temperature	0.9970	20
River A Extraction	1.0470	4	River B Extraction	0.9953	21
Turbidity	1.0420	5	Ammonia	0.9936	22
Wind Direction	1.0371	6	Total Algal Count	0.9924	23
Length of Day	1.0308	7	Sulfate	0.9897	24
Biochemical Oxygen Demand	1.0241	8	Odor	0.9894	25
Initial Cyanophyta	1.0117	9	Chloride	0.9802	26
Total Phosphorus/Orthophosphate	1.0100	10	pH	0.9797	27
Initial Chrysophytes counts	1.0099	11	Sky Cover	0.9787	28
Alkalinity	1.0089	12	Nitrite/Nitrate	0.9757	29
Reservoir A Extraction	1.0065	13	Wind Speed	0.9606	30
Total Hardness	1.0062	14	Prediction Period's Lagged Precipitation Total	0.9382	31
Color	1.0037	15	River A Streamflow	0.9367	32
Total Amorphous Material	1.0011	16	UV254	0.8948	33
Pumping Station 1 Extraction	1.0000	17	Total Organic Carbon	0.8325	34

Table 11.2 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
River B Extraction	1.0252	1	River A Streamflow	1.0000	18
Conductivity	1.0150	2	Length of Day	0.9999	19
Total Algal Count	1.0143	3	Pumping Station 1 Extraction	0.9999	20
Sulfate	1.0101	4	Sky Cover	0.9999	21
Heating Degree Days	1.0063	5	Reservoir A Extraction	0.9999	22
Nitrite/Nitrate	1.0055	6	UV254	0.9998	23
Initial Cyanobacteria counts	1.0045	7	Biochemical Oxygen Demand	0.9996	24
Chloride	1.0030	8	Dissolved Oxygen	0.9996	25
Initial Chlorophytes counts	1.0015	9	Total Organic Carbon	0.9993	26
Odor	1.0011	10	Total Suspended Solids	0.9990	27
Alkalinity	1.0009	11	Ammonia	0.9983	28
Wind Speed	1.0006	12	Turbidity	0.9971	29
Prediction Period's Precipitation Total	1.0006	13	Total Hardness	0.9966	30
Prediction Period's Lagged Precipitation Total	1.0005	14	pH	0.9952	31
Temperature	1.0005	15	River A Extraction	0.9885	32
Initial Chrysophytes counts	1.0001	16	Total Phosphorus/Orthophosphate	0.1723	33
Wind Direction	1.0000	17	River A Streamflow	1.0000	18

Table 12.3 Sensitivity Analysis for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Phosphorus/Orthophosphate	1.1291	1	Pumping Station 1 Extraction	1.0008	18
Conductivity	1.0385	2	Wind Speed	1.0004	19
Initial Chrysophyta	1.0274	3	Reservoir A Extraction	1.0000	20
Total Organic Carbon	1.0271	4	Wind Direction	0.9995	21
Color	1.0209	5	Initial Cyanobacteria counts	0.9982	22
River A Streamflow	1.0198	6	Temperature	0.9969	23
Dissolved Oxygen	1.0176	7	Total Algal Count	0.9951	24
Dissolved Oxygen	1.0173	8	River B Extraction	0.9950	25
Turbidity	1.0162	9	Chloride	0.9933	26
pH	1.0131	10	Sulfate	0.9893	27
Heating Degree Days	1.0092	11	Initial Chlorophytes counts	0.9864	28
Length of Day	1.0081	12	Biochemical Oxygen Demand	0.9836	29
UV254	1.0071	13	Nitrite/Nitrate	0.9819	30
Prediction Period's Precipitation Total	1.0054	14	Total Amorphous Material	0.9531	31
River A Extraction	1.0053	15	Prediction Period's Lagged Precipitation Total	0.9421	32
Ammonia	1.0032	16	Sky Cover	0.9335	33
Alkalinity	1.0026	17	Odor	0.9322	34

Table 13.4 Sensitivity Analysis for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Nitrite/Nitrate	1.2642	1	UV-254	1.0077	18
Total Algal Count	1.1345	2	Total Phosphorus/Orthophosphate	1.0030	19
Temperature	1.0955	3	Pumping Station 1 Extraction	1.0007	20
Turbidity	1.0464	4	Reservoir A Extraction	1.0002	21
Initial Cyanobacteria counts	1.0314	5	Prediction Period's Precipitation Total	1.0002	22
Ammonia	1.0270	6	Total Organic Carbon	1.0000	23
Conductivity	1.0244	7	River A Streamflow	0.9998	24
Initial Chrysophytes counts	1.0233	8	Wind Speed	0.9993	25
River A Extraction	1.0228	9	Prediction Period's Lagged Precipitation Total	0.9992	26
Sulfate	1.0182	10	Sky Cover	0.9989	27
Heating Degree Days	1.0159	11	Total Suspended Solids	0.9961	28
pH	1.0153	12	Biochemical Oxygen Demand	0.9943	29
Alkalinity	1.0146	13	Initial Chlorophytes counts	0.9940	30
Dissolved Oxygen	1.0143	14	Length of Day	0.9935	31
River B Extraction	1.0130	15	Odor	0.9920	32
Chloride	1.0122	16	Wind Direction	0.9903	33
Total Hardness	1.0086	17			

Table 14.5 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Temperature	1.3716	1	Turbidity	1.0113	18
Length of Day	1.3345	2	Sulfate	1.0107	19
Heating Degree Days	1.0960	3	Prediction Period's Lagged Precipitation Total	1.0080	20
Wind Speed	1.0776	4	Color	1.0051	21
Sky Cover	1.0714	5	Reservoir A Extraction	1.0000	22
Total Phosphorus/Orthophosphate	1.0703	6	Initial Chrysophytes counts	0.9999	23
Total Hardness	1.0573	7	Conductivity	0.9970	24
Chloride	1.0567	8	Wind Direction	0.9925	25
UV254	1.0510	9	Biochemical Oxygen Demand	0.9896	26
Alkalinity	1.0449	10	Nitrite/Nitrate	0.9854	27
Ammonia	1.0350	11	Total Amorphous Material	0.9843	28
River B Extraction	1.0311	12	Total Organic Carbon	0.9809	29
Pumping Station 1 Extraction	1.0278	13	Prediction Period's Precipitation Total	0.9228	30
River A Streamflow	1.0257	14	pH	0.8934	31
Odor	1.0242	15	Initial Chlorophytes counts	0.7609	32
Dissolved Oxygen	1.0206	16	Initial Cyanobacteria counts	0.7606	33
River A Extraction	1.0162	17	Total Algal Count	0.6885	34

Table 15.6 Sensitivity Analysis for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Turbidity	1.2027	1	Prediction Period's Lagged Precipitation Total	0.9989	18
Initial Chrysophytes counts	1.1142	2	Sulfate	0.9988	19
Dissolved Oxygen	1.0565	3	Prediction Period's Precipitation Total	0.9984	20
Temperature	1.0502	4	Odor	0.9981	21
River A Extraction	1.0414	5	Total Algal Count	0.9980	22
Heating Degree Days	1.0405	6	Initial Chlorophytes counts	0.9977	23
Total Hardness	1.0383	7	TotalPhosphorus/Orthophosphate	0.9972	24
Biochemical Oxygen Demand	1.0337	8	Total Organic Carbon	0.9948	25
Length of Day	1.0274	9	Nitrite/Nitrate	0.9945	26
Reservoir A Extraction	1.0233	10	Wind Speed	0.9915	27
Wind Direction	1.0192	11	Conductivity	0.9899	28
Initial Cyanobacteria counts	1.0186	12	Alkalinity	0.9828	29
UV254	1.0169	13	Ammonia	0.9765	30
Chloride	1.0082	14	Total Amorphous Material	0.9662	31
Sky Cover	1.0060	15	River B Extraction	0.9638	32
Pumping Station 1 Extraction	1.0036	16	pH	0.9285	33
River A Streamflow	0.9997	17	Color	0.6952	34

2. Original Models with Reduced Input Sets

Table 2.1 Sensitivity Analysis for two week-ahead predictions of cyanobacteria at Station 612 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal counts	1.7652	1	Wind Speed	1.0029	16
Initial Chrysophytes counts	1.1954	2	Sky Cover	1.0023	17
Turbidity	1.1830	3	Total Amorphous Material	1.0018	18
Color	1.1686	4	Conductivity	1.0015	19
Dissolved Oxygen	1.1039	5	Pumping Station 1 Extraction	1.0005	20
Temperature	1.0845	6	Chloride	1.0000	21
River B Extraction	1.0589	7	Prediction Period's Precipitation Total	1.0000	22
Initial Cyanobacteria counts	1.0437	8	Total Hardness	0.9999	23
Reservoir A Extraction	1.0179	9	UV254	0.9998	24
Alkalinity	1.0106	10	River A Extraction	0.9992	25
Wind Direction	1.0092	11	Prediction Period's Lagged Precipitation Total	0.9954	26
Length of Day	1.0088	12	River A Streamflow	0.9917	27
Initial Chlorophytes counts	1.0081	13	pH	0.9844	28
Ammonia	1.0066	14	Heating Degree Days	0.9826	29
Odor	1.0060	15			

Table 2.2 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 100 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes	1.3939	1	Heating Degree Days	1.0006	16
Odor	1.0930	2	Wind Direction	1.0003	17
Temperature	1.0602	3	Pumping Station 1 Extraction	1.0002	18
River B Extraction	1.0546	4	Dissolved Oxygen	1.0000	19
River A Extraction	1.0490	5	Alkalinity	0.9999	20
Initial Chrysophytes counts	1.0453	6	Total Organic Carbon	0.9988	21
Sky Cover	1.0323	7	UV254	0.9984	22
Total Algal Counts	1.0241	8	Total Hardness	0.9979	23
Initial Cyanobacteria counts	1.0235	9	Reservoir A Extraction	0.9976	24
Conductivity	1.0087	10	pH	0.9973	25
River A Streamflow	1.0051	11	Prediction Period's Lagged Precipitation Total	0.9971	26
Chloride	1.0046	12	Length of Day	0.9959	27
Biochemical Oxygen Demand	1.0028	13	Total Suspended Solids	0.9953	28
Wind Speed	1.0020	14	Turbidity	0.9929	29
Ammonia	1.0013	15	Prediction Period's Precipitation Total	0.9893	30

Table 2.3 Sensitivity Analysis for two week-ahead predictions of chrysophytes counts at Station 101 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Initial Chlorophytes counts	1.2785	1	River B Extraction	1.0230	16
Total Algal counts	1.2078	2	Dissolved Oxygen	1.0207	17
Initial Chrysophytes counts	1.1864	3	Ammonia	1.0187	18
pH	1.1513	4	Temperature	1.0130	19
Conductivity	1.0677	5	Total Hardness	1.0126	20
Pumping Station 1 Extraction	1.0565	6	Alkalinity	1.0107	21
Heating Degree Days	1.0468	7	Odor	1.0104	22
Wind Speed	1.0456	8	Chloride	1.0091	23
Total Amorphous Material	1.0415	9	River A Extraction	1.0090	24
Prediction Period's Precipitation Total	1.0364	10	River A Streamflow	1.0017	25
Prediction Period's Lagged Precipitation Total	1.0291	11	Reservoir A Extraction	1.0014	26
Turbidity	1.0287	12	Color	1.0012	27
Length of Day	1.0285	13	Sky Cover	1.0001	28
UV254	1.0266	14	Initial Cyanobacteria counts	0.9955	29
Wind Direction	1.0254	15			

Table 2.4 Sensitivity Analysis for two week-ahead predictions of cyanobacteria counts at Station 100 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Temperature	1.2000	1	Conductivity	1.0071	16
Length of Day	1.0734	2	Wind Speed	1.0070	17
Total Algal Counts	1.0658	3	Initial Chrysophytes counts	1.0062	18
River B Extraction	1.0616	4	Sky Cover	1.0061	19
Dissolved Oxygen	1.0267	5	Prediction Period's Lagged Precipitation Total	1.0049	20
Initial Cyanobacteria counts	1.0266	6	Reservoir A Extraction	1.0045	21
Initial Chlorophytes counts	1.0259	7	Ammonia	1.0037	22
Turbidity	1.0212	8	pH	1.0004	23
Wind Direction	1.0146	9	Heating Degree Days	0.9998	24
Odor	1.0116	10	Prediction Period's Precipitation Total	0.9997	25
Total Hardness	1.0105	11	Biochemical Oxygen Demand	0.9978	26
Total Suspended Solids	1.0098	12	Chloride	0.9968	27
Alkalinity	1.0096	13	UV254	0.9961	28
River A Extraction	1.0076	14	Total Organic Carbon	0.9948	29
Pumping Station 1 Extraction	1.0076	15	River A Streamflow	0.9921	30

Table 2.5 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 101 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal counts	2.5870	1	pH	1.0155	16
Initial Chrysophytes counts	1.8662	2	Sky Cover	1.0155	17
Initial Chlorophytes counts	1.4026	3	Ammonia	1.0125	18
Dissolved Oxygen	1.1630	4	River B Extraction	1.0083	19
Temperature	1.0984	5	Odor	1.0065	20
River A Streamflow	1.0932	6	Color	1.0040	21
UV254	1.0688	7	Pumping Station 1 Extraction	1.0038	22
Initial Cyanobacteria counts	1.0623	8	Total Hardness	1.0009	23
Alkalinity	1.0581	9	Prediction Period's Lagged Precipitation Total	0.9999	24
Prediction Period's Precipitation Total	1.0419	10	Reservoir A Extraction	0.9978	25
Heating Degree Days	1.0350	11	Conductivity	0.9957	26
Total Amorphous Material	1.0285	12	Wind Direction	0.9826	27
Length of Day	1.0260	13	River A Extraction	0.9811	28
Turbidity	1.0173	14	Chloride	0.9792	29
Wind Speed	1.0161	15			

Table 2.6 Sensitivity Analysis for one week-ahead predictions of chrysophytes counts at Station 612 excluding five water quality inputs

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal counts	1.9120	1	Wind Speed	1.0023	16
Initial Chrysophytes counts	1.7381	2	pH	1.0018	17
Initial Cyanobacteria counts	1.3142	3	River A Streamflow	1.0016	18
Color	1.1740	4	Pumping Station 1 Extraction	1.0012	19
Length of Day	1.1724	5	Prediction Period's Lagged Precipitation Total	1.0007	20
Temperature	1.1607	6	UV254	1.0004	21
Initial Chlorophytes counts	1.1325	7	Ammonia	1.0001	22
Total Hardness	1.0660	8	Odor	1.0000	23
Conductivity	1.0365	9	Prediction Period's Precipitation Total	0.9997	24
Heating Degree Days	1.0335	10	Alkalinity	0.9991	25
Turbidity	1.0304	11	Dissolved Oxygen	0.9985	26
Chloride	1.0222	12	Reservoir A Extraction	0.9971	27
Sky Cover	1.0188	13	River A Extraction	0.9952	28
Total Amorphous Material	1.0055	14	Wind Direction	0.9941	29
River B Extraction	1.0041	15			

3. Revised Models with Complete Input Sets

Table 3.1 Sensitivity Analysis for two week-ahead predictions of cyanobacteria at Station 612 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Reservoir A Extraction	1.2831	1	Ammonia	0.9989	18
River A Streamflow	1.2391	2	pH	0.9977	19
Initial Cyanobacteria counts	1.2143	3	Conductivity	0.9968	20
UV254	1.1753	4	River A Extraction	0.9963	21
Wind Direction	1.1014	5	Biochemical Oxygen Demand	0.9957	22
Turbidity	1.1008	6	Alkalinity	0.9926	23
Temperature	1.0976	7	Total Algal Counts	0.9910	24
Initial Chrysophytes counts	1.0856	8	Color	0.9875	25
River B Extraction	1.0775	9	Heating Degree Days	0.9853	26
Length of Day	1.0284	10	Total Organic Carbon	0.9835	27
Dissolved Oxygen	1.0244	11	Nitrate/Nitrite	0.9552	28
Odor	1.0224	12	Prediction Period's Precipitation Total	0.9523	29
Initial Chlorophytes counts	1.0183	13	Wind Speed	0.9483	30
Pumping Station 1 Extraction	1.0172	14	Total Hardness	0.9384	31
Chloride	1.0075	15	Total Phosphorus/Orthophosphate	0.9325	32
Total Amorphous Material	1.0047	16	Prediction Period's Lagged Precipitation Total	0.9303	33
Sulfate	1.0036	17	Sky Cover	0.9047	34

Table 3.2 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 100 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal Counts	2.3759	1	River B Extraction	1.0129	18
Initial Chrysophytes counts	1.5684	2	River A Streamflow	1.0096	19
Initial Cyanobacteria counts	1.4646	3	UV-254	1.0087	20
Temperature	1.1388	4	Prediction Period Precipitation Total	1.0050	21
Length of Day	1.1354	5	Dissolved Oxygen	1.0046	22
Total Organic Carbon	1.0544	6	Wind Direction	1.0045	23
River A Extraction	1.0480	7	Pumping Station 1 Extraction	1.0038	24
Total Hardness	1.0409	8	Odor	1.0019	25
Sulfate	1.0407	9	pH	1.0013	26
Wind Speed	1.0360	10	Conductivity	1.0004	27
Initial Chlorophytes counts	1.0345	11	Prediction Period's Lagged Precipitation	0.9995	28
Chloride	1.0302	12	Alkalinity	0.9960	29
Heating Degree Days	1.0292	13	Turbidity	0.9917	30
Total Phosphorus/Orthophosphate	1.0265	14	Reservoir A Extraction	0.9913	31
Nitrite/Nitrate	1.0183	15	Biochemical Oxygen Demand	0.9800	32
Ammonia	1.0130	16	Total Suspended Solids	0.8638	33
Sky Cover	1.0129	17			

Table 3.3 Sensitivity Analysis for two week-ahead predictions of chrysophytes counts at Station 101 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Ammonia	1.2272	1	Initial Chlorophytes counts	1.0035	18
River A Streamflow	1.0974	2	Biochemical Oxygen Demand	1.0027	19
Alkalinity	1.0723	3	Wind Direction	1.0000	20
Wind Speed	1.0658	4	Initial Cyanobacteria counts	0.9994	21
Prediction Period Precipitation	1.0640	5	Reservoir A Extraction	0.9989	22
River B Extraction	1.0511	6	Dissolved Oxygen	0.9982	23
UV254	1.0394	7	Nitrite/Nitrate	0.9981	24
Sky Cover	1.0391	8	Chloride	0.9971	25
pH	1.0360	9	Odor	0.9914	26
Conductivity	1.0291	10	Sulfate	0.9899	27
Total Organic Carbon	1.0264	11	T.Phosphorus/Orthophosphate	0.9897	28
Temperature	1.0257	12	Initial Chrysophytes counts	0.9892	29
Turbidity	1.0221	13	River A Extraction	0.9785	30
Prediction Period Precipitation Lag time	1.0160	14	Initial Total Algal Counts	0.9726	31
Total Amorphous Materials	1.0157	15	Pump Station 1 Extraction	0.9718	32
Colro	1.0142	16	Length of Day	0.9693	33
Heating Degree Days	1.0082	17	Total Hardness	0.9322	34

Table 3.4 Sensitivity Analysis for two week-ahead predictions of cyanobacteria counts at Station 100 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Turbidity	1.3611	1	Prediction Period's Lagged Precipitation Total	1.0019	18
Temperature	1.1139	2	Initial Chrysophytes counts	1.0019	19
Heating Degree Days	1.0450	3	Total Organic Carbon	1.0014	20
Dissolved Oxygen	1.0248	4	Total Phosphorus/Orthophosphate	1.0013	21
River A Extraction	1.0197	5	Chloride	1.0007	22
Initial Chlorophytes counts	1.0185	6	pH	1.0007	23
Total Hardness	1.0120	7	Biochemical Oxygen Demand	1.0004	24
Initial Cyanobacteria counts	1.0085	8	Prediction Period's Precipitation Total	1.0000	25
Length of Day	1.0073	9	UV-254	0.9997	26
Odor	1.0048	10	Sky Cover	0.9994	27
Reservoir A Extraction	1.0041	11	Wind Direction	0.9983	28
River A Streamflow	1.0039	12	Pumping Station 1 Extraction	0.9972	29
Total Suspended Solids	1.0036	13	Total Algal Counts	0.9961	30
Sulfate	1.0036	14	Alkalinity	0.9928	31
Conductivity	1.0035	15	Nitrite/Nitrate	0.9918	32
Wind Speed	1.0027	16	River B Extraction	0.9868	33
Ammonia	1.0024	17			

Table 3.5 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 101 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Temperature	1.6721	1	Color	1.0008	18
Heating Degree Days	1.3349	2	Initial Cyanobacteria counts	1.0000	19
Wind Speed	1.2141	3	Reservoir A Extraction	1.0000	20
Sulfate	1.1980	4	Ammonia	0.9997	21
Length of Day	1.1427	5	Prediction Period's Lagged Precipitation Total	0.9985	22
UV254	1.0733	6	Sky Cover	0.9970	23
Total Organic Carbon	1.0503	7	Initial Chrysophytes counts	0.9966	24
Turbidity	1.0485	8	Chloride	0.9954	25
River A Streamflow	1.0326	9	River B Extraction	0.9951	26
Dissolved Oxygen	1.0307	10	Conductivity	0.9938	27
Wind Direction	1.0238	11	Alkalinity	0.9895	28
pH	1.0138	12	Total Algal Counts	0.9876	29
Pumping Station 1 Extraction	1.0138	13	River A Extraction	0.9868	30
Biochemical Oxygen Demand	1.0131	14	Prediction Period's Precipitation Total	0.9804	31
Nitrite/Nitrate	1.0067	15	Total Phosphorus/Orthophosphate	0.9718	32
Total Hardness	1.0054	16	Initial Chlorophytes counts	0.9711	33
Odor	1.0042	17	Total Amorphous Materials	0.8655	34

Table 3.6 Sensitivity Analysis for one week-ahead predictions of chrysophytes counts at Station 612 with complete input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
River A Extraction	1.1290	1	Ammonia	0.9981	18
Heating Degree Days	1.1187	2	Biochemical Oxygen Demand	0.9974	19
Initial Chrysophytes counts	1.1059	3	Prediction Period's Lagged Precipitation Total	0.9972	20
Temperature	1.1023	4	Initial Cyanobacteria counts	0.9969	21
Dissolved Oxygen	1.0881	5	Total Hardness	0.9967	22
Alkalinity	1.0765	6	Chloride	0.9923	23
Nitrate/Nitrite	1.0443	7	Total Algal Count	0.9920	24
Reservoir A Extraction	1.0252	8	Color	0.9919	25
River A Streamflow	1.0244	9	Initial Chlorophytes counts	0.9911	26
River B Extraction	1.0154	10	Odor	0.9867	27
Total Phosphorus/Orthophosphate	1.0151	11	Pumping Station 1 Extraction	0.9827	28
Total Amorphous Material	1.0139	12	Sky Cover	0.9803	29
pH	1.0111	13	Wind Direction	0.9769	30
Total Organic Carbon	1.0091	14	Prediction Period's Precipitation Total	0.9702	31
Sulfate	1.0063	15	UV254	0.9571	32
Length of Day	1.0021	16	Turbidity	0.9565	33
Conductivity	1.0002	17	Wind Speed	0.9513	34

4. Revised Models with Reduced Input Sets

Table 4.1 Sensitivity Analysis for two week-ahead predictions of cyanobacteria at Station 612 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal Counts	1.9131	1	Color	1.0046	16
Initial Chrysophytes counts	1.5612	2	Wind Direction	1.0044	17
Reservoir A Extraction	1.4555	3	River A Streamflow	1.0003	18
Initial Chlorophytes counts	1.1948	4	UV254	1.0000	19
Turbidity	1.1062	5	Ammonia	0.9999	20
Initial Cyanobacteria counts	1.0936	6	Alkalinity	0.9998	21
Temperature	1.0507	7	Chloride	0.9995	22
Length of Day	1.0470	8	River A Extraction	0.9991	23
pH	1.0300	9	Dissolved Oxygen	0.9974	24
Prediction Period's Precipitation Total	1.0218	10	Conductivity	0.9972	25
Pumping Station 1 Extraction	1.0092	11	Odor	0.9952	26
Total Hardness	1.0069	12	Total Amorphous Material	0.9939	27
River B Extraction	1.0055	13	Prediction Period's Lagged Precipitation Total	0.9919	28
Heating Degree Days	1.0052	14	Sky Cover	0.9909	29
Wind Speed	1.0051	15			

Table 4.2 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 100 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Temperature	1.0945	1	Ammonia	1.0032	16
Heating Degree Days	1.0775	2	Odor	1.0024	17
Initial Chrysophytes Counts	1.0613	3	Prediction Period's Lagged Precipitation Total	1.0017	18
Initial Chlorophytes Counts	1.0524	4	Dissolved Oxygen	1.0016	19
Total Algal Counts	1.0390	5	Chloride	1.0012	20
Initial Cyanobacteria Counts	1.0373	6	Total Hardness	1.0005	21
River A Extractions	1.0363	7	Wind Direction	1.0000	22
Reservoir A Extraction	1.0268	8	Total Suspended Solids	0.9999	23
River B Extraction	1.0200	9	Length of Day	0.9999	24
Biochemical Oxygen Demand	1.0135	10	pH	0.9992	25
Sky Cover	1.0131	11	River A Streamflow	0.9988	26
Alkalinity	1.0115	12	UV254	0.9975	27
Total Organic Carbon	1.0110	13	Wind Speed	0.9972	28

Table 4.3 Sensitivity Analysis for two week-ahead predictions of chrysophytes counts at Station 101 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal Count	3.0052	1	pH	1.0146	15
Initial Chrysophytes Counts	1.8361	2	River A Extraction	1.0057	16
Length of Day	1.5600	3	Pumping Station 1 Extraction	1.0041	17
Initial Chlorophytes Counts	1.4537	4	Chloride	0.9977	18
Prediction Period's Lagged Precipitation Total	1.1710	5	Total Hardness	0.9941	19
Initial Cyanobacteria counts	1.0806	6	Odor	0.9920	20
Wind Direction	1.0675	7	Color	0.9902	21
Dissolved Oxygen	1.0471	8	Prediction Period's Precipitation Total	0.9876	22
Alkalinity	1.0293	9	Turbidity	0.9872	23
Conductivity	1.0266	10	UV254	0.9828	24
River B Extraction	1.0242	11	Ammonia	0.9825	25
Total Amorphous Materials	1.0225	12	Temperature	0.9675	26
Sky Cover	1.0190	13	Wind Speed	0.8919	27
River A Streamflow	1.0152	14	Heating Degree Days	0.8012	28

Table 4.4 Sensitivity Analysis for two week-ahead predictions of cyanobacteria counts at Station 100 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Turbidity	1.3511	1	Ammonia	1.0051	16
Heating Degree Days	1.1770	2	Chloride	1.0050	17
Dissolved Oxygen	1.0736	3	Total Organic Carbon	1.0019	18
Total Algal Counts	1.0557	4	River A Streamflow	1.0012	19
Alkalinity	1.0329	5	Length of Day	1.0011	20
Reservoir A Extraction	1.0308	6	Initial Chrysophytes Counts	1.0009	21
Prediction Period's Precipitation Total	1.0274	7	Wind Direction	0.9997	22
Biochemical Oxygen Demand	1.0238	8	Odor	0.9996	23
UV254	1.0158	9	Conductivity	0.9994	24
Sky Cover	1.0126	10	pH	0.9993	25
Initial Chlorophytes Counts	1.0113	11	Wind Speed	0.9991	26
River B Extraction	1.0073	12	Prediction Period's Lagged Precipitation Total	0.9990	27
Pumping Station 1 Extraction	1.0066	13	Total Hardness	0.9968	28
Temperature	1.0063	14	Initial Cyanobacteria Counts	0.9966	29
River A Extractions	1.0052	15	Total Suspended Solids	0.9958	30

Table 4.5 Sensitivity Analysis for one week-ahead predictions of chlorophytes counts at Station 101 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal Count	6.3468	1	Color	1.0122	15
Initial Chlorophytes Counts	3.7918	2	Ammonia	1.0104	16
Initial Chrysophytes Counts	3.6781	3	River B Extraction	1.0099	17
Length of Day	1.4414	4	Odor	1.0091	18
Temperature	1.3229	5	Sky Cover	1.0090	19
Alkalinity	1.2047	6	Prediction Period's Lagged Precipitation Total	1.0046	20
Heating Degree Days	1.1984	7	Wind Speed	1.0042	21
Dissolved Oxygen	1.1973	8	Chloride	1.0031	22
Initial Cyanobacteria Counts	1.0991	9	Pumping Station 1 Extraction	1.0001	23
Total Hardness	1.0747	10	Turbidity	0.9998	24
pH	1.0708	11	Total Amorphous Materials	0.9998	25
River A Streamflow	1.0172	12	River A Extraction	0.9935	26
UV254	1.0172	13	Conductivity	0.9862	27
Prediction Period's Precipitation Total	1.0168	14	Wind Direction	0.9821	28

Table 4.6 Sensitivity Analysis for one week-ahead predictions of chrysophytes counts at Station 612 with reduced input sets

Variable	Ratio	Rank	Variable	Ratio	Rank
Total Algal Counts	1.7531	1	Conductivity	1.0058	16
Initial Chrysophytes Counts	1.6910	2	Odor	1.0023	17
Initial Chlorophytes Counts	1.3148	3	Alkalinity	1.0015	18
Initial Cyanobacteria Counts	1.2678	4	pH	1.0011	19
River B Extraction	1.0735	5	Reservoir A Extraction	1.0011	20
Color	1.0723	6	UV254	1.0007	21
Heating Degree Days	1.0627	7	Prediction Period's Lagged Precipitation Total	1.0000	22
Turbidity	1.0602	8	Ammonia	0.9999	23
Length of Day	1.0349	9	Total Hardness	0.9996	24
Prediction Period's Precipitation Total	1.0300	10	Wind Speed	0.9994	25
Total Amorphous Materials	1.0256	11	Chloride	0.9979	26
Temperature	1.0173	12	Sky Cover	0.9934	27
Dissolved Oxygen	1.0149	13	Wind Direction	0.9914	28
River A Extraction	1.0091	14	Pumping Station 1 Extraction	0.9836	29
River A Streamflow	1.0081	15			