Final Draft

Annual Report for the Year 2000

CONSENT AGREEMENT

Concerning

Operation of the Platte River Hatchery

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and

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May 2001

Overview of the Consent Agreement

The purpose of the Consent Agreement is to provide for the control and reduction of phosphorus discharges from the Platte River Fish Hatchery as operated by the Michigan Department of Natural Resources (MDNR).

The parties have agreed to implement a strategy to reduce the phosphorus loading from the Hatchery and related operations such that it has environmentally neutral impacts on Big Platte Lake and it's associated watershed (see Figure 1). This strategy calls for a scheduled or phased reduction of phosphorus loading from the Hatchery to an eventual limit of 175 lbs per year with no more than 55 lbs released during any three-month period. In addition, Lower and Upper Weir operations will be confined between August 15 and November 14 each year. No more than 20,000 adult Coho or 1,000 adult Chinook salmon shall be allowed to pass upstream into Platte Lake in any given year. Fish captured at the weirs will be harvested and removed from the watershed. The agreement also calls for the Hatchery to make good faith efforts to minimize discharge flow rates and the use of antibiotics and disinfectants.

The Court has determined a volume-weighted total phosphorus concentration standard of 8.0 mg/m^3 for Big Platte Lake. This standard shall be attained no less that 95% of the time. In an effort to insure compliance with this standard, the MDNR has agreed to operate the Hatchery as described above and to encourage and assist other entities to reduce their discharge of phosphorus to the Platte Lake watershed.

The Court has ordered the appointment of the Implementation Coordinator to provide scientific and engineering methodology and guidance, to facilitate communication between the parties, and to resolve disputes that may arise as a result of the Agreement. The parties have determined that the Implementation Coordinator shall supervise the preparation of an annual audit report regarding the compliance of the Hatchery operations with the terms of the Agreement.

Complete background and details of the agreement are described in the Consent Agreement and will be discussed in the following paragraphs.

Summary for the Year 2000

The net Hatchery load for the year 2000 was 206 lbs. The maximum loading for any three-month period was 64.5 pounds. These loads are in compliance with the Consent Agreement.

A total of 19,874 adult Coho and 39 adult Chinook salmon passed the Lower Weir in 2000. All harvested salmon were counted and then removed from the watershed. A total of 15,681 adult Coho salmon were harvested at the Upper Weir for egg collection. This is approximately 79% of the salmon that passed through the Lower Weir. A total of 28 adult Chinook salmon were harvested at the Upper Weir or 72% of the number passed through the Lower Weir. The number of adult Coho that passed the Lower Weir was just within the Agreement specifications. Only about 4% of the allowable adult Chinook passed the Lower Weir in 2000. Therefore, overall weir operations in 2000 were in compliance with the Consent Agreement.

The annual-average volume-weighted total phosphorus concentration of Platte Lake was 6.5 mg/m^3 in 2000. However, the water quality standard of 8 mg/m^3 was attained only 88% of the time. This is not in compliance with the goal of 95% attainment.

A comprehensive review of the field sampling and laboratory procedures has been completed. Several problems were detected and corrected.

Discussions are underway with GLEC, CMU, and CT&E to obtain competitive cost proposals for laboratory analyses of the Hatchery, tributary, and Lake samples. CMU has participated in a blind test to determine the accuracy and precision of their methods for total phosphorus. The results show that CMU and GLEC measurements are consistent.

Technical and Cost proposals to develop a watershed phosphorus loading model were obtained from two engineering firms. An award to one of these firms is anticipated shortly.

Modification of the Hatchery, tributary, and Lake sampling strategy currently under review. The new sampling program must be consistent with added requirements of the watershed model and overall cost limitations.

Significant progress has been made to collaborate with the Benzie Conservation District regarding the development and application of watershed model. In addition efforts are well underway to coordinate with nearby lake-protection associations and other local planning and conservation agencies.

Microsoft EXCEL spreadsheets have been designed to maintain the Hatchery, tributary and Lake data. These efforts have kept pace with the data collection and analysis.

An excellent spirit of coordination, cooperation and communication has been maintained between the Implementation Coordinator and the parties. They have conducted conference call coordination meetings every two weeks. The minutes of these meetings are attached in Appendix 11.

Audit of Hatchery Operations

Flow

Paragraph 3.A.i commits the Hatchery to minimize the volume of its flow and to maintain accurate flow measurements. The Hatchery staff measures weir height at the two outlet locations and allocates the total outflow among Brundage Creek, Brundage Spring, or the Platte River. Paragraph 4.B.ii gives equations to be used for the outlet weirs. Paragraph 4.C.ii states that all the inlet and outlet flow measurement devices shall be re-calibrated by 31 Dec 1999.

The USGS made measurements in 2000 to verify the rating curves of the two Hatchery effluent weirs. The differences between the USGS and the Hatchery measurements for the Lower Weir were as much as 600% at low flow rates and as much as 20% at normal flow rates. The results were within 5% for the Upper Weir. These results indicate that it is important to improve the accuracy of the Hatchery effluent flow measurements. It is highly desirable to make these improvements a top priority of the Capital Improvement Project under consideration for the Hatchery.

To address these problems, the Lower Weir was closed as of June 200. All the Hatchery outflows are now consolidated into a single outflow at the Upper Weir. It is recommended that the Upper Weir be calibrated again for the higher flow regimes.

The allocation of total effluent flow to three different inflow sources is only qualitative at this time because of limitations of the physical plant. This situation is unacceptable and should be corrected as soon as possible. The preferred solution would be to combine the three inlet flows into one mixing box where the flow and concentration can be accurately measured. Alternatively, it may be possible to install separate measurement devices on each inlet source water pipe.

Well water

Paragraphs 3.B.i and ii discusses the possible use of well water to supplement Hatchery supply. This alternative does not appear feasible at this time, although the matter is still under study. Final resolution is expected shortly.

Total Phosphorus Loads

Paragraph 3.C.ii states that the interim Hatchery load will be less than 210 lbs for the pre-construction period including the year 2000. The maximum allowable phosphorus load may not exceed 75 lbs for any three consecutive month period. The net Hatchery loading for 2000 was 206 lbs. The maximum load for any three-month period was 64.5 lbs. These loads comply with the Consent Agreement. Appendix 1 contains an EXCEL spreadsheet that summarizes the Hatchery loading calculations for 2000. Note that linear interpolation was used in the spreadsheet to determine loads for the end or beginning of each month. This is the appropriate way to estimate the load and differs slightly from the method currently used by the Hatchery staff to determine yearly NPDES loading contributions. The Hatchery staff should use the linear interpolation method for future calculations.

Figure 2 shows a bar graph of the Hatchery loading for each month in 2000. Figure 3 shows the accumulative total phosphorus loading for 2000. Note than loads are higher in the spring and fall compared to the summer, and that the maximum load occurs during October. This is also the time of the year when Lake total phosphorus concentrations are a maximum (see discussion below). It is important to have a quantitative understanding of the relationship between the Hatchery loads and the Lake total phosphorus concentrations. It is therefore planned to develop an accurate water quality model of the Lake to determine the significance of higher Hatchery loads in the fall. Figure 4 shows the long-term pattern of decreasing Hatchery total phosphorus loads between 1980 to 2000. Also note that the total phosphorus loads during recent years are about 70% lower than loads from the Hatchery during the early 1990's. The water quality model should be capable of accurately simulating the water quality impacts of this historical trend.

Weir Operations

The 2000 weir operations have remained similar for the past two years. The Lower Weir was closed from August 15 until November 14, except for times to pass boats and canoes when salmon were not present and to pass salmon upstream for egg collection activities at the Upper Weir.

Salmon were released upstream by raising the boat gate a small amount and manually counting the salmon as they passed. Two Hatchery employees and one PLIA observer performed the counts. A total of 19,874 adult Coho and 39 adult Chinook salmon passed the Lower Weir in 2000. The number of salmon harvested was also estimated by periodically counting the number of salmon in a tote and multiplying the average of these numbers by the number of totes harvested. All harvested salmon were removed from the watershed.

The Upper Weir was installed and effectively stopped all upstream migrations of salmon after August 15. All salmon were individually counted during the harvest and egg collection operations at the Upper Weir. A total of 15,681 adult Coho salmon were harvested at the Upper Weir. This is approximately 79% of the salmon passed through the Lower Weir. A total of 28 adult Chinook salmon were harvested at the Upper Weir or 72% of the number passed at the Lower Weir.

Appendix 2 contains a Hatchery report that describes the operation of the Lower and Upper Weirs.

Capital Improvements

A Capital Improvement Project is underway. The overall objectives of this program are to minimize water use, to improve solids removal, and to consolidate the piping for the purpose of expediting measurement of inlet and outlet flows and concentrations.

The Capitol Improvement Project has the following four specific components. The first is the renovation of the existing outdoor raceway complex. This will facilitate better solids handling and will allow for a reduction in water use. This improvement will consist of a covered structure that will decrease the impact of avian predators and will reduce fish stress. Second, a new effluent management system will be installed. This will include a microscreening facility, a clarifier, sludge holding facilities and some improvements to the existing effluent pond. Third, the existing headbox will be re-designed and renovated. This modification will provide an opportunity to improve water quality sampling and flow measurement. Finally, new flow measurement devices will be installed and piping consolidated where possible.

Antibiotics and Disinfectants

Paragraph 4.E.ii commits the Hatchery to an evaluation of its antibiotic and disinfectant loads.

Antibiotic use at the Hatchery involves supplying oxytetracyctine (OTC) to Chinook salmon. The antibiotic is delivered to the fish in the feed. The total amount of OTC in the feed was 122.2 pounds in 2000 and 89.1 pounds in 2001. Monitoring of the Hatchery discharge for OTC occurred during 2000. Replicate grab samples were collected during the last day the OTC feeding cycle. The samples were collected from the discharge of an inside and outside raceway, the inlet to the settling basin, the two discharges, and from 300 feet below the lower discharge in the Platte River. The samples were analyzed for OTC by the RASL laboratory at the University of Michigan. The procedure has a detection limit of 0.05 mg/L. All samples contained 0.055 mg/L or less OTC.

Twenty-four composite and grab samples were collected on the last day of the treatment cycle during 2001. These samples were frozen and stored for possible future analysis. Laboratory analysis of these samples is not deemed necessary at this time. However, the samples should be frozen and stored for possible future analysis.

Parasite-S (formalin) is used as a disinfectant to control fungus growth on fish eggs. This product consists of 37% formaldehyde by weight in water. A total of 775 gallons of Parasite-S was used to control fungus on salmon eggs during the period between October 3 to December 27,2000. Formaldehyde was monitored in the discharge on three dates in 1999. The results of these tests showed that formaldehyde was below detection levels in all nine samples. Parasite-S use in 2000 was comparable to the use in 1999. Therefore formaldehyde measurements were not taken in 2000.

Chloramine-T was used on May 9 and 10, 2001 to control bacterial gill disease (BGD) that affects Chinook salmon. Twenty-four hour composite and grab samples were collected at various locations. However, it has been that determined that Chloramine-T degrades rapidly in water, and that samples must be analyzed within 2 hours of collection to obtain valid results. The 2001 samples were not processed within this time interval and were therefore not analyzed. It is planned to test for free-chlorine in future sampling efforts. This is a residual of Chloramine-T that can be easily measured using a Hach free-chlorine test kit. A Hach free-chlorine test kit has been ordered and will be used during the next testing period. In addition, free chlorine will be tested at the Elberta wastewater treatment facility.

Appendix 3 contains a detailed discussion of antibiotic and disinfectant use at Platte River Hatchery during 2000 and 2001.

Data Storage

Mr. Wil Swiecki and Dr. Michael Pattison have performed the huge task of constructing and maintaining an Excel spreadsheet database that contains the Hatchery loading data and calculations. This arrangement has worked very well and it is recommended that they continue this effort.

It is also recommended that the spreadsheet be expanded to include a running water and phosphorus balance for the Hatchery. This should include inflow and outflow of water from the Hatchery, the amount of phosphorus contained in fish food, the amount of phosphorus contained in harvested fish eggs, the amount contained in planted fish, the amount of phosphorus associated with solids removal, and the phosphorus removed in the settling ponds.

Audit of Compliance with Lake Phosphorus Standard

Paragraph 3.F.ii mandates a volume-weighted total phosphorus standard for Platte Lake of 8 mg/m^3 to be attained 95% of the time.

Table 1 lists the Hatchery total phosphorus load for 1990 to 2000. Also listed are annual average flows of the Platte River at US-31 as measured by the USGS. The measured minimum, maximum, and average volume-weighted total phosphorus concentrations of Platte Lake are also listed for this same time period.

Year	Hatchery Load (lbs/yr)	Ave Flow at US-31 (cfs)	Min TP mg/m^3	Max TP mg/m^3	Ave TP mg/m^3
1990	755	137	5.8	11.3	9.1
1991	745	138	5.3	10.5	7.8
1992	708	141	6.0	10.7	8.3
1993	271	146	5.1	10.8	7.8
1994	188	138	4.9	11.8	7.9
1995	307	120	5.7	11.1	8.2
1996	251	125	5.5	10.2	7.2
1997	170	131	5.2	9.0	6.5
1998	189	111	4.7	8.5	6.3
1999	199	105	3.8	8.1	6.3
2000	203	101	4.5	8.7	6.5

Table 1. Historical Changes in Hatchery Loading, Platte River Flows, and various Lake Parameters.

The average annual volume-weighted total phosphorus concentration of Platte Lake has declined from about 9.1 mg/m^3 in 1990 to about 6.5 mg/m^3 in 2000. Figure 5 shows a plot of the total phosphorus concentration of Platte Lake for the years 1990 to 2000. There were 44 days in 2000 when the total phosphorus concentration exceeded the 8 mg/m^3 standard. This corresponds to about 88% compliance as compared to the 95% requirement. Appendix 4 contains an Excel spreadsheet that demonstrates the calculation of the Platte Lake volume-weighted total phosphorus concentration.

The declines in Lake total phosphorus concentrations are generally consistent with similar declines of the total phosphorus loading from the Hatchery (Figure 4). However, recent average annual flows of the Platte River at US-31 are about 30% lower than flows recorded at the beginning of the decade (Figure 6). Each of these factors plays a role in the declining Lake total phosphorus concentrations. A water quality model must be developed to separate the significance of each of these factors and to determine quantitative relationship between the Hatchery loading, the Platte River flow, non-point total phosphorus loads, internal sediment loads and the total phosphorus concentration of the Lake. This task is planned for the coming years.

Total phosphorus concentrations have a seasonal pattern that is generally consistent from year to year. Figure 7 shows the seasonal variation of the volume-weighted total phosphorus concentration in Platte Lake for 1990 to 1997 (from Fuss). Figure 8 shows similar data for 1998 to 2000. Note that concentrations are usually elevated in the spring, low during the summer, and at or near maximum levels in the fall. The average concentrations vary between about 5 and 7 mg/m^3 for the first six months of the year for 1998 to 2000. The average value drops to about 5

mg/m^3 between mid-July and mid-September. The concentration then increases sharply until the end of the year. Concentrations during this period can exceed 8 mg/m^3. It is critically important to understand these dynamic patterns to facilitate efforts to comply with the water quality standards for the Lake.

High spring total phosphorus concentrations are undoubtedly linked to high spring flows and snow melt. This is discussed further below in Figures 12 and 13.

Measured vertical profiles of total phosphorus concentration can be used to gain insight into the factors that affect fall concentration changes in Platte Lake. Figure 9 shows vertical total phosphorus profiles for August 15, 2000, October 10, 2000 and October 24, 2000. During this period the volume-weighted average total phosphorus concentration increased from 5.4 to 7.8 mg/m^3. This is equivalent to a net increase of about 200 kg of total phosphorus over a 70 day time period. This dramatic increase is an important key to understanding the dynamics of total phosphorus concentrations in Platte Lake.

Note that both bottom and surface concentrations increase over this time period. The increase in bottom water concentrations is most likely due to sediment release under low dissolved oxygen or anoxic conditions. Platte Lake has received excess phosphorus loading for a period of many years. This phosphorus is used by phytoplankton for growth. These algal cells subsequently settle and accumulate in the bottom sediments. Over time this process has enriched the sediment phosphorus content of Platte Lake. The sediment total phosphorus content of Platte Lake is now estimated to be about 600 mgTP/kgDW in the deepest part of the Lake. This value is higher than other area lakes.

The bottom water concentrations of dissolved oxygen of Platte Lake can be low for extended periods. Figure 10 shows the changes of bottom water dissolved oxygen concentrations during 2000. Note that the concentration of dissolved oxygen drops below 2 mg/L for about 125 days. Figure 11 shows similar data for dissolved oxygen and associated concentrations of iron, manganese, and ammonia from MDNR data for 1987. These data show that reduced compounds are released from the sediments when the bottom water dissolved oxygen concentrations fall below about 2 mg/L. Oxygen concentrations were below 2 mg/L for about 100 days in 1987. Reliable dissolved phosphorus data are not available for this period, however a similar release pattern is expected. It is desirable to replicate the 1987 data, and therefore it is recommended to add bottom water chemistry and sediment chemistry to sampling program for 2001.

The phosphorus release rate from sediments can be estimated using the Nurnberg Equation[1]. This equation relates anoxic release rates to sediment total phosphorus as given below:

$$R = 6.3\ (\ TP\ )^{.76} \qquad (1)$$

where R is the release rate (mg P/m^2/day) and TP is expressed as gmTP/gDW. The estimated release rate for Platte Lake is about 4.3 $mgTP/m^2$/day. Laboratory studies using sediments from Platte Lake are recommended to verify the applicability of Equation 1.

The total phosphorus internal sediment loading to the Lake is calculated by multiplying the release rate by the anoxic area and the number of days the bottom water dissolved oxygen concentration is less than about 2 mg/L. If sediments associated with waters greater than 75 feet deep are considered anoxic, the bottom release area is about 255,000 m^2. This gives a release of about 77 kg over a 70 day period. This accounts for about 38% of the measured fall increase in Lake water total phosphorus concentration. This is a significant component of the

[1] Nurnberg, G.K., Prediction of Phosphorus Release Rates from Total and Reductant-Soluble Phosphorus in Anoxic Lake Sediments, Can. J. Fish. Aquat. Sci., Vol 45, 1988

overall phosphorus budget for the Lake. It is therefore important to quantify these calculations. This requires accurate measurements of area; days of low dissolved oxygen concentration, and sediment TP. The sampling program for 2001 has been designed to accomplish these goals.

Note that surface concentrations of total phosphorus also increase significantly in the fall (as well as in the spring). These increases may be associated with high fall tributary flows and elevated concentrations caused by the re-suspension phosphorus stored in the system during earlier lower flow periods. In addition, factors such as high fall Hatchery loads, decaying of salmon that enter the lake, decaying of lake or river macrophytes, and the re-suspension of solids from the lake bottom may all play a role in elevated fall concentrations.

For example, Figure 12 shows hydrographs for the Platte River at the USGS gauging station for 1999 and 2000. Figure 13 shows total phosphorus concentrations in the Platte River at the USGS station and at Deadstream Creek for 2000. Note that high flows and concentrations occur during both the spring and fall of 2000. These high loading events increase the concentration of total phosphorus in the Lake. The proposed event sampling program for 2001 and the development of the watershed loading model will address these issues.

It is also proposed to conduct field studies to measure the area, density and total phosphorus content of the macrophytes in the lake and the Platte River. The macrophytes could represent a significant sink of phosphorus at certain times of the year and a significant source at others. Thus they may play an important role in the dynamics of total phosphorus in the lake and represent an important component of the overall phosphorus budget.

Review of Sampling Program

Field and Laboratory Problems in 2000

The laboratory and sampling procedures were carefully reviewed during 2000. Several problems were noted and have been corrected. These include:

Stream samples from the USGS US-31 and the Deadstream stations were gathered from a shallow location by the field crew using waders. Sometimes bottom sediments were re-suspended within the zone where the sample was taken. Samples are now taken without entering the streams or disturbing the sediments.

Dissolved oxygen concentration, as determined by the Winkler Titration method and the ***Hydrolab*** instrument, were often found to be inconsistent. GLEC studied this problem and improved their field techniques and may purchase a new ***Hydrolab*** unit.

The plastic carboys used for the stream composite samples were not acid-washed every cycle. Bottles are now acid-washed every cycle by GLEC.

There is no permanent buoy located at the lake sampling station. This makes it difficult to find the proper location for sampling and setting the anchor may disturb the bottom sediments. This may result in incorrect measurements of the bottom water dissolved oxygen and total phosphorus concentrations. Efforts are underway install a permanent buoy to correct this problem.

2000 Hatchery Sampling Program

The 2000 sampling program used three measurements to define the input of water and total phosphorus to the Hatchery. These measurements were made at the following locations:

- Brundage Spring
- Brundage Creek
- Platte River just upstream of Hatchery

Two measurements are currently necessary to define the Hatchery gross output loading:

- Upper Effluent
- Lower Effluent

These five stations are measured every Tuesday and Friday throughout the year. Flow is measured (or estimated) in the field and total phosphorus and suspended solids are determined in the laboratory. The net Hatchery load is calculated as the difference between the gross outflow loading and the input loading.

2000 Tributary Sampling Program

Two additional tributary samples are taken to define the phosphorus loading to Big Platte Lake. These measurements are made at the following locations:

- Platte River at USGS
- Deadstream Creek

These stations were measured 22 times in 2000 at approximately two-week intervals throughout the year. Flow is measured in the field and total phosphorus and suspended solids are determined in the laboratory. The Lake outlet flow is also measured at M-22.

2000 Lake Sampling Program

Big Platte Lake was sampled at one central location in the deepest basin at the following depths:

- Just Below the Surface
- 7.5 feet
- 5 feet
- 30 feet
- 45 feet
- 60 feet
- 75 feet
- 90 feet (1 meter above the bottom)

This station was sampled 22 times at approximately two-week intervals throughout the year. Two samples were taken during ice cover.

The following parameters were measured in the field at 8 depths using a ***Hydrolab.***

- Dissolved Oxygen
- Temperature

The water samples were taken with a Kemmerer device at each depth. The samples were transferred to various laboratories where the following parameters were measured:

• Total Phosphorus	(triplicate)
• Chlorophyll	(2xSecchi Depth composite)
• Algae	(all 8 depths)
• Zooplankton	(all 8 depths)
• Alkalinity	(surface, 7,5, 15 and 30 feet only)
• Calcium Ion	(surface, 7,5, 15 and 30 feet only)
• Total Dissolved Solids	(surface, 7,5, 15 and 30 feet only)
• pH	(surface, 7,5, 15 and 30 feet only)

Secchi depth and temperature were recorded in the field. Water samples are fixed in the field for subsequent laboratory determination of dissolved oxygen using Winkler Titration methods.

Immediate Modifications

The following is a list of modifications that should be implemented as soon as practical:

1) Combine the three Hatchery inflows into one mixing box.

2) Use the Upper Weir for the Hatchery outflow (eliminate Lower Weir).

3) Measure flow and total phosphorus at M-22 every 2 weeks.

4) Use the M-22 staff gauge to determine Lake levels every two weeks.

5) ***Hydrolab*** parameters should include temperature, dissolved oxygen, conductivity, pH, and oxidation-reduction potential.

6) ***Hydrolab*** readings should be recorded every 2 meters.

7) Consider the use tube samples for composite measurements for phytoplankton and zooplankton to reduce cost.

8) Add ferrous iron (Fe^{+2}) measurements (triplicate, bottom 2 depths only).

9) The Hatchery spends about $3,000 per year for useless suspended solids measurements. These measurements are a mandatory component of the NPDES discharge permit. It is recommended that these measurements be conducted only one per week instead of the current two times per week schedule. In addition, methods should be investigated to determine suspended solids in the field using optical methods. The cost saving should be used for expanded event monitoring of sub-watersheds.

<u>Long-range Modifications</u>

The following is a list of possible modifications that should be considered when sampling program is changed to accommodate the watershed model and cost and quality control issues are resolved.

There are too many laboratories and agencies involved in this program to insure proper field methods, consistent data handling, and most importantly well defined quality assurance procedures. Evergreen Analytical measures the phosphorus content of the fish food. CT&E measures the concentration of suspended solids. GLEC measures total phosphorus and several field parameters. Another laboratory measures alkalinity, TDS and calcium. The phytoplankton and zooplankton are measured by Commonwealth Environmental. USGS, PLIA, and the Hatchery staff measure various flows. It is recommended that these measurements be consolidated at one laboratory to the extent possible. Discussions are underway with GLEC, CMU, and CT&E to obtain competitive cost proposals for laboratory analyses of the Hatchery, tributary, and Lake samples. CMU has participated in a blind test to determine the accuracy and precision of their methods for total phosphorus. The results show that CMU and GLEC measurements are consistent. Appendices 5, 6, and 7 are preliminary cost proposals for laboratory analyses by GLEC, CMU, and CT&E.

It is recommended that flow be measured using both in-stream meters (either Gurley or Marsh-McBirney) and staff gages at the M-22 outlet, Deadstream Creek, and at about three to six additional small streams about 25 times per year for a wide range of flow conditions. These data can be used to calibrate or verify the staff readings. Also data will be used to correlate Deadstream and other small stream flows with USGS flows. Flow measurements should be taken on the same day as chemistry measurements. In addition, we need flow, turbidity, and total phosphorus during wet weather and storm events. It may be necessary to purchase a Gurley meter and construct staff gages in the three small sub-watersheds. It may be possible to obtain technical assistance from the USGS concerning these matters.

The watershed loading model will require extensive data for calibration and validation. A detailed plan will be developed following the selection of a contractor. It is expected that it will be necessary to measure rainfall amounts and total phosphorus concentration at several locations within the watershed and possibly at one highly developed watershed outside Platte Lake drainage system. In addition it is expected that the flow, total phosphorus concentration and turbidity will be measured in several sub-watersheds during several wet-weather events. Measurements of pan evaporation may also be made to complete water balance calculations.

Alternatively, evaporation may be estimated using measurements of wind speed, water temperature, dew-point temperature, air temperature, and relative humidity.

The suspended solids measurements give little useful information because concentrations are very low (near detection). The concentration of suspended solids does not correlate well with total phosphorus or flow because concentration measurements lack precision. An investigation is underway to determine the application of turbidity measurements as replacement. These measurements can be done in the field. This will require the purchase of a Turbidity meter.

Walker will perform additional data analyses by the fall of 2001. These analyses will update formulations for daily flow and phosphorus loading using the 1997 to 2000 data. Walker will also examine possible correlation relationships between pH, calcium precipitation, chlorophyll, phytoplankton, zooplankton, and Secchi depth. In addition, he will examine the relationship between Secchi depth and the percent of the Platte River flow attributable to the Hatchery. These results may provide helpful insights that will be useful for the refinement of the sampling program. An understanding of the Secchi depth data may require an analysis of the alkalinity, calcium, and TDS data.

Special Studies

It is important to add sediment sampling and analyses to the program. Samples should be taken at approximately 8 locations at various depths in the Lake. The sediment should be analyzed for total phosphorus, solids density, water content, TOC, and Chemical Oxygen Demand (COD). Laboratory experiments should be conducted to determine phosphorus release rates and Sediment Oxygen Demand (SOD). These measurements will be used to develop correlation relationships between sediment total phosphorus concentration and anoxic release rates. The resulting relationship can be compared with the Nurnberg Equation. The COD measurements will be used as a correlation parameter with SOD.

Laboratory tests should be performed to determine the bio-availability of various sources of phosphorus. These tests use measurements of algal growth rates to determine the algal growth potential of phosphorus from different point and non-point sources. Results should be compared for watershed and Hatchery sources.

A macrophyte survey should be conducted to determine type, density, area, and phosphorus content. These data can be used to make first-cut approximations of the amount of phosphorus utilized during the growing season and the amount of phosphorus released during the fall die-off period. This information can be used to determine the significance of macrophyte activity on phosphorus dynamics in Platte Lake. Measurements should be conducted to determine the fate and transport of decaying macrophytes both in the Lake and in the major tributaries.

The magnitude of the internal sources of phosphorus from the sediments of Platte Lake is directly related to the area of the bottom that experiences anoxic conditions. Therefore, it is important to measure the area of bottom sediments that are in contact with overlying water that has low dissolved oxygen concentrations (< 2 mg/L). Therefore, surveys should be conducted in additional deep-water basins with the ***Hydrolab*** to search for such areas.

It would be appropriate to confirm earlier MDNR findings that the growth of phytoplankton in Platte Lake is limited by phosphorus. This can be accomplished by measuring the concentration of TKN, TKN-F, and nitrate in the Lake. It is recommended that these parameters be measured in the surface water and at 7.5 and 15 feet on two occasions in both July and August.

Water clarity, characterized by measurements of Secchi depth, is an important indicator of water quality conditions in Platte Lake. Laboratory studies should be conducted to enhance our understanding of the relationship among Secchi depth, light penetration, chlorophyll concentrations (or phytoplankton and zooplankton counts), calcium carbonate precipitation, pH, and color. Measurements of light attenuation as a function of depth should be obtained in the Lake using LICOR instrumentation. The filter-feeding activities of zebra mussels can reduce phytoplankton concentrations and consequently increase Secchi depth. A survey should be conducted to estimate the area, density, and size-distribution of resident mussels.

Data Storage

Mr. Wil Swiecki and Dr. Michael Pattison have performed the huge task of constructing and maintaining an Excel Spreadsheet that contains the Lake data. This arrangement has worked very well and it is recommended that they continue this effort.

It is also recommended that the spreadsheet be expanded to calculate a running water balance for the Lake. This should include flow from the Hatchery, flow from the watershed, rainfall and evaporation from the surface of the lake, and changes in lake-levels. The daily flows for Deadstream can be calculated by correlation with USGS measurements. The flow at the USGS station is the sum of non-point watershed flows upstream of the Hatchery, the Hatchery effluent flow, and the non-point flow from the watershed between the Hatchery and the USGS gauging station. Flows below the USGS station can be determined from estimates of the drainage area. The above calculations along with estimates of the lake storage can be used to calculate possible groundwater inflow or outflow. Similar calculations were performed by Walker, and the required correlation relationships will be updated using 1997-2000 data.

It is also recommended that the spreadsheet be expanded to calculate a running phosphorus balance for the Lake. This should include all internal and external sources of phosphorus. The internal sediment source can be estimated using the Nurnberg Equation and the monitoring data and other measurements can be used to estimate loads form the Hatchery, the watershed tributaries, rainfall, groundwater (including septic systems), and inputs from decaying salmon and alewife. Although some of these sources may be difficult to control and are not related to Hatchery operations (for example, alewife die-off), it is important to have a comprehensive understanding of all the phosphorus sources and sinks in order to the predict long-term consequences of alternative management activities.

Lake and Watershed Modeling

Lake Water Quality Model

It is important to develop an accurate water quality model of the Lake to determine the significance of Hatchery point loads, watershed flows and non-point loading, and internal loading from the sediments associated with low bottom water dissolved oxygen concentrations.

Water quality models for Platte Lake have been developed by in the past by Canale, Chapra, Lung, and Walker. Unfortunately, these models do not adequately address exchange processes between the water and the sediments and do not include dissolved oxygen as a model variable. Thus, these models must be improved before they can be used to accurately forecast changes in the water quality of Big Platte Lake.

However, at this time it is more important to focus resources on the development of a watershed-loading model. Furthermore, the field and laboratory procedures and the design of the sampling program have not been finalized to accommodate the needs of the watershed model. These tasks should take precedence over the development of the Platte Lake water quality model. Thus, it is recommended that these decisions be made before proceeding with further refinement of the water quality modeling work. Eventually (perhaps two years) it will be appropriate to develop a comprehensive water quality model for Platte Lake that has the best features of the above models. The new model will add dissolved oxygen as a variable and expand and refine the capabilities of the model to determine the long-term impacts of phosphorus release from the sediments. The analysis of the 1997 to 2000 data that will be performed by Walker will likely provide additional insights that will be useful to efforts to develop a new water quality model for Platte Lake.

Watershed Phosphorus Loading Model

We have received the LTI recommendations for a watershed model. They have recommended that we use a modified version of the Generalized Watershed Loading Function (GWLF) model. They believe that this is the best tool that meets the objectives of our application. This model has moderate complexity and has been successfully applied in numerous previous studies and has performed well when compared to measured data. Unfortunately this modeling tool is not well known, and the cost is about $170,000. Alternatively, LTI has submitted a cost estimate of $50,000 to develop the BASINS model for the Platte Lake watershed. We have received a proposal from QEA to accomplish similar technical tasks for a cost of $55,000.

It is recommended that we use the BASINS model. This model is well known and is supported by USEPA. I recommend that we hire LTI to develop the watershed model because their cost estimate is lower than QEA, and they are located in Michigan. A copy of both technical and cost proposals is included in Appendices 8 and 9. A description of the BASINS model is contained in Appendix 10.

Coordination with Local Planning Agencies

Significant progress has been made to collaborate with the Benzie Conservation District and other agencies regarding the development and application of the watershed and lake models. The District is developing a Partnership Agreement with the National Park Service as well as the MDNA and the PLIA. This Partnership will facilitate the efforts of the District to secure additional funds to support the objective of preserving the water quality of Platte Lake. In addition, lines of communication have been established with nearby lake-protection associations from Crystal and Long Lakes and other conservation agencies.

Appendices

Appendix 1. EXCEL spreadsheet summary of Hatchery total phosphorus for 2000.

Appendix 2. Hatchery report on the operation of the Lower and Upper Weirs.

Appendix 3. Report on antibiotic and disinfectant use at the Hatchery during 2000 and 2001.

Appendix 4. Excel spreadsheet for volume-weighted total phosphorus concentration.

Appendix 5. GLEC proposal for laboratory analyses.

Appendix 6. CMU proposal for laboratory analyses.

Appendix 7. CT&E proposal for laboratory analyses.

Appendix 8. QEA watershed model proposal.

Appendix 9. LTI watershed model proposal.

Appendix 10. Description of the BASINS watershed model.

Appendix 11. Minutes from meeting among the Implementation Coordinator, MDNR, and PLIA.