Consent Agreement Annual Report
2008

Report Prepared by

Dr. Raymond P. Canale
Implementation Coordinator
Emeritus Professor, University of Michigan

Gary Whelan
Michigan Department of Natural Resources
Fisheries Division

And

Wilfred J. Swiecki
Platte Lake Improvement Association

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Summary for the Year 2008

Overview

The goal of the Consent Agreement is to implement a long-term strategy to restore and preserve the water quality of Big Platte Lake. This goal is being advanced by minimizing the flow and phosphorus discharge from the Hatchery and by developing strategies to reduce non-point phosphorus loads from the watershed. Figure 1 summarizes the compliance with the Consent Agreement and the major accomplishments for 2008.

Compliance with Consent Agreement

The Consent Agreement mandates that the Hatchery net annual load be limited to a maximum of 250 lbs. during the construction period, 225 lbs. during a 3 year test period, and 175 lbs. thereafter. The corresponding maximum loads for any consecutive three month period are limited to 75 lbs., 70 lbs., and 55 lbs. The five year compliance period started on July 1, 2007. The net Hatchery annual loading for 2008 was 174.8 lbs. This is just within the requirement. The maximum load for any 3 month period was exceeded in April 2008 (60.8 lbs.) and May 2008 (55.8 lbs.). These loading violate the 55 lbs. limit. The average water use at the Hatchery was 6.24 mgd which is less than the Consent Agreement limit of 20 mgd.

The average volume-weighted total phosphorus concentration of Big Platte Lake was 7.7 mg/m^3 in 2008. The water quality goal of 8.0 mg/m^3 was achieved 63% of the time. This is not consistent with the goal of 95% attainment as stipulated in the Consent Agreement.

A total of 5,029 adult coho and 181 adult Chinook salmon passed the Lower Weir in 2008. These numbers are in compliance with the Consent Agreement limits of 20,000 adult coho and 1,000 adult Chinook salmon. Excess salmon that accumulated below the Lower Weir were harvested, counted, and removed from the watershed. A total of 3,625 adult coho salmon were harvested for egg collection at the Upper Weir. This is 72% of the number of the coho salmon that were counted passing through the Lower Weir. A total of only 3 adult Chinook salmon were harvested at the Upper Weir. This is less than 2% of the number that were counted passing through the Lower Weir.

Major Accomplishments for 2008

- Efforts continue to improve the accuracy of the phosphorus mass balance calculations for the Hatchery.

- A phosphorus loading model from the Hatchery has been developed. The components of the model are the net load, fish food, fish production, pond loss, and trucked phosphorus from the sludge storage tank. Efforts continue to improve the accuracy of the model.

- A bioenergetic fish growth model for the Hatchery has been developed using the Wisconsin Fish Bioenergetics Model as well as other approaches. Validation is underway.

- Brundage Creek and Brundage Spring input flow meters were calibrated using a volumetric (bucket) method.

- The JN and Sigma samplers were moved to more representative and comparable locations. A complete report is included in Appendix A.

- Tests were performed that clearly demonstrate that total phosphorus measurements from the JN and Sigma samplers are comparable when both technologies sample the same water. A complete report is included in Appendix B.

- Measurements were made that show that little or no water leaks directly from the effluent pond to the Platte River. This test confirms that the flow measurements at the Upper Discharge site are accurate reflections of total water use at the Hatchery.

- Experiments have been completed to determine the bio-availability various sources of phosphorus to Big Platte Lake in cooperation with Central Michigan University (CMU). The study plan used algal assay procedures and a bio-availability model. The project is the basis of a Master's Degree thesis currently being written.

- A long term phosphorus model has been developed for the water and sediments of Big Platte Lake. The model is based on historical as well as current water quality monitoring data. The model has been tested and has been is shown to be reliable for a range of loading conditions. The model can be used with confidence to predict annual average

phosphorus concentrations in the lake as a function of changes in flow conditions and phosphorus loading from the watershed. The model can be used to develop a Total Minimum Daily Load (TMDL) and phosphorus reduction strategy for the Lake. A manuscript has been submitted for peer review and possible publication in the Journal of Water Resources Planning and Management of the American Society of Civil Engineers.

- A comprehensive seasonal ecosystem model with several dependent variables and forcing functions is under development for Big Platte Lake. This model also has many coefficients that must be estimated using field measurements or through the process of model calibration. Although estimates of these model coefficients may be somewhat uncertain, the model can be used in conjunction with simpler models to help refine understanding of water quality and food web dynamics in Big Platte Lake.

- The capabilities and functionality of the database are being expanded on an ongoing basis. Phosphorus and hydraulic mass balance reports have been created for the Hatchery, watershed, and Big Platte Lake. Accounting and billing differences with CMU have been resolved regarding laboratory analyses. Future invoices from CMU will be linked to the database.

Recommendations and Action Items

- The differences between phosphorus and turbidity data from the Jug & Needle and Sigma samplers have been resolved. It is recommended that the Jug & Needle sampling equipment be abandoned and used only for backup applications.

- All agree that the Sigma sampler data should be used to calculate the annual and 3-month average loading from the Hatchery. All agree that the crossover date shall be July 1, 2009. The loading for Consent Agreement purposes will be based on Jug & Needle data up to and including June 30, 2009. The Sigma sampler data will be used to determine loads on and after July 1, 2009.

- It is recommended that permanent conduit replace the flexible tubing for the Sigma samplers and that a cleaning procedure be implemented to allow easy maintenance on a weekly basis for both samplers.

- It is imperative that continuing focused efforts be expended to accurately measure all the inputs and outputs of phosphorus from the Hatchery so that mass balance calculations can be verified each year. Our understanding of the operation of the Hatchery and our ability to track movement of various phosphorus pathways comes under significant question without such mass balance closure.

- More emphasis must be placed on accurate measurement of the amount of phosphorus removed from the Hatchery when the solids storage tank is cleaned. It is recommended that the hauling company be required to provide the Hatchery staff a three day notice prior to cleaning. The tank should be thoroughly mixed during drawdown and washed down and cleaned at the end. It is recommended that triplicate samples be taken at the beginning, middle, and end of each individual truck load. It is suggested that the tank be cleaned at minimum one time per year, preferably during early or mid-summer so that the surface water of the tank can be used for lawn irrigation.

- The phosphorus associated with harvested (shipped, planted, and morts) fish and fry tissue is a critical variable associated with understanding the fate of phosphorus that enters the Hatchery as food is transferred to harvested fish. It is recommended that fish tissue phosphorus samples be collected and sent to CMU for analysis.

- It is recommended that phosphorus content of the fish feed as provided by the manufacturer be verified by providing split samples to CMU for analysis.

- All SOP documents and equipment maintenance schedules should be reviewed and updated annually. Certification letters regarding the accuracy of the net phosphorus loading, fish production, and weir numbers in the database should be sent to the Implementation Coordinator for inclusion in the Annual Report.

- Studies of the bioavailability of Hatchery and non-Hatchery phosphorus sources should be completed.

- The Implementation Coordinator should continue efforts to calibrate and validate the water quality models for the lake.

- The Implementation Coordinator should continue efforts to calibrate and validate the fish bioenergetic and Hatchery process model. Improvements in the current model based on

recommendations of the Hatchery staff should be incorporated.

- It is recommended that a meeting be held for the purpose of describing the structure and organization of the database to all interested parties. The purpose of this exchange is to facilitate the operation of the database in the event Jim Berridge is no longer in a position to perform this task.

- It is recommended that a program be designed to collect data that can be used to verify bioenergetics model. This should involve the collection of data that better describes the growth of fish in the system, improved temperature and dissolved oxygen measurements, fish tissue phosphorus measurements, and the phosphorus in the feed and that lost in the raceway overflows.

- It is recommended that tests be conducted to determine the feasibility of re-programming the Sigma samplers to collect 3 day composites rather than 24 hour composite samples two times per week. This strategy will allow collection of data that better characterizes the input and discharge of phosphorus from the Hatchery.

- It is recommended that operational data be collected to help improve the understanding and efficiency of the disk filters. The goal should be to provide data that will allow timely maintenance of the filters to maintain peak performance.

- It is recommended that random blank total phosphorus samples continue to be sent to CMU as a means to maintain high levels of quality assurance.

- It is recommended that nitrogen sampling discontinued in Big Platte Lake and all tributaries. It is also suggested that plankton sampling be limited to 3 times per year in Big Platte Lake and that all sampling of Little Platte Lake be discontinued until budget constraints removed.

- It is recommended that the PLIA web site be expanded to include more timely lake water quality information. The web site should not have active database capabilities, but rather information should be updated approximately every two weeks in the summer.

Acknowledgements

The Implementation Coordinator would like to take this opportunity to thank Gary Whelan (MDNR Fisheries Division) and Wil Swiecki (PLIA) for their continuing contributions to this project. Gary has extraordinary leadership and management skills and has kept this project focused and moving forward. Wil has been tireless in his efforts to ensure the reliability of the data and has displayed incredible perseverance working toward the PLIA goal of preserving the water quality of the Lake. As a result, excellent coordination and communication has been maintained within our group as well as with many outside organizations and individuals. The minutes of our coordination meetings in 2008 are contained in the Appendix C.

Jim Berridge (PLIA) deserves a special medal for outstanding service to Platte Lake. He has contributed his talents and endless hours of his time to create an Access database for the laboratory and field data collected on this project. This daunting task is an ongoing process. All those interested in preserving the water of Big Platte Lake owe him their gratitude.

Aaron Switzer (MDNR Fisheries Division) has the major responsibility of collecting the field data and has done an absolutely outstanding job with this task. He has contributed not only through his perseverance and consistency but also through thoughtful analysis of procedures and data. He always stands ready to get "just a few more samples" to satisfy the needs of Ray, Gary, and Wil. The reliability of the data would suffer without his careful and conscientious efforts.

We also acknowledge and appreciate the support and assistance of Edward Eisch (MDNR Fisheries Division) for his overall management of the facility along with its personnel, ensuring the development of Hatchery SOPs, and the design and implementation of the Hatchery flow measurement program. He has been instrumental in assuring that Hatchery meets its commitments to the Consent Agreement.

Janice Sapak (MDNR Fisheries Division) has been key in collecting, verifying, and analyzing all aspects of the Hatchery production data. She also writes an annual report on fish production activities that has been incorporated into this report.

The authors would also like to thank and acknowledge the valuable contribution of many individuals from CMU. Jenny Estabrook and Scott McNaught have left no stone unturned in their efforts to evaluate and improve their laboratory methods. Scott McNaught has reviewed the historical plankton data, recommended much improved methods for sample collection, and added

biomass measurements.

Finally, several additional individuals associated with the PLIA have made significant contributions to this project:

- Jerry Heiman has done an excellent job measuring the flow rates and water quality parameters of several tributaries.

- Mike Pattison has done a terrific job developing and maintaining the PLIA web site with the latest version of the database.

- Tom Inman has worked with the Hatchery staff on counting the Fall Salmon Runs.

- Sally Casey has been making weekly open water Secchi Depth measurements for over 25 years.

- Joe Francis has been measuring the pH of Big Platte Lake for many years.

Hatchery Operations

Antibiotic Use (Jan Sapak)

The antibiotic use at the Platte River State Fish Hatchery in 2008 was largely focused on the within label feeding of oxytetracycline (OTC) to Chinook salmon to produce a readable mark on the vertebra of hatchery produced fish. The OTC was added to the feed during manufacturing and was obtained from BioOregon of Warrenton, Oregon. The OTC (TM 100) was mixed in the feed at a rate of 40 pounds per ton of feed. The medicated feed was fed to all rearing units of Chinook salmon at a rate of 2% of the body weight for four days, with one day off and then fed again for another 4 days. The treatment occurred between April 12 and May 28, 2008. Not all rearing units were fed on the same days, and the maximum treatment was 65.1 kg of treated feed per day. A total of 1,260 kg of treated feed were fed during the treatment period. The total amount of OTC in the feed in 2008 was 25.2 kg compared to 24.2 kg in 2007 because slightly more Chinook salmon were produced, requiring additional feed. In 2008 no OTC (TM 100) was fed for disease treatment purposes. The hatchery discharge flow during the treatment period averaged 7.147 MGD (million gallons per day).

Antibiotics were also used to treat a bacterial infection of Bacterial Kidney Disease (BKD) in coho salmon. Gallimycin, a brand name for erythromycin, was used to top-dress feed for 21 days, from September 6, 2008 through September 26, 2008. The maximum treatment was 1.641 kg erythromycin per day and a total of 31.31 kg of erythromycin were fed during the treatment period. The hatchery discharge during the treatment period averaged 6.052 MGD.

Disinfectant Use (Jan Sapak)

Parasite-S was used in 2008 to control fungus on fish eggs. Parasite-S is a trade name for formalin that consists of 37% formaldehyde by weight in water. The standard treatment used is a 15-minute flow-through with formalin at a concentration of 1 to 600 (1,667 ppm). Formalin was used from October 7, 2008 through January 8, 2009 to treat fungus on salmon eggs. During this period a total of 588 gallons of formalin was used. The maximum treatment was 5.4 gallons per day, during a 15 minute period. Hatchery flows averaged 6.529 MGD during the 2008 salmon incubation season.

Chloramine-T (CT) was used only once in 2008, to control early mortalities in coho salmon fry in various rearing units on January 23, 2008. A one hour flow-through treatment was administered and a total of 411.3 g of CT was used. The hatchery discharge during this period was 6.048 MGD.

Weir Operations (Jan Sapak)

The Consent Agreement with the Platte Lake Improvement Association allows 20,000 adult Coho to be passed upstream of the Lower Platte River Weir during the fall salmon run. This number ensures that sufficient eggs and milt can be obtained in order to maintain the MDNR Coho stocking program. The agreement also allows for passage of up to 1,000 adult Chinook salmon.

During the fall of 2008, both the Upper and Lower Platte River Weirs were operated in much the same fashion as in 2007 however the adult coho returns were down significantly. The return of adults in 2007 was the highest in recent years and the return in 2008 was the lowest on record. The number of returning jacks was significantly higher than in 2007, indicating a potentially high run of adults in the fall of 2009. A high return of jacks generally indicates a high return of adults the following year, but this relationship did not hold true for the 2007 jacks and 2008 adult returns.

The Lower Weir grates were installed on August 15, 2008 and removed for the season on November 6, 2008. The weir grates are generally left in place until November 15, but due to the

reduced number of coho salmon adults, the MDNR and PLIA agreed to open the weir early so that adult coho salmon would be able to pass upstream unhindered in an attempt to meet the egg take needs for the state. As fish collected below the weir in sufficient numbers, coho salmon were passed upstream for egg take purposes, and surplus Chinook salmon, and coho salmon jacks, were harvested and removed from the river. Fish were passed upstream of the weir by raising the boat gate slightly and manually counting the number of fish by species that swam upstream under the gate. For harvest operations, the pumps were turned on and fish were allowed into the holding pond, where they were later removed. Members of the Platte Lake Improvement Association were contacted prior to passing fish upstream and were invited to observe the operation.

In 2008, 181 adult chinook salmon, 15 jack Chinook salmon, 5,029 adult coho salmon, 8,277 jack coho salmon, 51 steelhead trout and 3 brown trout were passed upstream of the Lower Weir. In addition, a total of 895 adult chinook, 74 jack chinook salmon, 881 jack coho salmon and 5 pink salmon (which were only listed in the comments of the weir database) were harvested at the Lower Weir and shipped to American Canadian Fisheries, Inc. of Bear Lake, Michigan. At the Bear Lake facility, MDNR staff conducted biological sampling of the season's spawning run.

All of the dam boards for the Upper Weir were in place by August 26, 2008, and any migrating salmon were directed to the maturation ponds after this time. Coho egg take occurred between October 20 and November 12, 2008. After egg take all fish were harvested and shipped to the contractor. In 2008, a total of 3 adult Chinook salmon, 3 jack Chinook salmon, 3,625 adult coho salmon and 6,882 jack coho salmon were harvested from the Upper Weir and shipped to the contractor at the Bear Lake processing plant. The ponds were harvested for the final time, and weir operation was suspended for the season on November 25, 2008.

The total number of fish that were unaccounted for between the Lower and the Upper Platte River Weirs included 1,404 adult coho salmon, 1,395 jack coho salmon, 178 adult Chinook salmon, and 71 jack Chinook salmon. It is assumed that these fish were either caught by anglers, or spawned and died in the river prior to reaching the Upper Weir.

Egg Take and Egg Incubation (Jan Sapak)

The coho salmon egg take operation occurred at the Platte River State Fish Hatchery between October 20 and November 12, 2008. A total of 3,512,189 coho salmon eggs were taken and fertilized. This included 3,025,021 eggs for the Platte River State Fish Hatchery and 487,168 for other state agencies, including Indiana and Illinois. The out-of-state requests were not met with

green eggs, and the eggs from October 29 and November 12 were incubated at Platte River State Fish Hatchery until eye-up stage and then shipped to the Bodine State Fish Hatchery in Indiana and the Jake Wolf State Fish Hatchery in Illinois. The number of green eggs taken for the Platte River State Fish Hatchery was almost twice the number taken in the fall of 2007 because the rearing assignment for coho salmon was returned to a normal production of approximately 1.5 million yearlings for the spring of 2010.

Chinook salmon eggs were taken at the Little Manistee and Swan River Weirs and transferred to Platte River State Fish Hatchery in October 2008. A total of 4,181,559 eggs were incubated at the Hatchery. Incubation took place during the months of October, November and December, and the earliest hatching Chinook salmon were put in tanks at the end of December.

On October 16, 2009 a Chinook salmon egg-take was conducted at the Lower Platte Weir for the purpose of comparing immediate, on-site fertilization with delayed fertilization which occurred at the hatchery. Eggs from this study were discarded after the eye-up stage, upon completion of the study protocol.

Fish Production (Jan Sapak)

During the course of the year, 1,411,530 (595.94 kg) fry were placed in the rearing units. This includes 393.94 kg of Chinook and coho salmon fry added in January, and 201.1 kg of Chinook and coho fry added in March.

The Chinook and coho salmon were reared for production purposes, and during calendar year 2008, the Platte River State Fish Hatchery raised and stocked (planted) 749,049 (36,138.0 kg) coho salmon in the Platte River. In addition, 2,462,113 (26,331.98 kg) fish were raised and shipped to other locations outside the Platte River watershed. This includes 421,063 (16,781.16 kg) yearling coho salmon and 2,041,050 (9,550.82 kg) spring fingerling Chinook salmon.

During the course of the year a total of 39,301.8 kg of feed was fed to the production lots of coho and Chinook salmon. This feed was predominantly BioOregon BioDry 1000 LP. Silver Cup Low Phosphorous Steelhead diet was also fed in small amounts, and both of these diets contained less than 0.9% phosphorous. A small amount of BioOregon BioVita Starter (less than 3.7% of the annual food fed) was fed to fry and this diet was approximately 1.5% phosphorous.

At the end of the calendar year there were 636,681 (23,287.89 kg) of yearling coho salmon on hand. Also, there were approximately 4.4 million coho and Chinook salmon fry in incubation.

Waste Handling (Jan Sapak)

Throughout the production cycle all egg and fish mortalities were removed from the incubators and rearing units on a daily basis. Mortalities were weighed or counted and disposed of at a certified landfill, or in the case of egg mortalities, to the salmon harvest contractor.

In an effort to improve incoming water quality, the outside raceways were set up in a three-pass system with coho salmon in B and C series. Four raceways in A series were used as a settling basin to help remove sediment before the water passed through B Series. Baffles were removed from the A raceways and silt was allowed to settle out before the water passed through the disc filter. The sediment was periodically removed from the raceway by pumping it directly to the line leading to the clarifier. The sediment was then captured in the sludge tank. Operating the raceways in this fashion resulted in much improved water quality for the fish.

Fish waste was removed daily from the rearing units either by manual cleaning or automatic filtering of the wastewater. The filtered waste was directed to a clarifier and finally, the sludge tank where it was stored. The sludge storage tank was pumped by BioTech Agronomics, Inc. on July 21-23, 2008 and a total of 144,000 gallons of sludge was removed. All sludge was land applied per the Michigan Department of Environmental Quality's Manure, Paunch and Pen Waste Exemption guidelines at a site outside of the Platte River watershed.

Net Total Phosphorus Load

Water used to culture fish becomes enriched with phosphorus as it passes through the Hatchery from fish excretion, egestion, and from unconsumed feed. The net phosphorus daily loading from the Hatchery is defined as the difference between the phosphorus loading that leaves the system and the phosphorus entering the system from the three possible water sources (Brundage Spring, Brundage Creek, and the Platte River) on a given day. Negative net loads on any day are set equal to zero for calculation purposes as specified in the Consent Agreement. Linear interpolation is used to determine the net load on days when no measurements were taken. This may require the use of the last measurement of the proceeding year and the first measurement of the following year to complete the calculation. The summation of daily net loads for the year gives the annual net phosphorus loading. The concentrations of total phosphorus and turbidity of

the Hatchery inlet and outlet flows are currently measured on samples collected using two methods. For several years, a composite sample has been taken using a jug equipped with a fine gauge needle that slowly allows air to escape from the jug. Automated Sigma Samplers were installed in association with the Hatchery renovation program. These samplers obtain 24-hour composite samples by pumping sub-samples at regular intervals. The official Hatchery loading is calculated from Jug & Needle total phosphorus measurements as specified in the Consent Agreement. The net phosphorus load was 174.8 lbs. for 2008. Appendix D is a spreadsheet that shows the calculations in detail. Figure 2 shows the total annual net phosphorus loading from the Hatchery from 1990 to 2008. Note that the loads since 2000 are about 25% of those in 1990. However, there is considerable variation with the 2005 load being higher than the loads in 2004, 2006, and 2007. Figure 3 shows the 3-month net phosphorus loads for 2008. Note that the loads for April and May of 2008 violate the Settlement Agreement limit of 55 pounds. It is important to understand the variations shown in Figure 2 and the violations shown in Figure 3 so that steps can be taken to avoid Settlement Agreement infractions if changes in fish production are desired or plant operations are altered.

Sigma vs Jug & Needle Sampling Methods

Previous Annual Reports discussed differences between results for turbidity and phosphorus samples collected using the Sigma and Jug & Needle equipment. These differences have finally been resolved! It has been determined that the two collection methods give essentially identical results when the sampling locations and collection periods are same. Figures 4 through 7 show comparisons between Sigma and Jug & Needle samples taken at Brundage Spring, Brundage Creek, the inlet to the pond, and the Upper Discharge collections sites. Note than when the location and collection times are identical, the Sigma and Jug & Needle results are quite similar with correlation coefficients greater than 0.9 for each sampling site. On the other hand, when sampling locations or times are not matched significant deviations may occur. It has been decided to abandon the Jug & Needle samples and use Sigma samplers because of their flexibility and reliability. Refer to Appendices A and B for a complete discussion of the consolidation of the sampling locations and testing associated with the Sigma and Jug & Needle sampling equipment.

Phosphorus Mass Balance

The **Law of Mass Balance** can be used to understand and develop a model for changes in the net load from the Hatchery as a function of production activities and facilities operation. The Law of Mass Balance states that the rate of accumulation of any conservative substance in a system

is equal to the difference between the rates of input and output through the system boundaries (see Figure 8). It is important to recognize that the Law applies to any conservative substance such as water or total phosphorus for any closed boundary such as the Hatchery. The mass balance equation applies for both non-steady state conditions (also called time variable or dynamic) and steady state (also called non-time variable) cases. Note that the Law of Mass Balance is not an amorphous theoretical concept. Rather it is a dependable, practical, and exact tool that can be used to determine how well we have specified and measured the terms in the equation. If the mass balance equation does not seem to work very well it is a reflection of how accurately we have measured the terms in the equation and not a condemnation of the Law itself. The mass balance equation simply requires that the accumulation of phosphorus in the system (in the case the Hatchery) is equal to the difference between the amount of phosphorus that enters the system (Inputs) and the amount leaving the system (Outputs).

Accumulation of P in the Hatchery = Sum on Inputs – Sum of Outputs (1)

The input terms refer to any phosphorus that enters the Hatchery, these terms include:

1. Food P. This term is the amount of phosphorus associated with the food that is fed to the fish in the Hatchery starter building and raceways. Note that the term is food actually fed and not feed that may have been purchased and stored at the facility. It is calculated by multiplying the weight of the food fed times the phosphorus content of the feed.

2. Source Water P. This is the amount of phosphorus contained in all of the Hatchery source water. The sources are Brundage Spring and Creek, the Platte River, and Service water. The input amount is determined by multiplying the flow rate times the phosphorus concentration.

3. Fry Tissue P. This term refers to the phosphorus introduced to the system when fry are added into the fish inventory. It is calculated by multiplying the wet weight biomass of the fry times the measured percent phosphorus in the fry tissue. Note that this approach avoids the need to count or weigh the egg harvest and egg morts. Note that if all other terms in the mass balance equation were zero the input of fry tissue phosphorus would exactly equal the accumulation of phosphorus in the system.

The output terms refer to phosphorus that leaves the Hatchery, these terms include:

1. Shipped, Planted, and Mort Fish Tissue P. This term refers to all the phosphorus that leaves the Hatchery in the form of fish tissue. Note that the mass balance equation does not care if the fish are shipped to another watershed, planted in the Platte River, or disposed as mortalities. This term is calculated by multiplying the whole wet weight biomass of the fish times the measured percent phosphorus in the fish tissue.

2. Discharge P. This term refers to the gross loading of phosphorus that leaves the system as flowing water. These flows include the Upper and Lower Discharges and the finishing pond by-pass. Currently, the Upper Discharge is only outlet flow. Note that this term is calculated by multiplying the discharge flow rate times the phosphorus concentration. The Net Discharge is the difference between the measured Gross Discharge and the sum of the measured inputs, and is used for NPDES and Settlement Agreement purposes.

3. Trucked P. This term refers to the amount phosphorus that is trucked away from the Hatchery usually as a result of emptying and cleaning the solids storage tank. This term is calculated by multiplying the measured number of gallons of liquid trucked away times the measured phosphorus concentration of the liquid.

The accumulation terms are calculated by subtracting the outlets from the inputs. Accumulation can be positive or negative. There are three major accumulation terms.

1. Fish Tissue P. This term refers to the fish phosphorus present in the Hatchery Building and raceways. It is calculated by multiplying the whole wet weight biomass of the fish times the measured percent phosphorus in the fish tissue. If the Fish Tissue P is greater at the end of the year than the start of the year the accumulation term is positive. If the Fish Tissue P is less at the end of the year than the start of the year then this term is negative. Note that additions, transfers, or removals of fish from the system are not considered in the calculation because such factors are accommodated by other terms in the mass balance equation.

2. Tank P. This term refers to the amount of phosphorus in the solids storage tank. It is the average phosphorus concentration of the solids in the tank multiplied by the tank volume. This term can also have a positive or negative value depending on the amount of phosphorus in the tank at the start and end of the year. Phosphorus removed by truck is included in separate terms in the mass balance equation.

3. Pond P. This term refers to the amount phosphorus that settles and is stored in the bottom of the pond. Phosphorus that settles to the bottom is prevented from leaving the by the pond clay liner. This term can be measured directly, but is usually calculated by subtracting all the inputs of phosphorus to the pond from the outlets. Normally, the inputs are greater than the outlets. Other terms in the mass balance would need to be added to cover the case where the pond is drained and bottom materials removed.

Mass Balance Application Formulation

The non-steady state form of the Mass Balance equation can be applied to the Hatchery on an annual basis and expressed in terms of regulatory, fish production, and facilities operation as shown on the bottom of Figure 8 and Equation 2.

Net P Load = Food – Production – Tank Retention – Pond Retention (2)

The net P load is simply the difference between the measured Gross Discharge Loading and the summation of the loadings from the various source waters. All the input terms are routinely measured. Food In represents the phosphorus in the food fed to the fish. The Production term is the annual amount of phosphorus associated the net growth of new fish biomass. The net annual production of fish is defined as the phosphorus equivalent of the fish that leaves the Hatchery as Morts, Shipped or Planted or contributes to an increase in the fish inventory in the raceways. Increases or decreases in inventory and the transferred fish are offset by the amount of fry that annually enter the system. The remaining terms are losses or retentions due to cleaning and trucking tank phosphorus, phosphorus settling to the bottom of the pond, or storage of phosphorus in the sludge tank. If the amount of phosphorus in the tank is less at the end of the year compared to the start, then the Tank retention term is negative and contributes to the Net Load.

Hatchery Mass Balance for 2008

Figure 9 shows Hatchery mass balance terms for 2008. The phosphorus associated with the source water and discharge was measured using the Sigma sampling method. Similar calculations are also available for the Jug & Needle method. The fish production terms were calculated using a fish tissue phosphorus content of 0.4% of the gross wet weight, a value that is consistent with recent measurements. However, it is recommended that this effort measurement be continued because of critical role this value plays in the mass balance calculations. There were about 180 lbs. more phosphorus associated with fish resident in the system at the beginning

of the year when compared to values at the end of the year. This means that some of the fish biomass planted in the Platte River or shipped to other systems in 2008 originated from 2007 production. Monthly average amounts of phosphorus associated with fish in the system, fish food, and that planted and shipped is also shown in Figure 10.

The solids storage tank began operation collecting and thickening the underflow from the clarifier on September 9, 2003 as shown in Figure 11. The tank has been emptied and cleaned 5 times as of the end of 2008. A small amount of phosphorus was also removed during November 2005 that is not shown. Linear interpolation is used to estimate the amount of phosphorus in the tank at the start and end of each year. The 2006 measurements of the trucked loss were adjusted to account for phosphorus removed when Raceway A was used as a clarifier to remove sediments from the source water.

The retention of phosphorus in the pond is determined by adding the inputs from the screens, clarifier, and tank overflows and subtracting the outputs measured at the Upper Discharge. The Sigma measurements in 2008 resulted in a pond retention of 60.85 lbs as shown in Figure 12. Figure 13 shows Hatchery phosphorus mass balance summary calculations for other years using both the Sigma and Jug & Needle equipment. The measured sum of input phosphorus is higher than the sum of outputs except for JN 2004 and JN 2005. Typically the measured net load is 100 to 200 pounds lower than what is expected based on fish production levels and the amount removed by trucking from the sludge tank. This means that the measured inputs are too high or that the measured outputs are too small. These results suggest the following possible explanations:

1. The source water phosphorus loading is lower than is being measured.
2. The discharge loading is actually larger than that being reported.
3. The actual pond losses are greater than those being measured.
4. The phosphorus in the food is actually lower than that reported by the supplier.
5. The biomass of the fish leaving the system is larger than that reported.
6. The phosphorus associated with fish tissue is greater than 0.4%.
7. The actual tank losses are greater than those being measured.

The first three items above are related to measurements of flow and phosphorus associated with the source water, the input to the pond, and the upper discharge. Significant efforts have been made to measure, calibrate, and verify that flow rates associated with these components are accurate. Therefore, it is assumed that any errors with these terms in the mass balance equations are associated with measurement of total phosphorus rather than flow rate. It is

imperative that significant efforts be expended to accurately measure all the inputs and outputs of phosphorus from the system so that mass balance calculations can be verified each year. Our understanding of the operation of the Hatchery and our ability to track movement of various phosphorus pathways comes under significant question without such mass balance closure. Rational management of the Hatchery is problematical without this understanding of fundamental processes. For example, one uncontrolled variable is temperature which affects all parts of this living system. As we improve our understanding of the bioenergetics of the system, we expect to make significant gains in improving the accuracy of the mass balance calculations and make predictions regarding how the net load of the Hatchery will change with changes production, feed rates, and treatment facility operation.

Mass Balance Application

Figure 14 shows the annual phosphorus mass balance equation or model for the Hatchery for the special case when the accumulation terms are zero and the sum of the inputs equals the sum of the outputs. This form of the equation can be used to gain insight into the relationship between fish production and the net load for the case where the fish inventory and the amount of phosphorus stored in the sludge tank are the same at the start and end of the year.

In recent years, fish culture activities involve the use of about 50,000 KG of fish food per year. This food averages about 0.9% phosphorus. Typically the Hatchery produces 50,000 KG of fish that have a phosphorus tissue content of about 0.4%. As shown in Figure 14, these production activities result in 550 pounds of “excess” phosphorus and that 375 pounds must be removed if the Hatchery is to remain compliant with the 175 pound net annual load as specified by the Consent Agreement. Note that insight into the magnitude of the amount of phosphorus that must be removed for the discharge results directly from mass balance principles if feeding and fish production estimates are available.

MDNR Fish Production Model

The Hatchery staff is faced with the responsibility to operate the facility so the discharge is compliant with the Consent Agreement annual and 3-month limits. This task is arduous because the temperature of the water in the raceways varies, both daily and seasonally, and the need to rapidly increase the size of the fish to meet OTC marking and other fish management requirements. The challenge is to use the disk filters in conjunction with the clarifier, sludge storage tank and finishing pond to remove 375 pounds of phosphorus from the discharge. Alternatively, food use and fish production might be lowered to reduce the discharge.

The Hatchery staff use a simple production model to assist them to attain these goals as shown in Figure 15 and described by Equation 3:

New Fish Weight = (Last Fish Weight – Mortality Weight)
+ (Weight of Food Fed/Conversion Ratio) (3)

This formulation is implemented by counting the mortalities and multiplying by the average weight of an individual fish to obtain the weight of mortalities. The new weight is then the old weight minus the mortalities plus any new increase in weight as a result of feeding. The new weight produced from feeding is simply the weight of the feed divided by a conversion factor. The conversion factor is an empirical number based on staff observations over many production cycles. As a result, the model often does a reasonable job of predicting the new weight of fish as shown in the example in Figure 15.

Unfortunately this model is not robust enough to quantitatively respond to the complex management issues involved in operating the Hatchery in a manner that is consistent with the restraints of the Consent Agreement and production goals. Some of the limitations are:

1. The model does not address the amount or fate of phosphorus losses that are an inevitable consequence of normal feeding schedules.

2. The model does not have a quantitative way to adjust the conversion ratio if the energy or phosphorus content of the feed changes.

3. The model does not have a quantitative way to adjust the conversion ratio if the temperature changes.

4. The model fails to account for the maximum consumption rate of the fish. The consumption ratio must eventually become larger and larger as the feeding level increases.

5. The model does not account for the time required for the fish to grow in response to the feeding. Equation 3 suggests that the new fish weight is attained immediately when the feeding is increased. There are implicit time restraints in this equation that are not specified.

The Hatchery staff need a quantitative (better) approach that can guide production activities and facilities operation because violations (or near violations) of the Consent Agreement still occur. The next two sections of this report discuss progress to date regarding the development of such a tool to assist management of the Hatchery.

Bioenergetics Approach for Fish Production Model

Figure 16 shows bioenergetic and phosphorus processes that occur in the raceways. The bioenergetic processes can be simulated by the Wisconsin Fish Bioenergetics Model (Kitchell et al. 1977, Warren and Davis 1967). This model assumes that the energy associated with the growth of new fish biomass is equal to the energy gained through feeding minus the energy associated with respiration, excretion, and egestion. The balanced energy equation is represented by the following formula:

$$C = G + R + S + F + U \quad (4)$$

Where: C = rate of energy consumption; G = somatic and reproductive tissue elaboration; R = standard metabolic rate; S = metabolic rate increase from specific dynamic action (heat increment); F = waste losses due to egestion (feces); and U = waste losses due to excretion (urine). Note that C and R are primarily functions of temperature and the size of the fish. U and F are either constants or temperature variable fractions of C. This model is well-known and has documented biochemical mechanisms which have been used in a wide range of applications. The model has limited capability to simulate the effects of food availability and its limitation on the consumption rate, and does not directly handle diurnally fluctuating temperatures.

The growth rate of the weight of an individual fish is given by Equation 5.

$$dW/dt = \mu * W \quad (5)$$

where μ is defined as the net specific growth rate and has units of per time, usually 1/day and W is the weight in grams of an individual fish (wet weight).

The finite difference form of this equation can be used to calculate W as a function of time (growth).

$$W_{i+1} = W_i + [\ \mu_i * W_i\ ] * \Delta t \quad (6)$$

where i+1 refers to the day after day i. Equation 7 is an explicit formulation that combines the equation for fish growth and the energy balance.

$$dW(T) = [J_a*(1-u)*C - J_o*(A*R+S*C)]/J_f \quad (7)$$

where dW(T) is the change in fish mass, g/day; J_a is the energy density of food, J/g (wet); J_o is the oxycaloric conversion, J/mgO_2 ; J_f is the energy density of the fish predator, J/g (wet); A is an activity multiplier; and u is the sum of the g/day lost through excretion and egestion.

The growth rate of an individual fish is constrained by the energy content of the consumed food and the energy losses as described above. However, in addition to energy considerations, the food consumed must also satisfy the nutrient requirements of the new fish biomass. For example, if we assume that the fish biomass has a constant composition, then the new wet weight of fish biomass produced has an associated tissue phosphorus requirement that must be supplied by the food consumed. In addition, some of the phosphorus consumed in the food is lost through excretion and egestion. The consumption of phosphorus associated with the feed and the subsequent retention of phosphorus in the fish tissue and the recycling of phosphorus by losses through fecal matter and urine, and is modeled using a mass balance equation for phosphorus.

A preliminary mass balance formulation for phosphorus in the fish tissue is illustrated in Figure 17. This equation simply states that consumed phosphorus is either incorporated into new fish biomass or lost through egestion and excretion. Note that this equation includes energy balance considerations because is the consumption and loss rates of phosphorus (CP and LP) can be determined from the Wisconsin formulations. Figures 18 and 19 illustrate the fact that consumption of phosphorus in the food depends not only on temperature and other bioenergetic consideration but on the available food supply, or in the case of hatchery applications, the food application rate. If the food application rate exceeds the maximum consumption rate as limited by the bioenergetics, then excess food is available that cannot be consumed. This excess food is essentially wasted and must be either removed using treatment operations or lost through the discharge from the facility. If the food application rate is less than the bioenergetic potential of the fish, then the food application rate limits the growth of the fish rather than temperature and other energy constraints. If the food application rate is less than the potential consumption rate the growth rate of the fish slows down or may become negative in a starvation mode.

It is recommended that efforts continue to refine the mass balance process model for the hatchery. The purpose of this development is to give the operators a potentially real-time quantitative tool that can be used to optimize fish production and food utilization as well as to meet the phosphorus discharge limits.

A preliminary approach to this model has been described in previous Annual Reports. The next step is to add bioenergetic restraints to the consumption and loss components of the model and to refine the mechanisms in the model that contribute to losses of energy and phosphorus. It is recommended that tests of the model be performed at the hatchery by increasing the frequency of measurements of fish growth and mortality losses.

Lake Water Quality

Big Platte Lake

Total Phosphorus: The annual variation of volume-weighted total phosphorus in Big Platte Lake for 2008 is shown in Figure 20. The average annual volume-weighted total phosphorus concentration in 2008 was 7.71 mg/m^3. There were 137 days when the total phosphorus concentration exceeded the 8.0 mg/m^3 goal. The Consent Agreement mandates that the volume-weighted total phosphorus concentration of Big Platte Lake be maintained below 8.0 mg/m^3 95% of the time. This corresponds to about 63% attainment as compared to the 95% requirement.

Dissolved Oxygen: Figure 21 shows that the annual variation of dissolved oxygen at eight depths in Big Platte Lake. The dissolved oxygen depletion in the hypolimnion of Big Platte Lake is closely related to temperature stratification and the onset of spring stratification. The concentration of dissolved oxygen dropped below 2 mg/L in waters deeper than 90 feet for 122 days in 2008 although this number may be inaccurate because of difficulties with the YSI sampling equipment. This is an important period because dissolved phosphorus will be released from the sediments during this anoxic period. Shallower water experienced shorter periods of low dissolved oxygen conditions. These data can used to calculate the phosphorus release from the sediments. This internal loading of phosphorus can be compared to both non-point and point sources and is used by the lake water quality model to simulate the annual dynamics of phosphorus in the lake. Ultimately, the magnitude of the internal source of phosphorus will be used to determine how quickly the lake will respond to changes in input phosphorus loadings.

Secchi Depth: Secchi depth is a common and simple method used to measure water clarity and an important indicator of water quality conditions in Big Platte Lake. The 2008 annual variation of

Secchi depth in Big Platte Lake is shown in Figure 22 and has a distinct seasonal pattern. The high summer Secchi depths that occur around day 180 roughly correspond to high zooplankton counts as shown in Figure 22. Similarly as expected, low Secchi depth values are associated with high phytoplankton counts and chlorophyll concentrations.

Inorganic Nitrogen: Figure 23 shows seasonal variation of surface and bottom water nitrite and nitrate concentrations in Big Platte Lake for 2008. The concentration during spring and early summer is about 275 mg/m^3 in both the surface and bottom layers of the lake. This is similar to the maximum concentrations measured in rainwater. The lake concentrations decrease with the onset of summer algal growth. Note that the surface concentration reaches a minimum of about 10 mg/m^3 around day 240. The bottom water concentration also decreases with time reaching a short-lived minimum around day 270. The low summer nitrite and nitrate concentrations may be growth rate-limiting for some algae and a competitive advantage may be present for nitrogen-fixing blue-green species (Bowie et al. 1985). Little data are available for the concentrations of ammonia or organic nitrogen in Big and Little Platte Lakes. It is recommended that nitrate and nitrite be measured in Big and Little Platte Lakes, and measurements of ammonia and filtered and non-filtered total nitrogen be added to the sampling program during when budget limitations are lifted. These measurements are important to provide a better understanding of the role of inorganic phosphorus and nitrogen concentrations in regulating the plankton dynamics of the lake and will assist in the calibration the ecosystem model discussed below.

Plankton: Phytoplankton populations have a number of water quality implications. They reflect mixing conditions in the lake, nutrient availability, and have an impact on color, foam, water transparency, and other visible signs of nutrient enrichment. Zooplanktons are important because their phytoplankton foraging activities are implicated with mid-summer clearing events in the lake. In addition, zooplankton transfers primary production energy to fish in the lake. The fish community of the lake can affect water quality through top to bottom down mechanisms. For example, heavy fish predation on zooplankton can relieve pressure on the phytoplankton. An increase in phytoplankton can result in a decrease in water transparency. These important and complex interactions are described in more detail in Appendices E and F authored by Dr. Scott McNaught from Central Michigan University.

Little Platte Lake

Little Platte Lake is located about one-half mile north of the north-shore of Big Platte Lake and is essentially an artificially raised water level wetland. It has a surface area of about 805 acres or about 35% of that of Big Platte Lake. The maximum depth is only about 8 feet, compared to 95

feet for Big Platte Lake. Approximately 12,000 feet, or more than 60% of the shoreline of Little Platte Lake is wetland that is owned by the State of Michigan. About one-half of the flow from the upper part of the North Branch of the Platte River watershed passes through Little Platte Lake. This flow, along with local drainage into Little Platte Lake, rejoins the other half of the North Branch flow before entering the Platte River just upstream of the outfall into Big Platte Lake. The North Branch is the 2nd largest tributary to Big Platte Lake with a flow of about 20% of that of the Main Branch of the Platte River. Thus, the water quality of Little Platte Lake has an effect on the water quality of Big Platte Lake.

Figures 24 through 26 compare the surface concentration of three water quality variables in Big and Little Platte Lakes in 2008. The data in Figure 24 show that the total phosphorus of Little Platte Lake is about 6 or 7 mg/m^3 greater than that of Big Platte Lake. Figure 25 shows that the chlorophyll in Little Platte Lake is usually higher than that in Big Platte Lake. This is consistent with the differences in total phosphorus. Figure 26 compares the nitrite and nitrite concentrations in the two lakes for 2008. Both nitrite and nitrite concentrations are low in winter in Little Platte Lake and decrease to algal growth rate limiting levels during the spring then remain low for the remainder of the year. This low level of inorganic nitrogen is expected to promote the growth of nitrogen-fixing blue-green algae such as *Anabaena*. Phytoplankton samples were collected in Little Platte Lake in 2008 and are discussed in a separate report by CMU. It is recommended that sampling of Little Platte Lake be continued during 2009 or when funds are available so that the cause of high phosphorus can be better understood. The results from this effort are valuable because s sampling program is a valuable. These measurements are important to provide a comparison between Big and Little Platte Lakes and understanding the factors that regulate the plankton dynamics in each system.

Watershed Flow and Phosphorus Balances

Watershed Flow Balance

Figure 27 shows the long-term trend of mean annual flow of the Platte River as measured at the USGS station at US 31. The mean annual Platte River flow at the USGS station was 114.76.4 cfs in 2008. This flow is lower than the long-term average flow of 124.2 cfs since 1990. Thus, 2008 can be characterized as a drier than the average year. Figure 28 shows an annual average flow balance for the lower watershed starting at Fewins Road and extending to the outlet of Big Platte Lake. The flow balance also includes the tributary water diversion and discharge by the Hatchery. Tributary and non-point flows and flows at intermediate locations on the Platte River

are based on correlations with the USGS measured flows at US-31. These correlations were developed over a three-year period using flow measurements at intermediate locations in the watershed. Flow at the USGS location is about 2.2 times the flow at Fewins Road, and the Lake outlet is about 2.7 times that of the flow at Fewins Road. Figure 29 shows that there were approximately 24 storms events at the USGS site in 2008 where flow flows rapidly increased and then receded over a one or two day period. The majority of these events occurred during the spring time as expected. Daily hydrograph data from the Platte River at USGS were compartmentalized into base flow and wet weather event flows. The average flow during the storm events was 157.3 cfs. The daily average flow during dry or baseline conditions was 111.8 cfs. The storm flows occurred only about 6.6% of the time during 2008, but accounted for almost 9% of the total amount of water that entered Platte Lake through tributaries. Baseline flows accounted for 91% of the hydraulic inputs.

Watershed Phosphorus Balance

The development of an accurate annual phosphorus balance for the watershed is not a simple task because the Platte River and tributary loadings are highly affected by flow spikes that occur during several storm events throughout the year. The River was sampled for total phosphorus concentration during only one or two of these storm events in 2008 from a total of 24 (see Figure 29). Thus, estimates of the total phosphorus loading into Big Platte Lake based on the 27 routine measurements are expected to underestimate the loading because of the under representation of storm events. Unfortunately, it is impractical to measure flow and phosphorus concentration during every storm event at all key locations in the watershed every year.

However, extensive storm event measurements were taken from 2004 to 2006 at the Old Residence location on Brundage Creek, and at the Stone Bridge and USGS sites on the Platte River using continuous water sampling equipment. The average event total phosphorus concentrations at these locations were 72.6, 28.7, and 50.95 mg/m^3, respectfully. The storm event concentrations at the Fewins site and North Branch sites were assumed to be identical to those measured at the Stone Bridge site. The measured storm event total phosphorus concentrations measured at the Old Residence site on Brundage Creek were also used to characterize storm events for the Stanley, Carter, and Collision sites. The total phosphorus concentrations during baseline flow conditions were averaged for all years for Stanley, Carter, and Collision Creeks because limited measurements are available for these sites and they are no longer included in the regular monitoring program. These data, along with the regular monitoring data for 2008 were used to determine the total phosphorus loads into Big Platte Lake.

The baseline or dry conditions total phosphorus loads were determined for each site according to Equation 8.

Baseline TP Load = Annual Average Baseline TP Concentration * Annual Average Baseline Flow * Percent of the time the flow is at Baseline conditions (8)

The storm event or wet conditions total phosphorus loads were determined for each site according to Equation 9.

Storm Event TP Load = Annual Average Storm Event TP Concentration * Annual Average Storm Event Flow * Percent of the time the flow is at Storm Event conditions (9)

These estimates along with measured flows and phosphorus concentrations entering and leaving the Hatchery were used to complete the phosphorus balance for the watershed as shown in Figure 30. Note that 28% of the load of total phosphorus to Big Platte Lake occurs during storm events, compared to only 9% of the flows. Storm events are disproportionate because both storm event flows and total phosphorus concentrations are larger than corresponding dry weather or baseline conditions.

The mass balance calculations were extended to Big Platte Lake by using measured dissolved oxygen concentrations in Big Platte Lake to estimate the sediment release of phosphorus during anaerobic periods and rainfall data to calculate atmospheric phosphorus loadings. The difference between the biomass of fish that pass the lower weir and the biomass of fish actually harvested at the upper weir represents a potential source of phosphorus to Big Platte Lake if not removed by anglers or other means. The maximum estimated amount from this source assuming no fish were removed by anglers or other means was only about 12 pounds in 2008. This value is based on an unusually small number of measurements and probably underestimates the actual contribution of phosphorus to the Lake from lost fish. These inputs allow calculation of the annual average settling velocity of 17.4 m/yr and a corresponding phosphorus retention of 58.5%. These values are consistent with estimates determined for other years when more extensive data were available and with those observed in other lakes (Chapra, 1997). All these computations are automatically performed by the project database.

It is the authors' opinion that the above calculations are good representations of the hydraulic and phosphorus watershed balances despite the assumptions and approximations used in the analyses. Practical alternatives to this approach are problematic. Maximum total phosphorus concentrations during storm events are typically an order of magnitude higher than during base

flow periods. Thus, load estimates based on routine measurements alone likely underestimate actual non-point loads because many storm event spikes are missed. Thus, the monitoring program needed to compile a more accurate phosphorus balance for the total watershed is monumental. The BASINS model (discussed below) can also be used to estimate the phosphorus balance for the watershed. This model takes into account daily weather data and hydrographs for each site in the watershed. However this model requires: the input of accurate data to characterize the local rainfall patterns throughout the watershed; real-time atmospheric weather conditions; and knowledge of hydraulic conditions in prior years. Thus, preparing the inputs for BASINS to simulate a given year is a significant and costly task, and not necessarily more accurate than the above approach. Given the difficulties and limitations of both direct monitoring and BASINS modeling, the current approach is considered the best alternative and a reliable screening tool that can be reliably used for planning applications. In addition, it would be useful to explore applications of intermediate level complexity models to predict stream flow such as those proposed by Limbrunner et al. (2005). However, if watershed planning issues arise in the future that involve large expenditures or significantly influence watershed land use, it is recommended that the full dry and wet weather monitoring program be resumed and that the BASINS model be re-calibrated.

Watershed Management

The goal of the Platte River watershed management program is to control and minimize the input of point and non-point phosphorus loads to Big Platte Lake thereby protecting its water quality. In order to be effective however, such a program must be accurate and reliable and have scientific credibility. Such quantitative capability must be grounded by a comprehensive water quality monitoring program. The resultant data must be analyzed and synthesized using well designed watershed loading and lake water quality models. The goal of this section is to describe ongoing efforts to develop these important tools. Figure 31 illustrates the overall approach.

BASINS Watershed Phosphorus Loading Model

Non-point phosphorus loads from Platte River watershed have been measured and analyzed using the Better Assessment Science Integrating Point and Non-point Sources (BASINS) approach. BASINS is an EPA supported watershed model and simulation tool. Hydraulic transport modeling within BASINS is based on the *Hydrologic Simulation Program* (HSP). The BASINS framework also includes models that simulate stream total phosphorus and suspended

solids concentrations. BASINS model calculations for flow and water quality are dependent primarily on weather conditions, local soil type, and land use within the watershed. The BASINS model has been calibrated for this river system so that it can reliably simulate input of non-point pollutants from the watershed to the Platte River and ultimately to Big Platte Lake for various rainfall conditions. It can also predict the consequences of future land use management scenarios in the Platte River watershed by simulating the generation and movement of pollutants such as sediment and phosphorus from the watershed depending on the land use. These results can be used as inputs to a water quality model for the Big Platte Lake. In this way, the BASINS and lake models work together to help assess the effects of both point sources such as the Hatchery and non-point sources such as agricultural operations, forests, and land developments on water quality in Big Platte Lake.

The BASINS model has been calibrated using extensive flow and water quality data for the Platte River watershed collected by Hatchery staff and PLIA members between 1990 and 2005. This program included the measurement of flow, total phosphorus, and suspended solids during numerous storm events. The BASINS modeling effort was conducted by LimnoTech, Inc. through contracts from the PLIA and the Benzie Conservation District. Funding to the District originated with grants from the MDEQ and USEPA. The project produced a Graphical User Interface (GUI) that allows users such as the PLIA to calculate changes in phosphorus loading to Big Platte Lake as a function of changes in land use and nutrient abatement projects. These changes in loadings can be used to calculate the annual average phosphorus concentration of the lake itself when coupled with a lake phosphorus model.

Lake Water Quality Modeling

It is important to recognize that the reliability of any lake water quality model is a function of model complexity. The complexity of a model depends on spatial resolution, time-scale, the number of dependent variables, and the number of model coefficients that define the physical, chemical, and biological rate processes. Each model forcing function and coefficient must be specified before the model can be used to calculate the system response. These model inputs can be constant or time-variable. They can be in the form of a mathematical function or as a series of measurements, both of which have error components associated with them. These model inputs are not usually known with exact certainty. The overall reliability of the model decreases as the number of model inputs and their uncertainty increases unless large amounts of data are collected to support it. Thus, it is usually better to keep models simple to avoid unnecessary complications and assumptions. At the other end of the spectrum, a lake model that

is too simplistic may be easy to operate and maintain but may not realistically simulate ecosystem processes.

Three separate Big Platte Lake water quality models are being simultaneously developed to accommodate these considerations. A one-coefficient steady state model has simple model mechanisms and is easy to apply and defend, however this model does not provide detailed insight into the chemical and biological dynamics of the lake and cannot predict changes in water quality as a function of time. A non-steady state dynamic model with an intermediate level of complexity has been completed for bottom water concentrations of dissolved oxygen and lake and sediment concentrations of total phosphorus. This model has five coefficients that have numerical values determine by calibration using extensive data collected over a period of many years. The model can predict time variable changes in phosphorus in the lake that result from sediment release as sediment concentrations in the sediment change in response to changes in external loading conditions. A more complex ecosystem model is being developed to provide more insights into the detailed chemical and biological components of the lake ecosystem. This model requires explicit numerical values for many coefficients and forcing functions that are difficult to quantify without introducing significant uncertainty. Our approach is to rely primarily on the one-and five coefficient models for watershed planning applications. The ecosystem model will be used with caution in conjunction with the other models to provide in-depth understanding of the lake water quality dynamics when appropriate.

One-Coefficient Model Development

The one-coefficient model for total phosphorus in Big Platte Lake assumes the lake is completely mixed in both the horizontal and vertical directions. It includes point, non-point, and internal loading and discharge through the outlet. The only model coefficient is the apparent settling velocity (v_s) that results in a net loss of phosphorus to the sediments. This is the simplest deterministic, yet realistic model for total phosphorus and is widely used in various forms (Chapra, 1997). The annual average total phosphorus concentration is given in Equation 7.

$$p = W /(Q + v_s A) \qquad (7)$$

In Equation (1), p is the annual average volume weighted total phosphorus concentration of the lake, W is the annual total point and non-point phosphorus load into the lake, Q is the hydraulic flow rate into the lake, v_s is the apparent settling velocity, and A is the area where settling occurs. The first step in the development of the one coefficient model is to construct annual average balances for water and phosphorus for the lake and watershed. These balances can be

developed for the Platte River watershed using the BASINS model as well as direct phosphorus measurements as discussed above. Figure 30 shows calculations based on measurements conducted in 2008. The mass balance includes: phosphorus associated with fish lost between the lower and upper weirs; atmospheric phosphorus loading; and phosphorus release from the sediments. These inputs and data for the annual average volume-weighted total phosphorus concentration in the lake can be used to calculate the apparent settling velocity using Equation 7. The calibrated value for the apparent settling velocity for 2008 is 17.4 m/yr. This compares well to the long-term average value of 19.9 m/yr (Standard Deviation = 3.9 m/yr) since 1990. Applications of the one coefficient model have been discussed in previous Annual Reports.

Five-Coefficient Water and Sediment Model Development

State and local planning agencies may be obligated to determine allowable phosphorus loads and devise recovery strategies for lakes that do not meet water quality goals as part of the Total Maximum Daily Load (TMDL) process. A paper has been written and submitted for publication that presents the modeling results that are a critical component of any TMDL process for Big Platte Lake and the Platte River watershed. The calibrated BASINS model is used to simulate total phosphorus loads from the watershed. A non-steady state five-coefficient model was developed and applied to determine total phosphorus concentrations in the lake water and sediments. Temperature and dissolved oxygen models were used to predict the number of days that the hypolimnion is anoxic to facilitate calculation the internal phosphorus loading due to sediment release. The water and sediment dynamic model calculates the allowable non-point source watershed phosphorus loading that is consistent with the goal of maintaining the total phosphorus concentration of Big Platte Lake below 8 mg/m^3 95% of the time. This goal can be achieved if the annual average lake concentration is 6.4 mg/m^3 as determined by correlation using extensive measurements of total phosphorus in the lake over a period of many years. The calibrated models can also be used to determine allowable phosphorus loads for Big Platte Lake for various hydraulic and non-point phosphorus loading conditions. Model development and subsequent planning applications are expedited in this case because of the availability laboratory measurements of sediment phosphorus release rates and an extraordinarily comprehensive database of current and historical lake and tributary water quality measurements.

Figure 32 illustrates the five-coefficient total phosphorus model for Big Platte Lake and the bottom sediments. The model has single water and sediment layers that are assumed to be completely mixed in both the horizontal and vertical directions. The phosphorus model mechanisms include: point and non-point external loads; discharge through the outlet; settling losses to the bottom sediments; internal loading due to release from the sediments; and sediment burial. The non-

steady state mass balance equations are similar to those used by Chapra and Canale (1991) and Canale and Seo (1999) and are given by:

$$V_w \frac{dP_w}{dt} = W - QP_w - v_s A_s P_w + v_r A_r P_s \quad (1)$$

$$V_s \frac{dP_s}{dt} = v_s A_s P_w - v_r A_r P_s - v_b A_r P_s \quad (2)$$

where: A_r = Phosphorus Release Area (m^2); A_s = Settling Area (m^2); P_s = Sediment Total Phosphorus Concentration (mg/m^3); P_w = Water Total Phosphorus Concentration (mg/m^3); Q = Hydraulic Flow Rate (m^3/yr); t = Time (yr); v_b = Sediment Burial Rate Velocity (m/yr); v_r = Phosphorus Release Rate Velocity (m/yr); v_s = Settling Rate Velocity (m/yr); V_s = Volume of Lake Sediments (m^3); V_w = Volume of Lake Water (m^3); and W = Total Annual Phosphorus Loading (kg/yr).

Significant phosphorus release from the sediments of Big Platte Lake occurs only when the sediments are anaerobic. These conditions occur when the average concentration of dissolved oxygen in the hypolimnion is less than about 2 mg/L (MI DNR 1990). Thus, it is necessary to have a model that predicts the seasonal variation of the hypolimnetic dissolved oxygen concentrations to permit calculation of the fraction of the year when significant sediment release occurs. Equation 3 is a differential equation that is the basis of the dissolved oxygen component of the Lake model.

$$V_h \frac{dDO_h}{dt} = v_e A_e (DO_e - DO_h) - A_r (HOD) \quad (3)$$

where A_e = Area of the Thermocline (m2); DO_e = Epilimnion Dissolved Oxygen Concentration (mg/L); DO_h = Hypolimnion Dissolved Oxygen Concentration (mg/L); HOD = Hypolimnetic Oxygen Demand Rate ($mg/m^2/d$); v_e = Exchange Rate Velocity between Epilimnion and Hypolimnion (m/yr); and V_h = Volume of Hypolimnion (m^3). The hypolimnetic dissolved oxygen model mechanisms include hydraulic exchange between the epilimnion and hypolimnion and the hypolimnetic oxygen demand rate. Equations 1 through 3 represent a simple yet robust non-steady state model that can simulate long-term changes in lake water and sediment total

phosphorus. Similar models have been successfully used in a wide variety of applications (for example, Lung and Canale 1977; Seo and Canale 1996).

Figure 33 shows model projections for the annual average total phosphorus concentration in Big Platte Lake as a function of watershed flow conditions. The model calculated lake phosphorus concentration for high flow conditions was 9.7 mg/m^3 assuming that the Hatchery was at the permit limit of 175 lbs/yr. The lake phosphorus concentration under these high conditions exceeds the goal. The model calculated lake phosphorus concentration for low flow conditions was 6.0 mg/m^3 assuming that the Hatchery was at the permit limit of 175 lbs/yr. The lake phosphorus concentration under these low conditions is less than the goal. The model calculated lake phosphorus concentration for typical flow conditions was 7.6 mg/m^3 assuming that no actions are taken to reduce the non-point phosphorus load and that the Hatchery was at the permit limit of 175 lbs/yr. The lake phosphorus concentration under these low conditions exceeds the 6.4 mg/m^3 the goal.

The model calculations indicate that 825 pounds of phosphorus must be removed from non-point sources to achieve the goal; therefore an action plan is needed to attain the required phosphorus loading reductions. This requires an analysis of the effectiveness of various watershed management practices intended to reduce the non-point phosphorus loading. A local ordinance requires lakeside residents to construct retention basins to collect the runoff from all impervious surfaces to allow percolation into the groundwater. The calibrated BASINS model for the Platte River watershed estimates that the event mean concentration of this runoff has a total phosphorus concentration of approximately 250 mg/m^3 and that local groundwater has a concentration of about 6 mg/m^3. A maximum potential phosphorus reduction of about 86 kg/yr could be attained if all 500 lakeside residents complied with the ordinance. This is equivalent to about 23% of the needed reduction in phosphorus loading to meet water quality goals under “Typical” conditions. Buffer zone ordinances are being considered to reduce the non-point phosphorus loads to the Lake. Although buffer zone vegetation reduces erosion, it is not considered effective for the removal of phosphorus over the long-term because phosphorus retained by plants in the spring and summer is released with plant senesce in the fall. Therefore, lakeside residents are being encouraged circumvent this recycling by collecting beach debris and cutting, harvesting, and removing excess buffer zone vegetation 2 to 3 times per year as suggested by Dillaha et al. (1986). Measurements indicate that typical shoreline debris material has a water content of about 75% and contains about 0.25% phosphorus by dry weight. Therefore, a total phosphorus loading reduction of about 70 kg/yr could be attained if each lakeside property owner removed approximately 225 kg of vegetative litter and beach debris (wet weight) from their property per year. A typical 9 kg bag of lawn and garden fertilizer used in the

area contains 10% phosphorus, or 0.9 kg per bag. Lakeside residents are being encouraged to only use phosphorus-free fertilizers. Detailed fertilizer sales volume and application rate data are not available for the local area; however, if 50% of the 500 lakeside residents currently use one bag of fertilizer per year, then a potential reduction of 227 kg of phosphorus could be attained with the use of phosphorus-free fertilizers. A summary of these calculations is shown in Figure 34.

It is important to note that the reductions in phosphorus loading estimated for the actions described above are a maximum because even without the remedial measures, some phosphorus would naturally percolate into the groundwater. It is not possible to quantitatively evaluate the actual phosphorus reduction achieved in practice compared to the potential reductions described in the previous paragraphs. In addition, note that the model calculations presented above do not account for increases in the non-point phosphorus loads that result from the future growth of population and commercial activities. Therefore, a long-term monitoring program should be implemented to both verify the effectiveness of the corrective efforts and detect long-term trends in watershed development.

Ecosystem Model

More complex water quality models have been developed for Big Platte Lake in the past by Canale et al. (1991), Chapra (1996), Lung (2000), and Walker (1998). Unfortunately, even these models do not adequately address exchange processes between the water and the sediments, and do not include algal productivity, dissolved oxygen, or Secchi Depth as model variables. A more comprehensive water quality model for Big Platte Lake has been under development that will predict algal blooms, light attenuation (extinction coefficient or Secchi Depth), and the internal loading of phosphorus from the sediments associated with low bottom water dissolved oxygen concentrations. The model mechanisms allow modeling of phosphorus, water clarity, and dissolved oxygen. Progress on this model has been delayed in recent years to allow focus on the five-coefficient model discussed I the previous section. It is planned to make additional improvements in the ecosystem model as more monitoring data become available and model applications become significant. The complex model mechanisms and comparisons with the one-coefficient model have been described in detail in previous Annual Reports.

Special Studies

Overview

The development, calibration, validation, and application of the BASINS watershed loading model and the water quality models for Big Platte Lake are based on the Hatchery, tributary, and lake monitoring data. However, it is also important to enhance the model reliability by conducting special studies that are independent of the regular monitoring data that will provide direct estimates of some of the model coefficients and clarify model mechanisms.

Phosphorus Bio-availability

Laboratory tests have been completed to determine the bioavailability of different point and non-point sources of phosphorus. Phosphorus bio-availability experiments were performed using the green alga *Scenedesmus.* The tests will measure the growth rate of the test algal species as well as other kinetic and stoichiometric coefficients to determine the bio-availability of various sources of phosphorus. This work will be the subject of a Master's Thesis study for a student at Central Michigan University and will be completed in 2009.

Monitoring Program

Objectives

The overall purpose of the monitoring program is to facilitate and support the goals of the Consent Agreement. The sampling program has the following specific objectives.

- To quantify the net phosphorus loading from the Platte River State Fish Hatchery as required by the NPDES permit and the Consent Agreement.

- To determine the volume-weighted total phosphorus concentration of Big Platte Lake to insure compliance with water quality goals as stated in the Consent Agreement.

- To construct mass balances for water and total phosphorus for the Hatchery, Big Platte Lake, and watershed.

- To support the continued calibration, validation, and application of the BASINS model for watershed total phosphorus loading as a function of land-use, soil type, and weather conditions to allow the full implementation of this watershed planning tool.

- To support the development, calibration, validation, and application of water quality models for Big Platte Lake that are used to assist overall watershed planning efforts.

- To evaluate and document changes in water quality following possible future remedial activities within the watershed.

The sampling plan for 2009 involves collecting data from the hatchery, watershed streams, and Big Platte Lake. However, the 2009 watershed sampling program has been significantly reduced because of State budget restrictions. In particular, all sampling of Little Platte Lake has been eliminated; no nitrogen or total dissolved phosphorus samples are being taken; and only three samples will be obtained for phytoplankton and zooplankton. The sampling program for the Hatchery has also been downsized because of the abandonment of the Jug & Needle method. Otherwise, the core of the sampling program for the Hatchery has retained.

Hatchery

The net Hatchery total phosphorus load is evaluated by subtracting the inlet load from the total outlet loading. Measurements of flow, total phosphorus concentration, and turbidity are currently taken at four or five locations two times per week using both the Jug & Needle and Sigma samplers. It is recommended to maintain this regular schedule in 2009 and develop evidence that allows the use of the Sigma samplers as the sole sampling device. In addition, the overflow rate of the clarifier and the time required to re-fill the clarifier are measured daily. The re-fill rate is used to calculate the overflow rate of the sludge tank. The phosphorus concentration of the clarifier and sludge tank overflow are measured approximately weekly using grab samples.

The phosphorus content of each lot of fish food is measured on split composite samples provided by the supplier. This split sample is further split and sent to both CMU and LSSU for analysis. Data have been collected for the period from August 2006 through April 2008. It is recommended that measurements by CMU be continued to facilitate more accurate mass balance calculations for the Hatchery.

Watershed

The tributary sampling program is designed to calculate the non-point phosphorus loading into Big and Little Platte Lakes. Measurements of flow, phosphorus, and turbidity are taken on a regular basis independent of flow conditions. These data allow evaluation of water quality for various hydrologic conditions, provide sub-watershed loading estimates, assist in defining high priority remediation areas, and support the calibration, validation, and application of the BASINS watershed model. The recommended monitoring program for 2009 contains three sites in the Platte River – one just upstream of the Hatchery, another at the USGS Station on US31, and the last below Big Platte Lake on M-22. One sample should be taken of the North Branch of the Platte River at Deadstream Road.

It is recommended that Big Platte Lake be sampled every two weeks during the year. A calibrated Yellow Springs Instruments (YSI) meter is used to measure dissolved oxygen, temperature, pH, conductivity, and ORP. Discrete depth and tube samples are analyzed for total phosphorus, turbidity, alkalinity, chlorophyll, total dissolved solids, and calcium. Vertical net hauls should be taken for zooplankton one time during the spring, summer, and fall. A surface composite (tube sampler) and grab bottom sample should be taken during these same periods for phytoplankton. Secchi depths are measured with a standard Secchi disk. It is recommended that four more upstream tributary sites be added and samples be taken for nitrate and TN if current budget restraints are lifted.

Cost

A summary of the sampling frequency and the measured parameters for each station is listed in Figure 35. Separate cost estimates are provided for the Hatchery and watershed sampling programs using CMU unit costs.

Quality Assurance and Control

Extensive efforts were made to insure the accuracy of the various field and laboratory procedures. CMU regularly measures the phosphorus concentration of purchased standards that have concentrations of 5 and 10 mg/m^3. The average concentration of 30 measurements of the 5 mg/m^3 purchased standard solution for 2008 was 5.003 mg/m^3 with a standard deviation of 0.013 mg/m^3. The average concentration of 30 measurements of the 10 mg/m^3 purchased standard solution for 2008 was 10.01 mg/m^3 with a standard deviation of 0.014 mg/m^3. These results are extraordinarily accurate and precise and provide strong confidence regarding the

reliability of the CMU phosphorus measurements. Bottles containing distilled water are randomly included with regular samples scheduled for measurement of phosphorus. This is done to insure that bottle and sample identification information are properly tracked through the measurement and laboratory handling process. Appendix G contains a detailed discussion of the results of this effort to insure the integrity of sample tracking. These efforts should be continued indefinitely to insure overall quality control.

Appendix H contains up to date SOP documents and Appendix I contains Certification Letters that specify that all data have been accurately entered into the database, checked and verified by responsible Hatchery staff members.

Data Management

The ACCESS database organizes and stores data from the current sampling program for the Hatchery, tributary streams, Big and Little Platte Lake stations, the Hatchery weather station, and USGS sampling location at US 31. The Platte Lake Watershed Sampling Database consists of three components: Field; Data Manager; and Data Viewer. The Field component is used to enter various measurements taken in the field or Hatchery laboratory analyses. Field measurements, bottle numbers, and measurement instructions are sent to the Data Manager and CMU. Laboratory results for various bottle numbers are sent to the Data Manager in the form of EXCEL spreadsheets using email. The Data Manager imports the laboratory results and matches this information with the bottle numbers obtained from the Field component. At this point, conflicts such as inconsistent bottle numbers and missing data are resolved. The Data Manager updates the Data Viewer and distributes new data files through email. The reports examined through the Data Viewer are used to track progress on the Hatchery loading and Big Platte Lake water quality and produce graphs and tables for the Annual Report.

Despite the database and EXCEL programs developed to accommodate all data management tasks, significant communication and coordination is required on an ongoing basis to insure that all data are correctly entered and displayed. These efforts should be continued into the future to promote the reliable application of the data. It is recommended that documentation of the database organization and computer code be completed and then kept current.

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ANNUAL REPORT FIGURES

Overview for 2008

Annual Loading = 174.8 vs. 175 lbs limit (JN)

3 Month Loading = 60.8 (Apr) and 55.8 (May) lbs vs. 55 lbs limit

Hatchery Flow = 6.24 vs. 20 mgd limit

5,029 passed vs. 20,000 Adult Coho limit

181 passed vs. 1,000 Adult Chinook limit

Lake TP Concentration: 7.7 mg/m^3 volume - weighted

63% vs. 95% compliance with 8 mg/m^3 goal

Annual Average Hatchery P Mass Balance methodology has been completed.

Hatchery Bio-Energetic, Process & Feeding Model – development & calibration underway.

JN and Sigma sampling sites consolidated.

Watershed P and Flow Mass Balance have been refined & completed.

Long-term model for phosphorus in water and sediments completed for Lake.

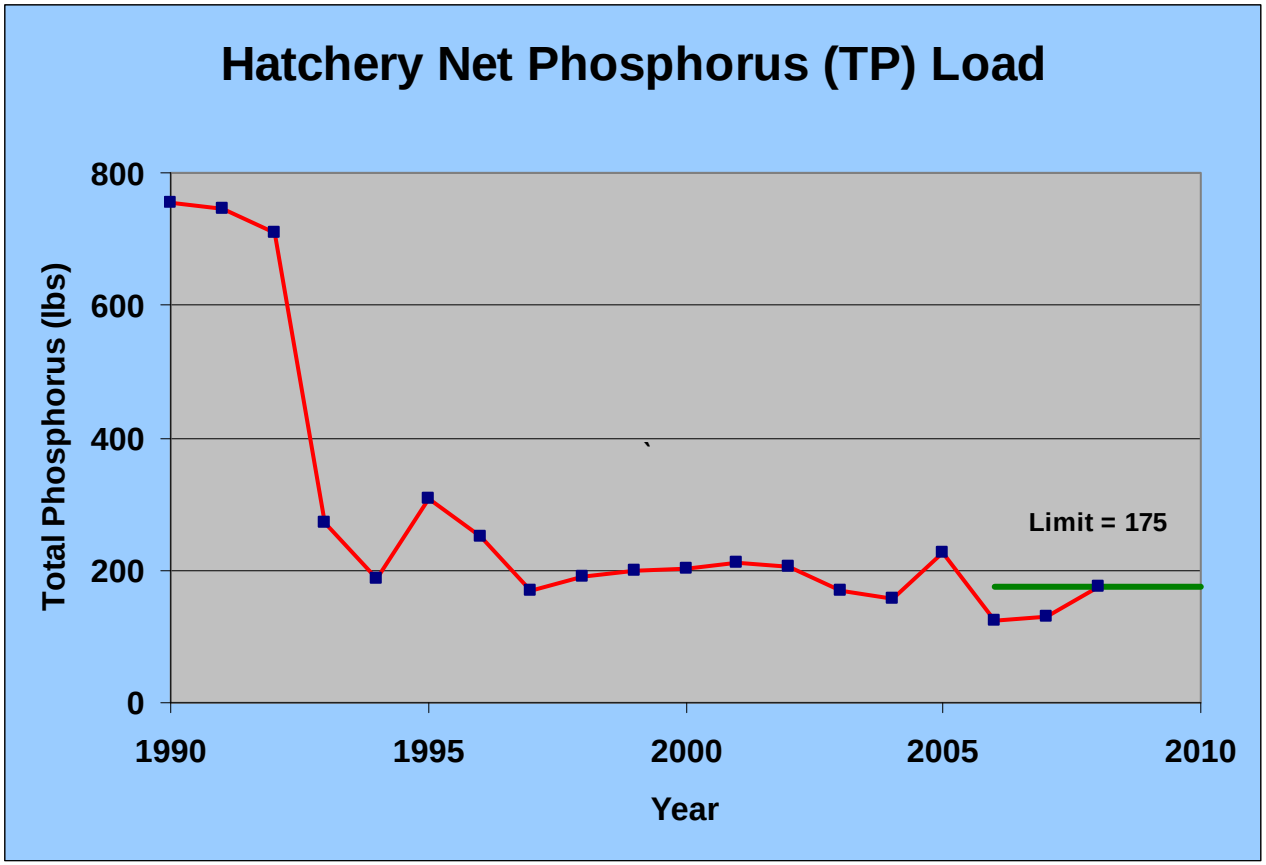
TMDL manuscript completed and submitted to ASCE for peer review

Special Studies: Bio-availability study report preparation underway.

CMU billing and NPDES reporting connected to database.

Database documentation meeting scheduled for summer 2009.

Figure 1. Overview of 2008 Annual Report.



Why worry as long as the load is below 175 Lbs/Yr?

What factors cause load to go up like 2005 & 2008?
Why 3 Month violations for the past 3 years?
Suppose you want to increase production in the future, what is the non-compliance risk?
Suppose you want to control loading from another MDNR Hatchery facility?

We need to quantitatively understand the link between
Net Load and Fish Production Activities and Plant Operations

Figure 2. Hatchery phosphorus loading changes over time.

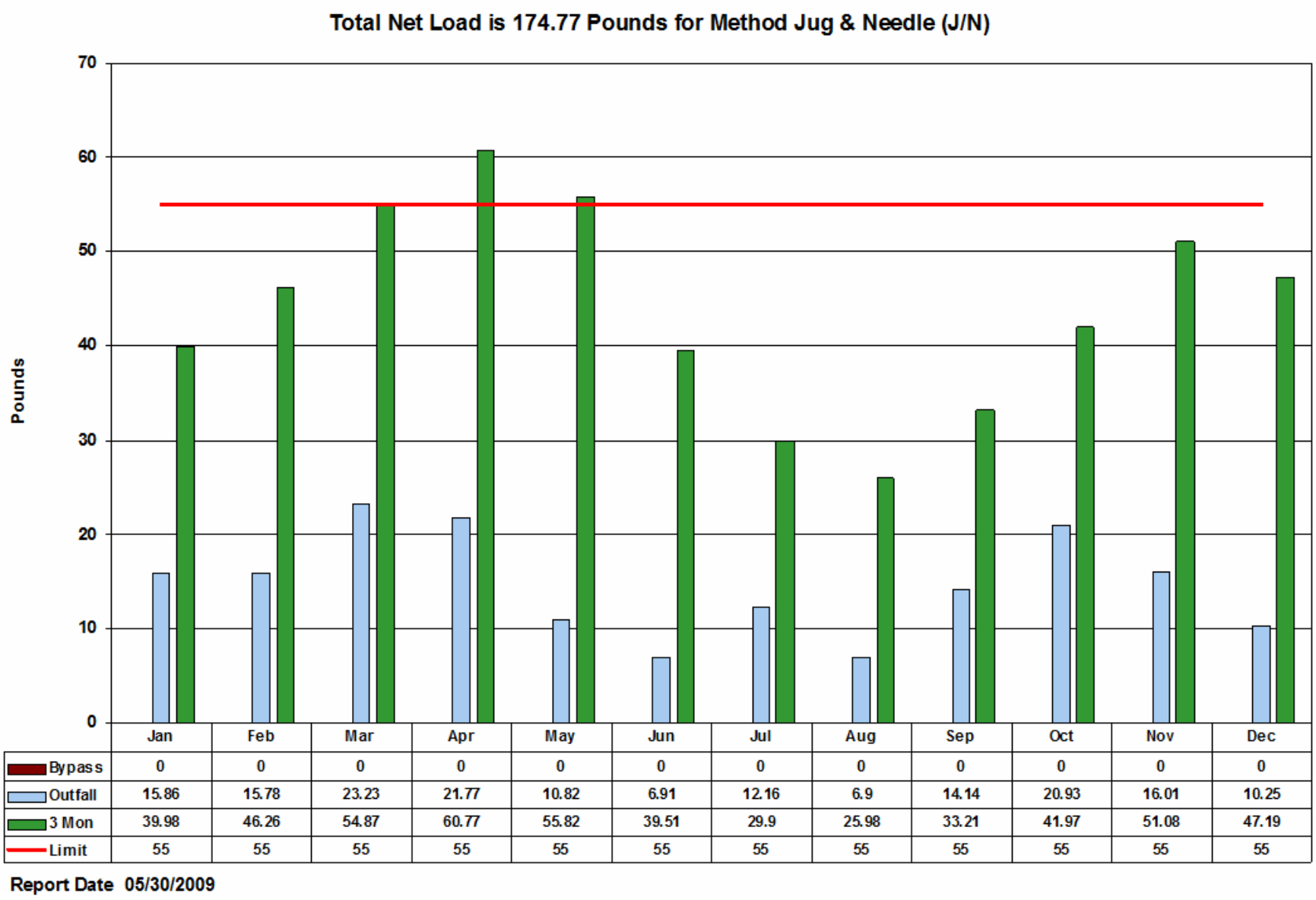


Figure 3. Hatchery monthly phosphorus loads.

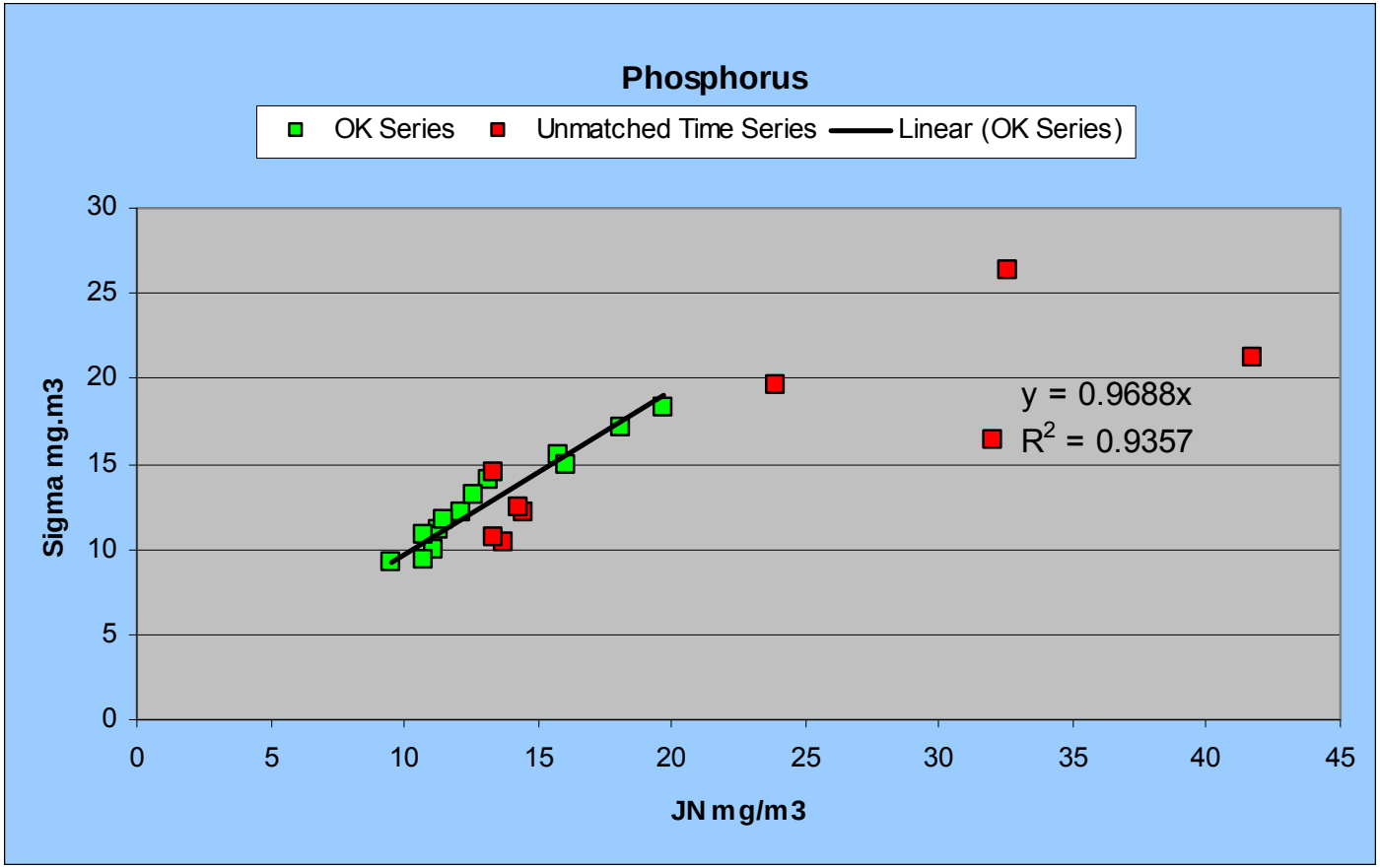


Figure 4. Phosphorus using JN vs Sigma equipment for Brundage Spring site.

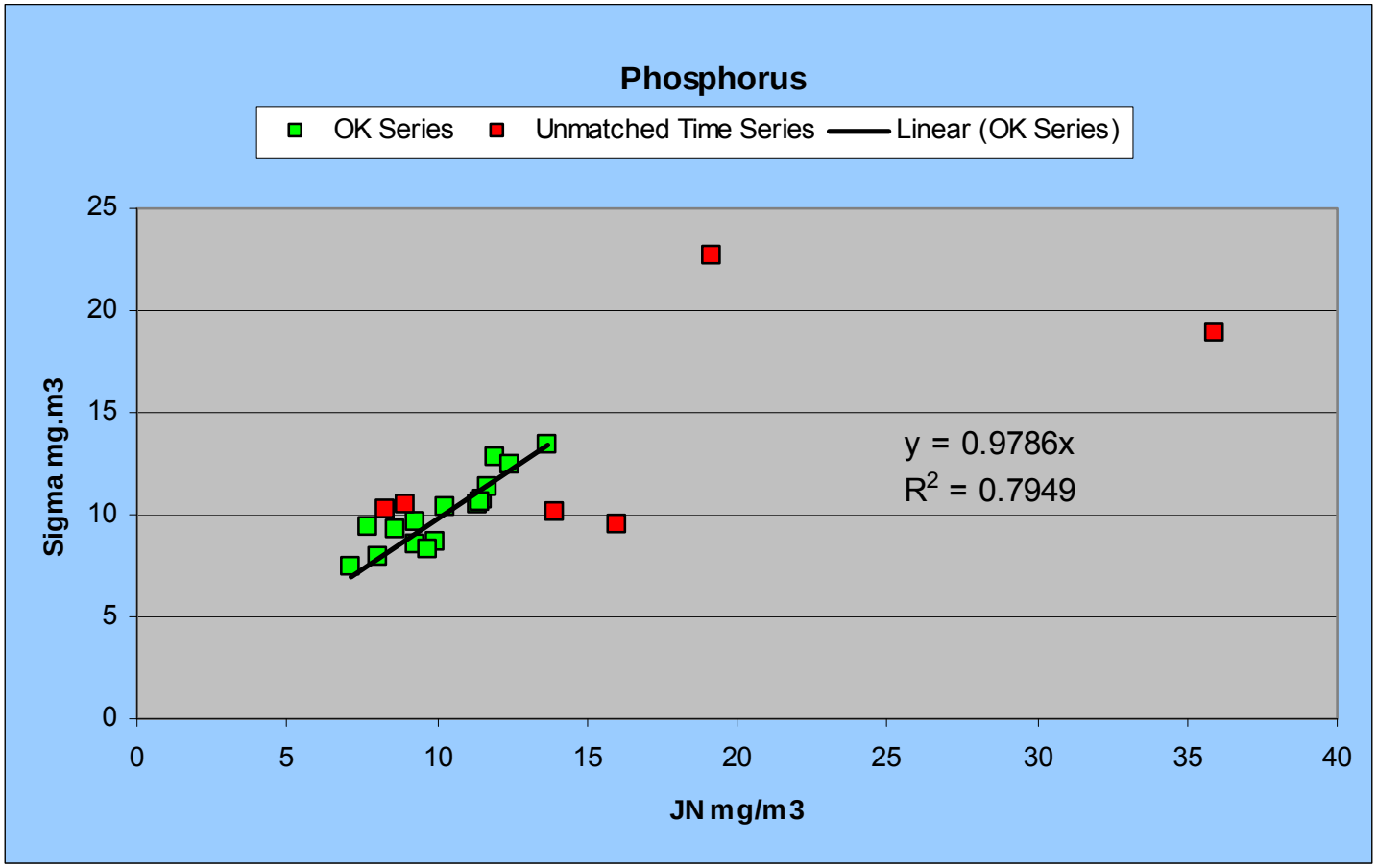


Figure 5. Phosphorus using JN vs Sigma equipment for Brundage Creek site.

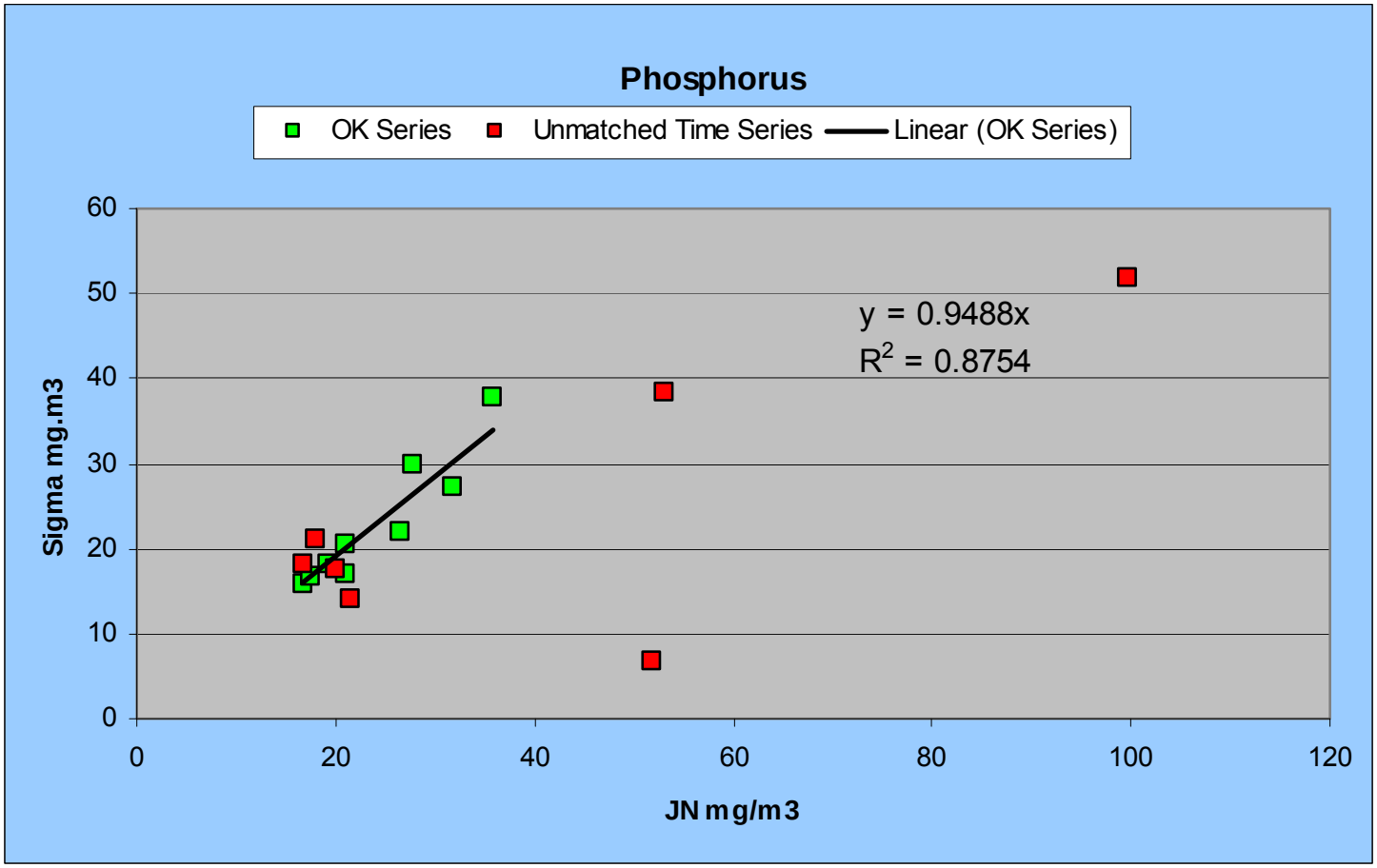


Figure 6. Phosphorus using JN vs Sigma equipment for Pond Inlet site.

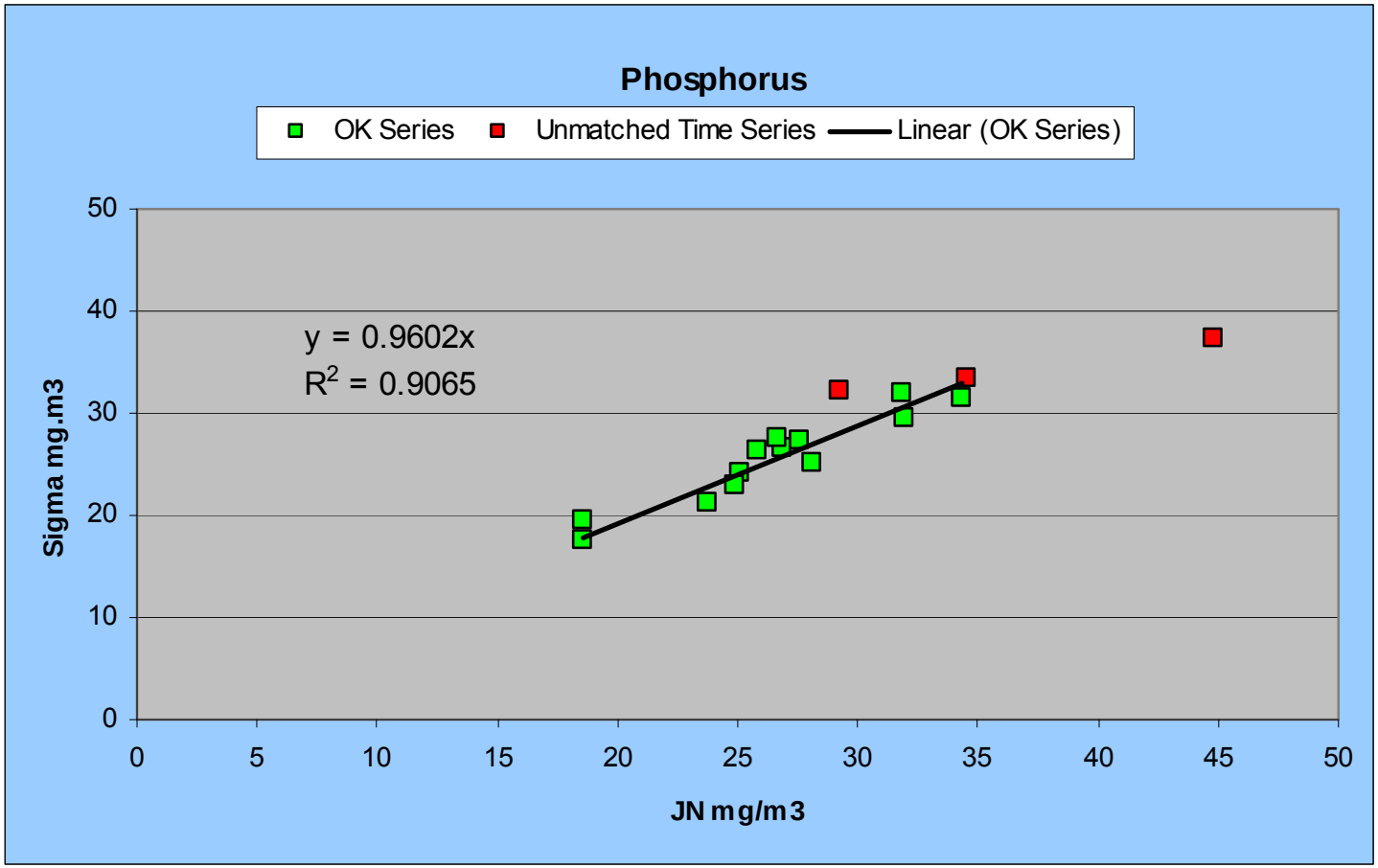


Figure 7. Phosphorus using JN vs Sigma equipment for Upper Discharge site.

General Case: | End - Start = Inputs - Outputs |

Fish	Source Water	Discharge
Tank	Food	Planted Fish
Pond	Fry	Shipped Fish
		Mort Fish
		Trucked Sludge

Definitions & Assumptions

Net Load = Discharge – Source Water

Harvest = Σ [Planted + Shipped + Mort] Harvest = Fish that leave the Hatchery

Fish Increase = Fish End – Fish Start

Production = Increase of Fish Inventory + Harvest – Fry In Production = Actual Net Growth of new Fish Biomass

Tank Retention = Trucked + Tank End – Tank Start

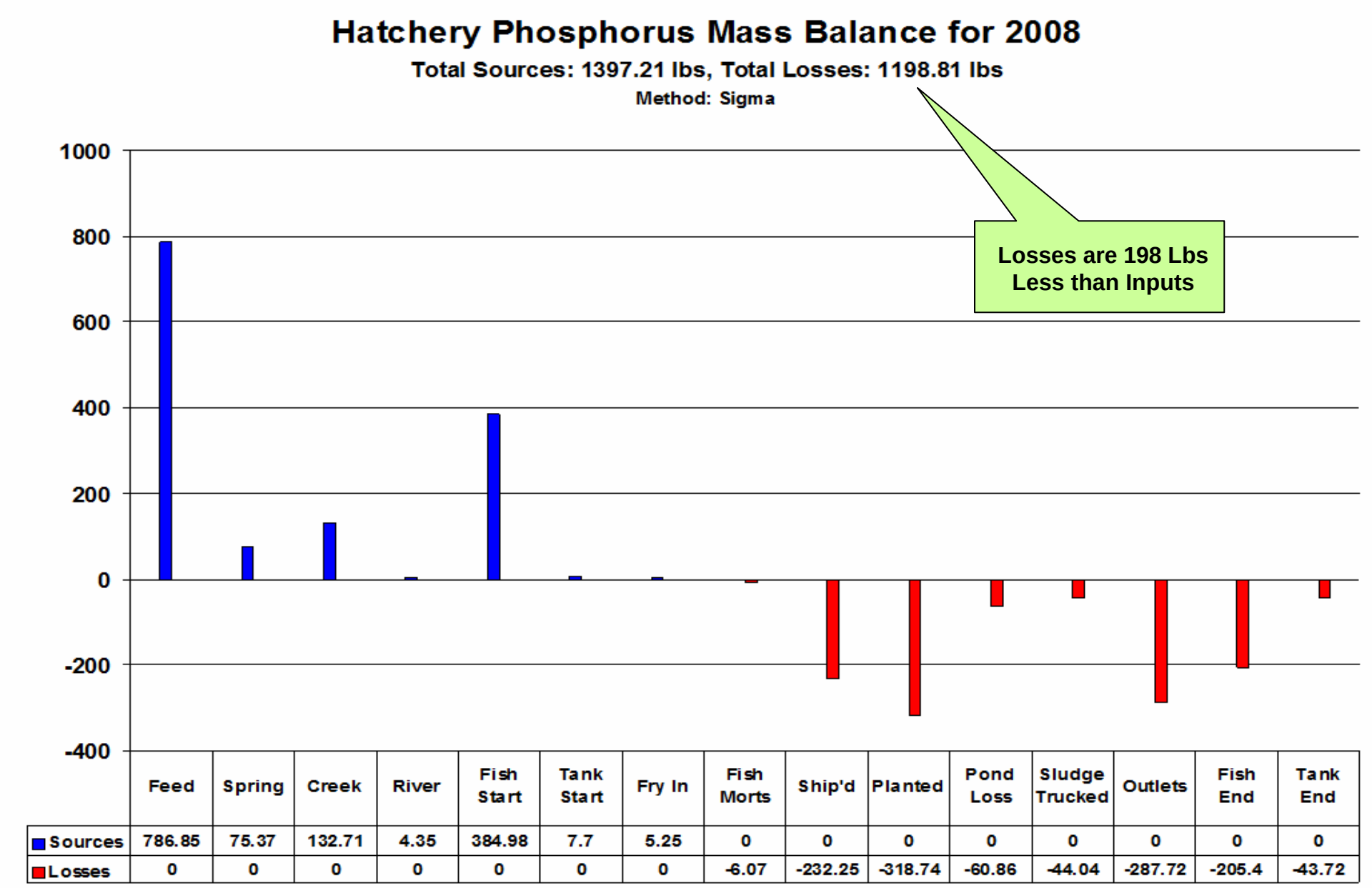
Pond Retention = Inputs to Pond from Screens, Clarifier, and Tank overflows - Discharge

Discharge – Source = Food – [Harvest + Fish End – Fish Start – Fry] - Trucked – Pond + [Tank Start – Tank End]

Net Load = Food – Production – Tank Retention – Pond Retention

Observe that Production ≠ Harvest because some of the Harvest could come from inventory depletion.

Figure 8. Definition of terms in Mass Balance Equation.



	Feed	Spring	Creek	River	Fish Start	Tank Start	Fry In	Fish Morts	Ship'd	Planted	Pond Loss	Sludge Trucked	Outlets	Fish End	Tank End
Sources	786.85	75.37	132.71	4.35	384.98	7.7	5.25	0	0	0	0	0	0	0	0
Losses	0	0	0	0	0	0	0	-6.07	-232.25	-318.74	-60.86	-44.04	-287.72	-205.4	-43.72

Report Date 05/30/2009

Figure 9. Hatchery Mass Balance for 2008 (Sigma).

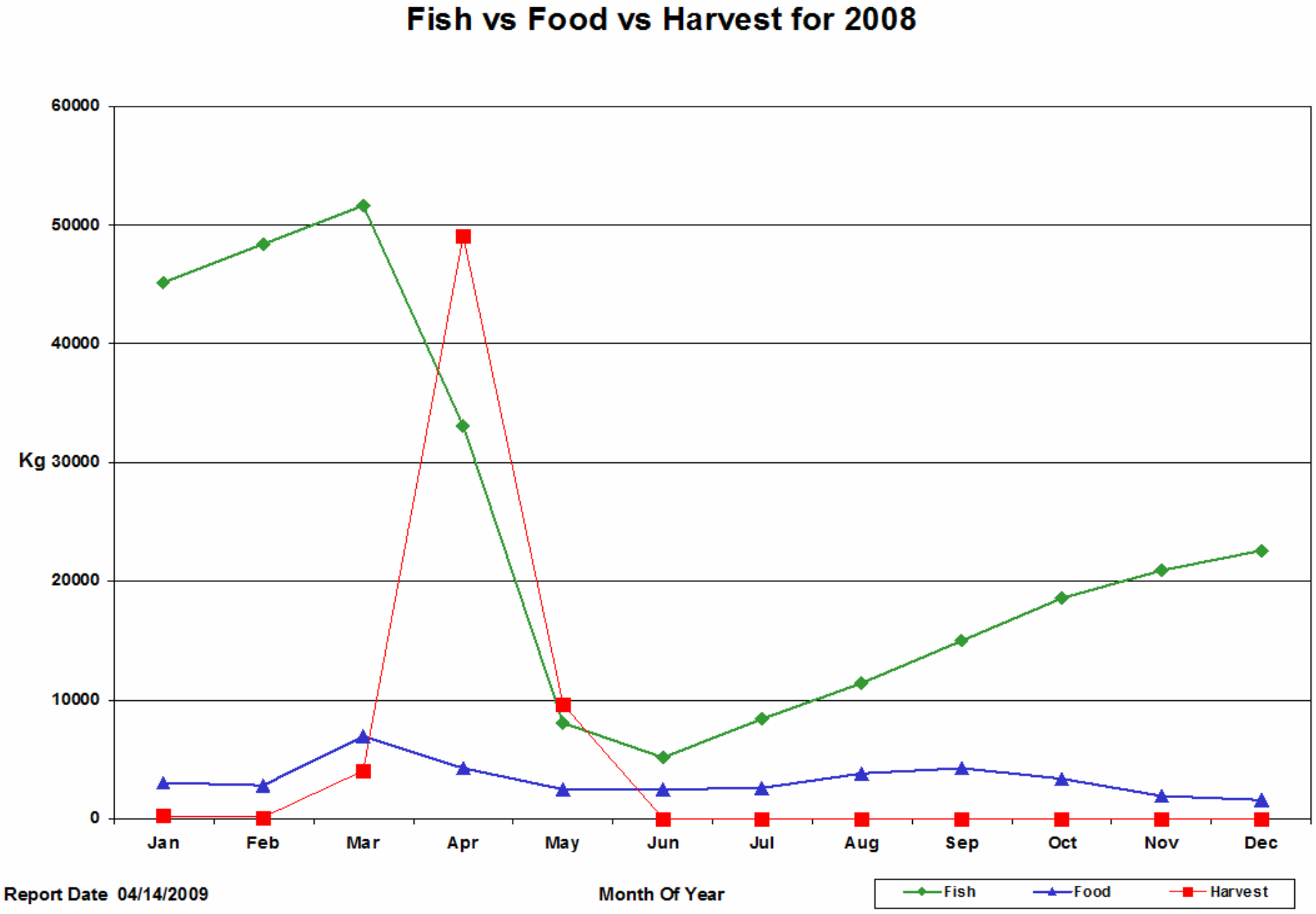


Figure 10. Month data for fish, food, and harvest for 2008.

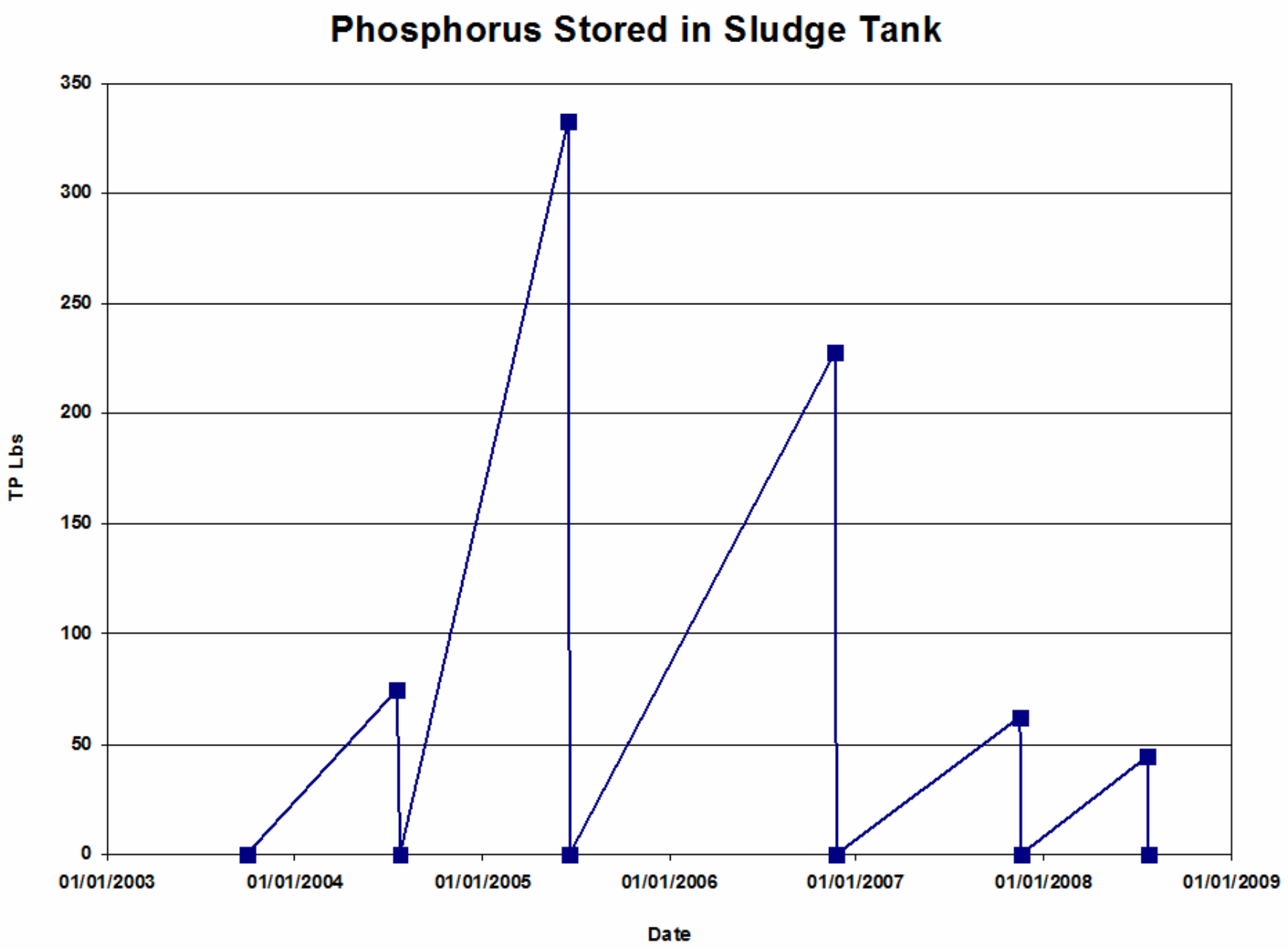


Figure 11. Sludge Tank Trucking Events

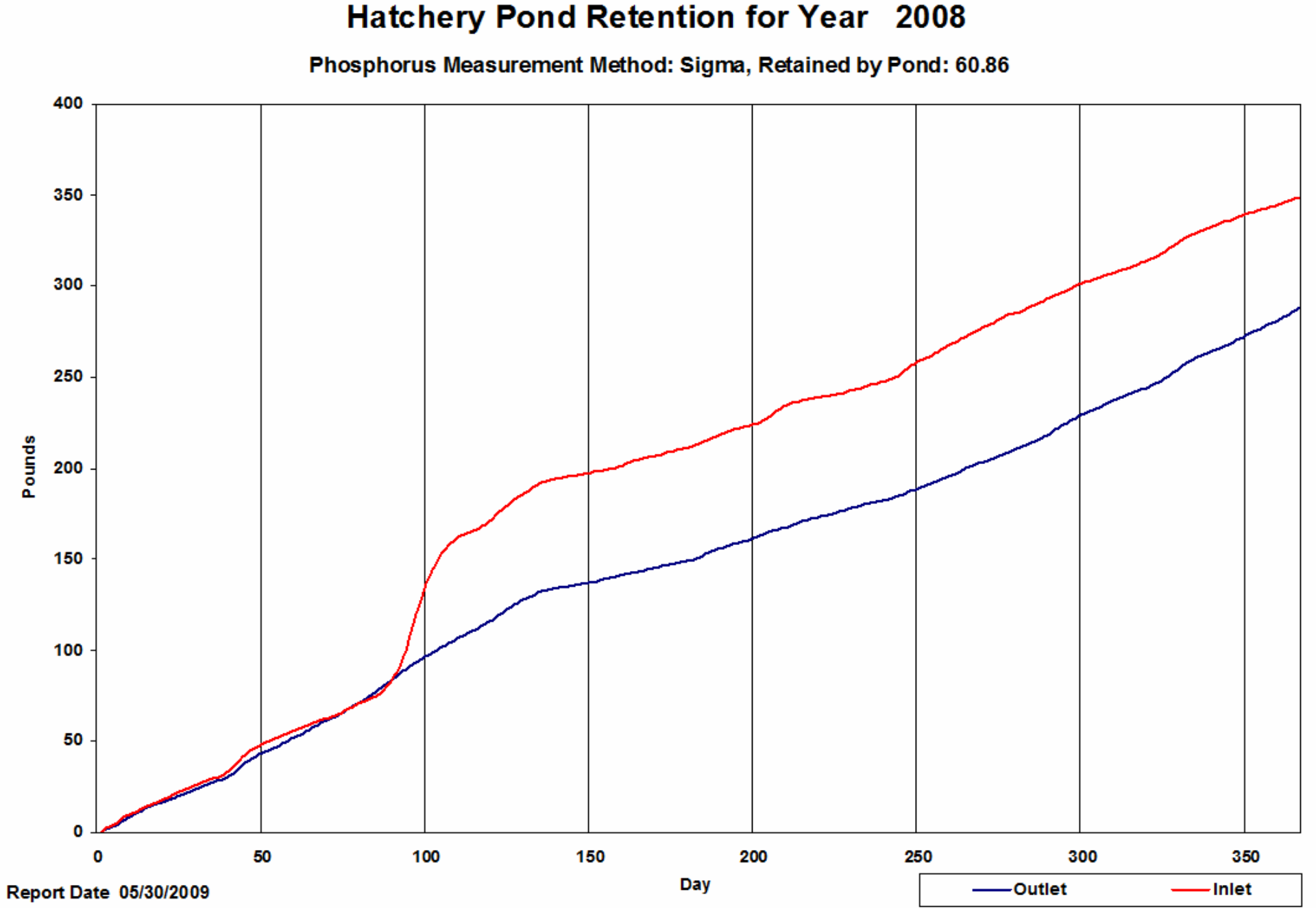


Figure 12. Pond retention data for 2008.

Typically the Measured Load is 100 to 200 Lbs P LOWER than what is expected based on Production Activities and Facility Operations

Measured Out - In	Food - Σ Out	Food In	Production	Tank Retention	Pond Retention	Year	Method
210	619	1272	617	0	37	2001	JN
206	431	1019	563	0	25	2002	JN
171	238	704	358	24	85	2003	JN
100	127	704	358	24	195	2003	Sigma
161	134	1071	624	214	99	2004	JN
135	185	1071	624	214	47	2004	Sigma
231	199	993	540	255	-1	2005	JN
201	253	993	540	255	-55	2005	Sigma
127	235	963	525	150	53	2006	JN
100	284	963	525	150	4	2006	Sigma
130	298	1016	552	63	102	2007	JN
104	115	1016	552	63	285	2007	Sigma
175	345	787	372	65	5	2008	JN
103	289	787	372	65	61	2008	Sigma

Annual Totals in Lbs P

Net Load Determined by Direct Measurement

Net Load Expected if Measurements of Food, Production, Tank, and Pond are accurate

If we knew for sure that Pond was ineffective, Maybe we could by-pass or dredge. If we knew for sure that the Trucked P is going down, maybe we could maintain the filters better. If we knew for sure that we are using “excess” food, maybe we could cut back without affecting Production.

Figure 13. Hatchery phosphorus mass balance for various years.

Net Load = Food – Production – Tank Retention – Pond Retention

Net Load | **Fish Rearing Activities** | **Plant Operations**

Typical Operation:

Assume Fish Inventory at the End = Start
Tank Contents at the End = Start

Food Use = 50,000 KG @ 0.9 % P = 990 Lbs P (conversion Ratio = 1.0)
Production = 50,000 KG @ 0.4 % P = 440 Lbs P

= 550 Lbs Excess
= - 175 Limit
= 375 Lbs

What can be done to eliminate the 375 Lbs ??? (Note it must be eliminated to meet Agreement)

1. Reduce the Conversion Ratio = Food Applied/Fish Produced
2. Reduce fish production.
3. Increase Screen Efficiency so that more P can be removed from the tank by truck.
4. Increase P removal in pond, and eventually remove from the Hatchery by dredging.

Figure 14. Mass balance expressed in operational terms.

MDNR Biomass Predictor Model

New weight = (last weight - mortality weight) + (food fed quantity / conversion ratio)

Example (March 2009)

Old Fish = 28,664 KG
New Fish = 34,089 KG

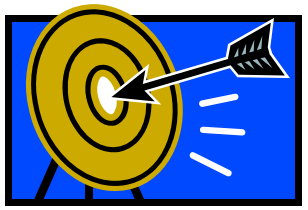
Food = 4759 KG @ 0.94%P

Mort = 90.8 KG

Coho Conversion Ratio = 1.1
Chinook Conversion Ratio = 0.95

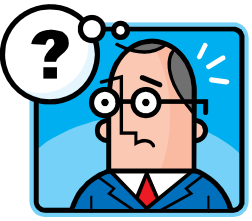
New Weight = 28,664 – 90.8 + 4759/1.1 = 32,900 KG

Works Pretty Well !!!!



However:

4,759 KG of Fish Food contains = 4,759(0.0094) = 44.7 KG or 98.3 Lbs of P
4,759 KG of New Fish Biomass contains = 4,759(0.004) = 19.0 KG or 41.9 Lbs of P



What happens to the other 25.7 KG or 56.4 Lbs of P ???? (compare to limit)

What would happen to the Conversion Ratio and Production if the % P of the Food went up or down ??
What would happen to the Conversion Ratio and Production if the Temperature was lower or higher ??

What would happen if 4,759 KG of Food was fed to 4,759 KG of Fish ?? Would the Fish really Double ??

Suppose the 4,759 KG of Food was supplied in 1 week instead of 1 month, would the same increase be attained??

Can we generalize the DNR model using what we know about Bio-Energetics
along with insights and experiences of the staff to obtain quantitative answers to these questions?

Figure 15. Discussion of MDNR biomass predictor model.

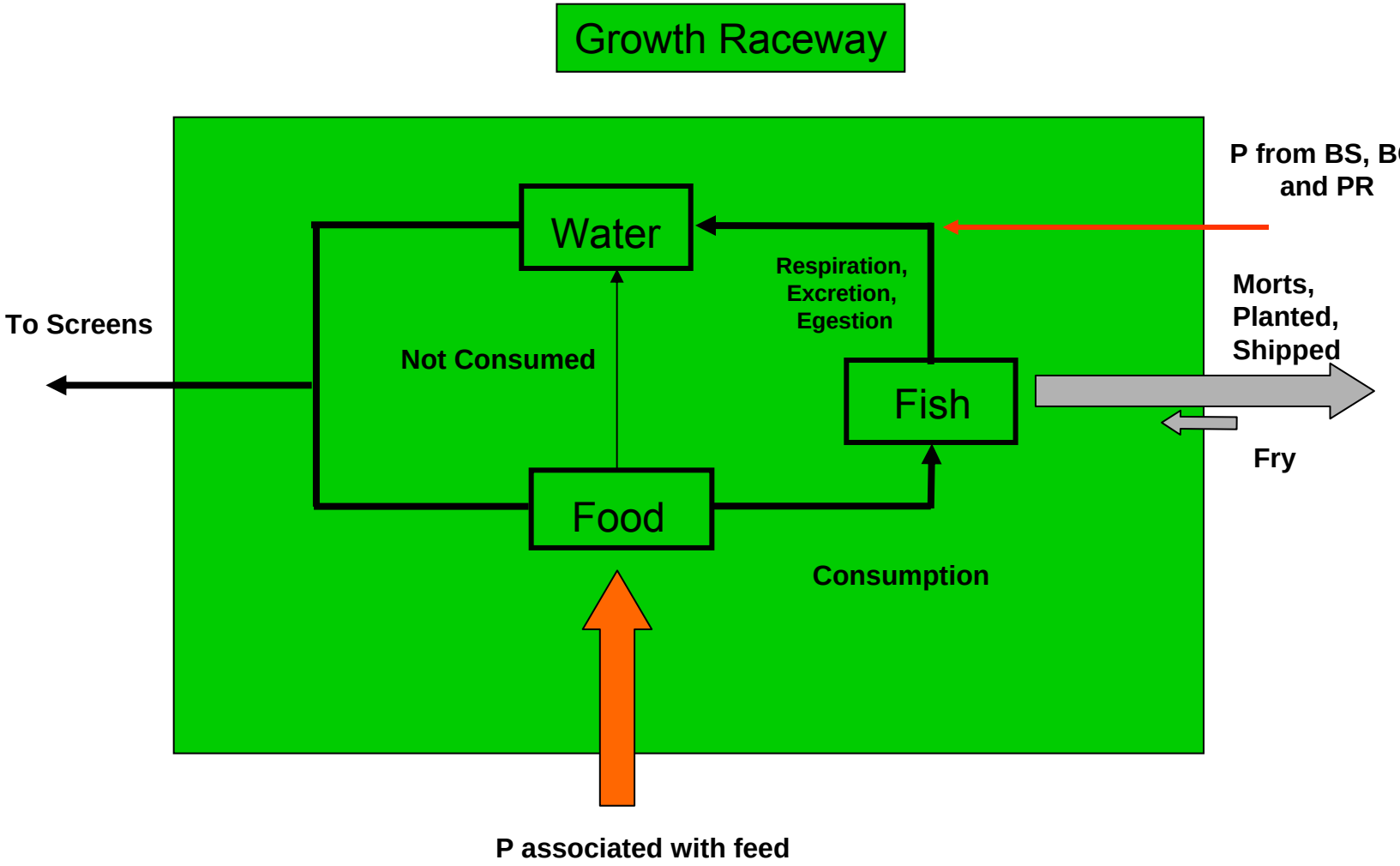
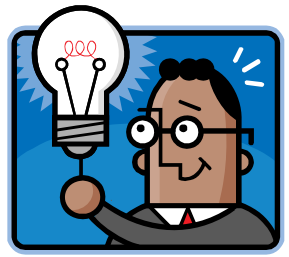


Figure 16. Fish growth model mechanisms.

Proposal For New Bio-Energetics Based Fish Phosphorus Model



Change = Gains - Losses

$$dFishP/dt = CP(T) * FishP - LP(T) * FishP \quad \text{(as P)}$$

Rate of Change of fish biomass P

CP(T) is the consumption rate of phosphorus in the food. It is a function of temperature and the size of the fish. CP(T) is based on bioenergetics.

Units = 1/day

LP(T) is the loss rate of phosphorus. It is a function of temperature, the size of the fish, and the activity level. Includes all losses from urine and fecal matter. UP(T), and FP(T) are based on bioenergetics.

Units = 1/day

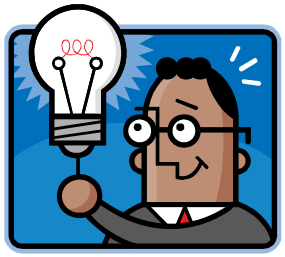
$$dFishP/dt = \Delta FishP / \Delta time = (New\ FishP - Old\ FishP) / \Delta time$$

Note: New Fish = Increase in inventory + morts + Harvest

$$New\ FishP = Old\ FishP + [CP(T) - LP(T)] * Old\ FishP * \Delta time$$

New weight = (last weight - mortality weight) + (food fed quantity / conversion ratio)

Figure 17. Bio-energetic based phosphorus mass balance model.



dFishP/dt = CP(T) * FishP - LP(T) * FishP (as P)

Must include food Limitation factor

CP(T)* FishP (KG/Day) = Food Application Rate if Food Application Rate < CP(T)*FishP
CP(T)* FishP (KG/Day) = CP(T)*FishP if Food Application Rate > CP(T)*FishP

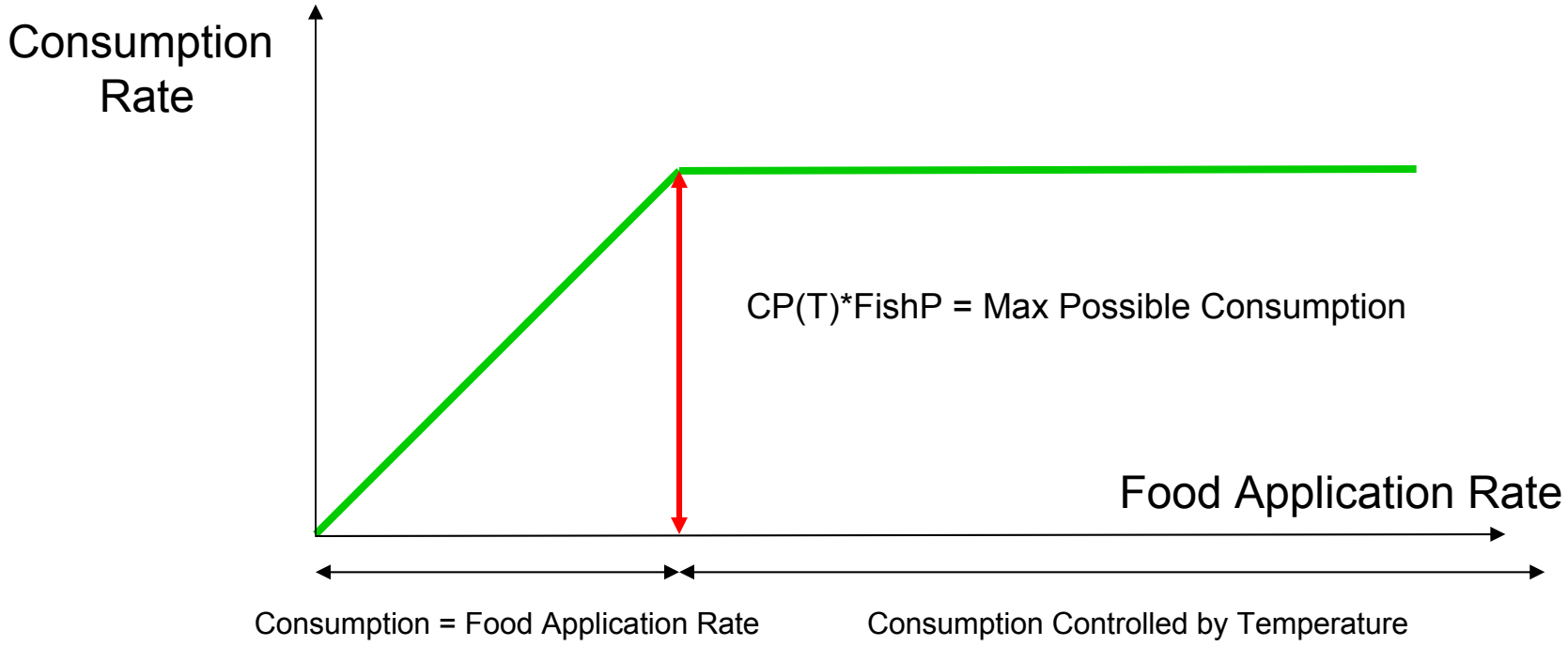


Figure 18. Relationship between food consumption rate and food supply rate.

$$dFishP/dt = CP(T) * FishP - LP(T) * FishP \quad \text{(as P)}$$

CP(T)* FishP (KG/Day) = Food Application Rate if Food Application Rate < CP(T)*FishP
CP(T)* FishP (KG/Day) = CP(T)*FishP if Food Application Rate > CP(T)*FishP

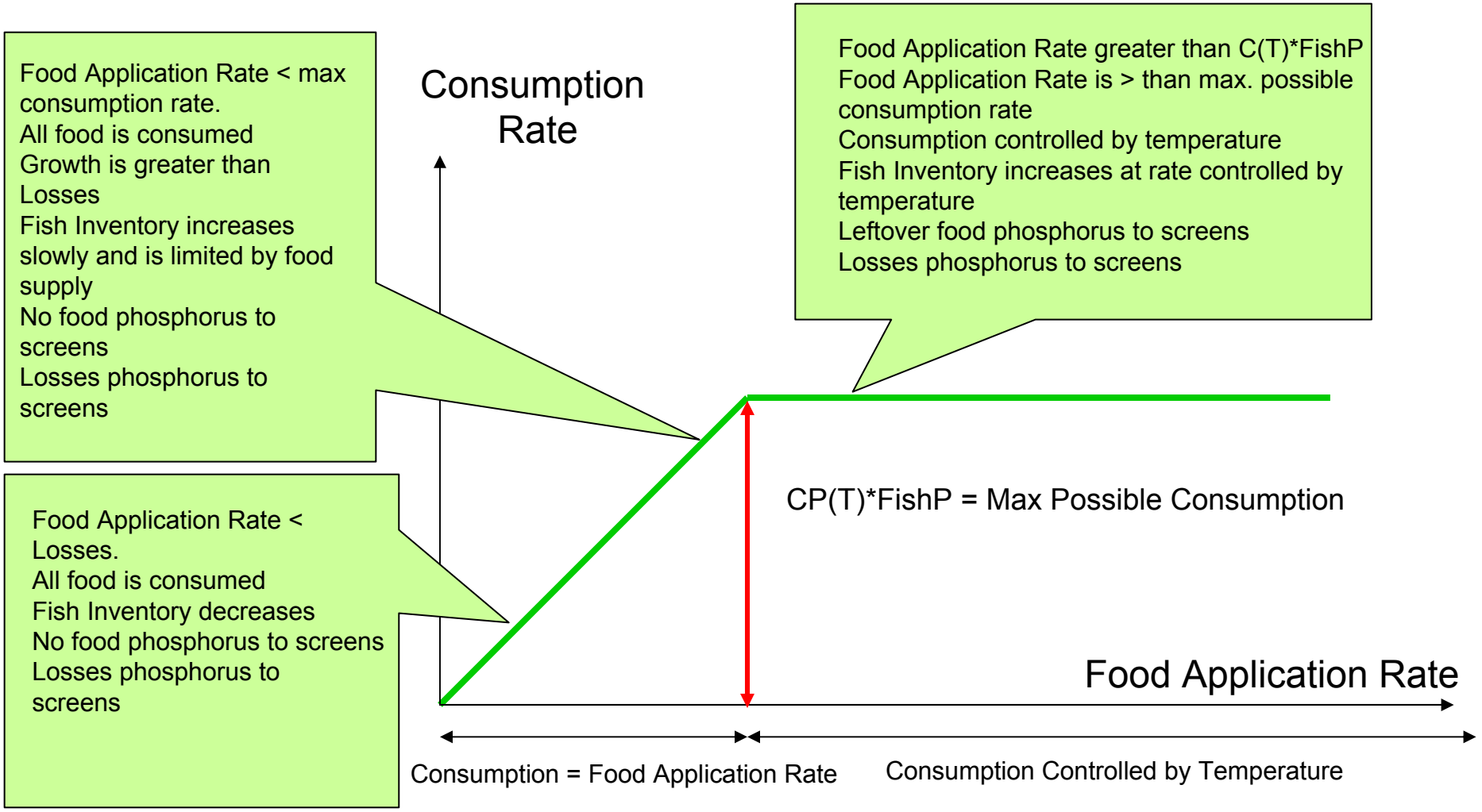


Figure 19. Discussion of three phases of consumption.

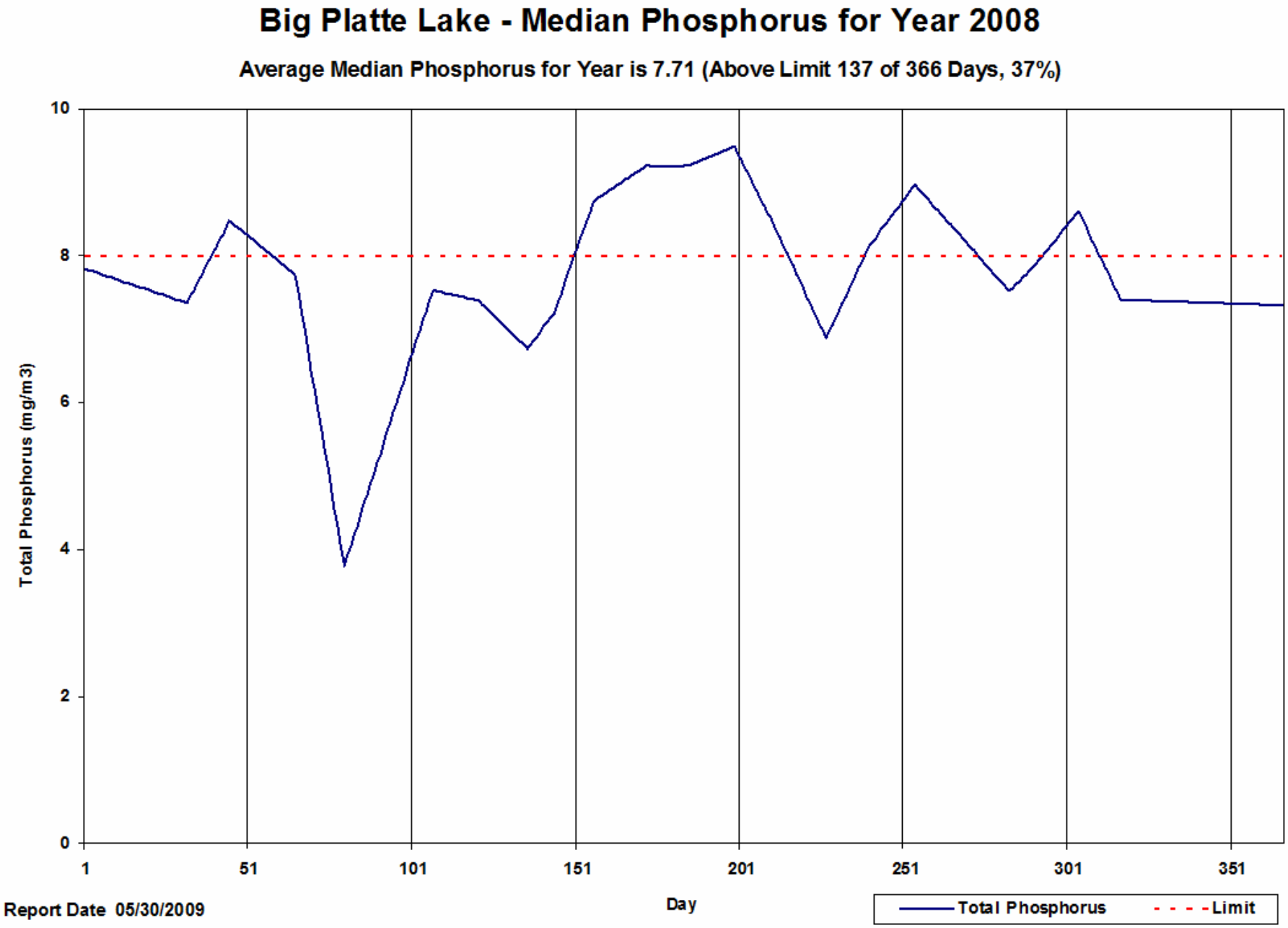


Figure 20. Volume-weighted total phosphorus concentration in Big Platte Lake for 2008.

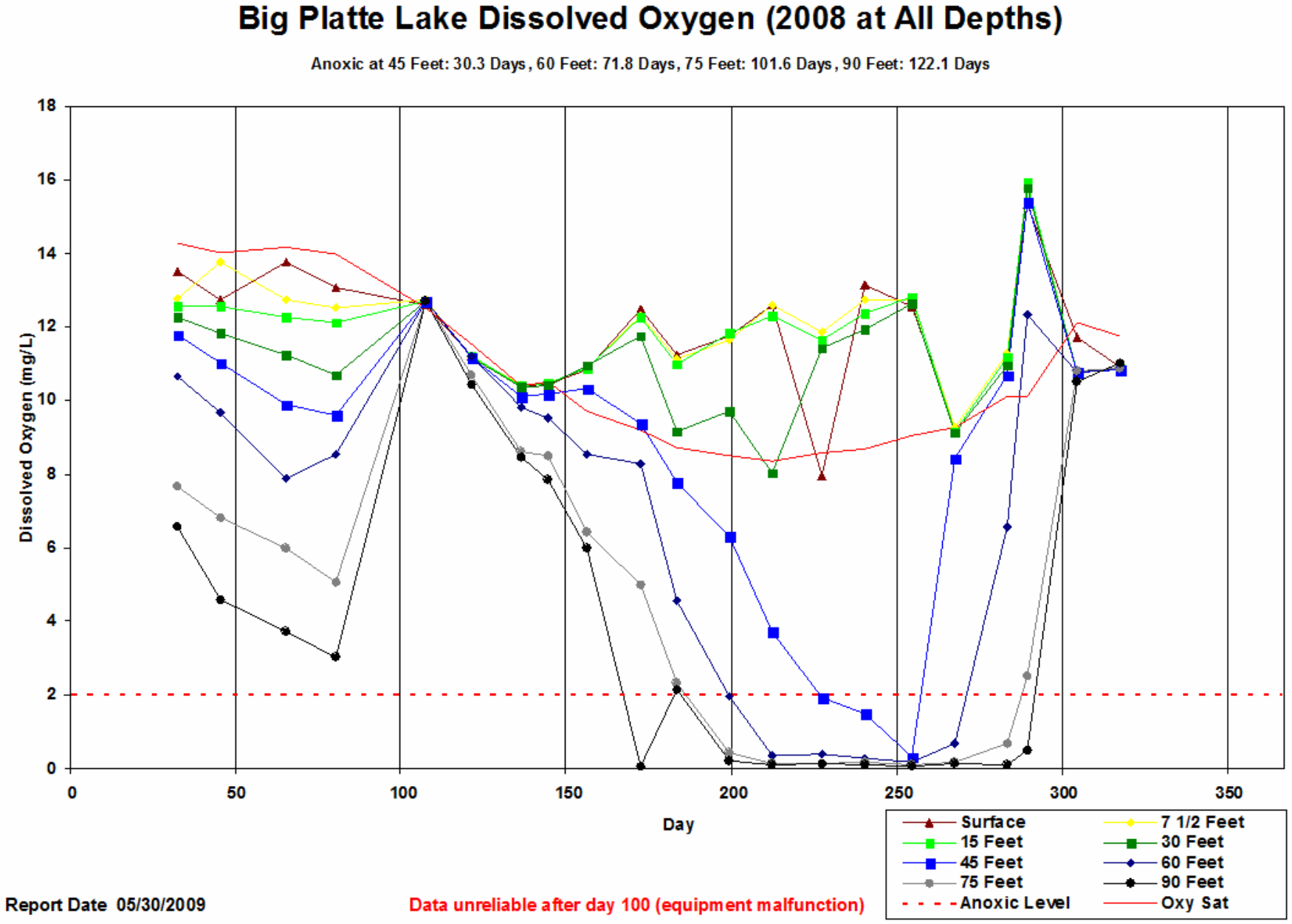


Figure 21. Dissolved oxygen as a function of depth for 2008.

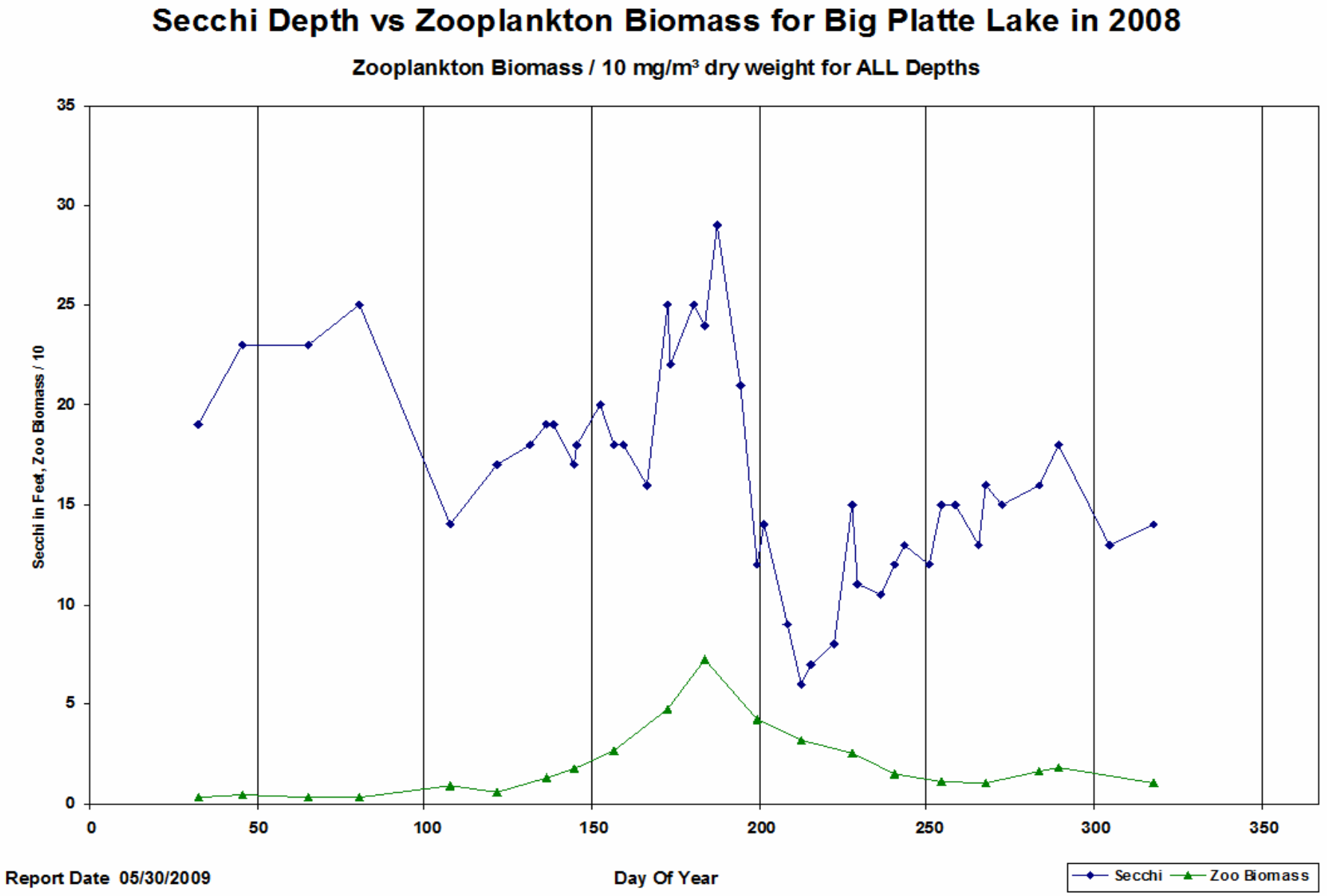


Figure 22. Secchi depth and zooplankton biomass for 2008.

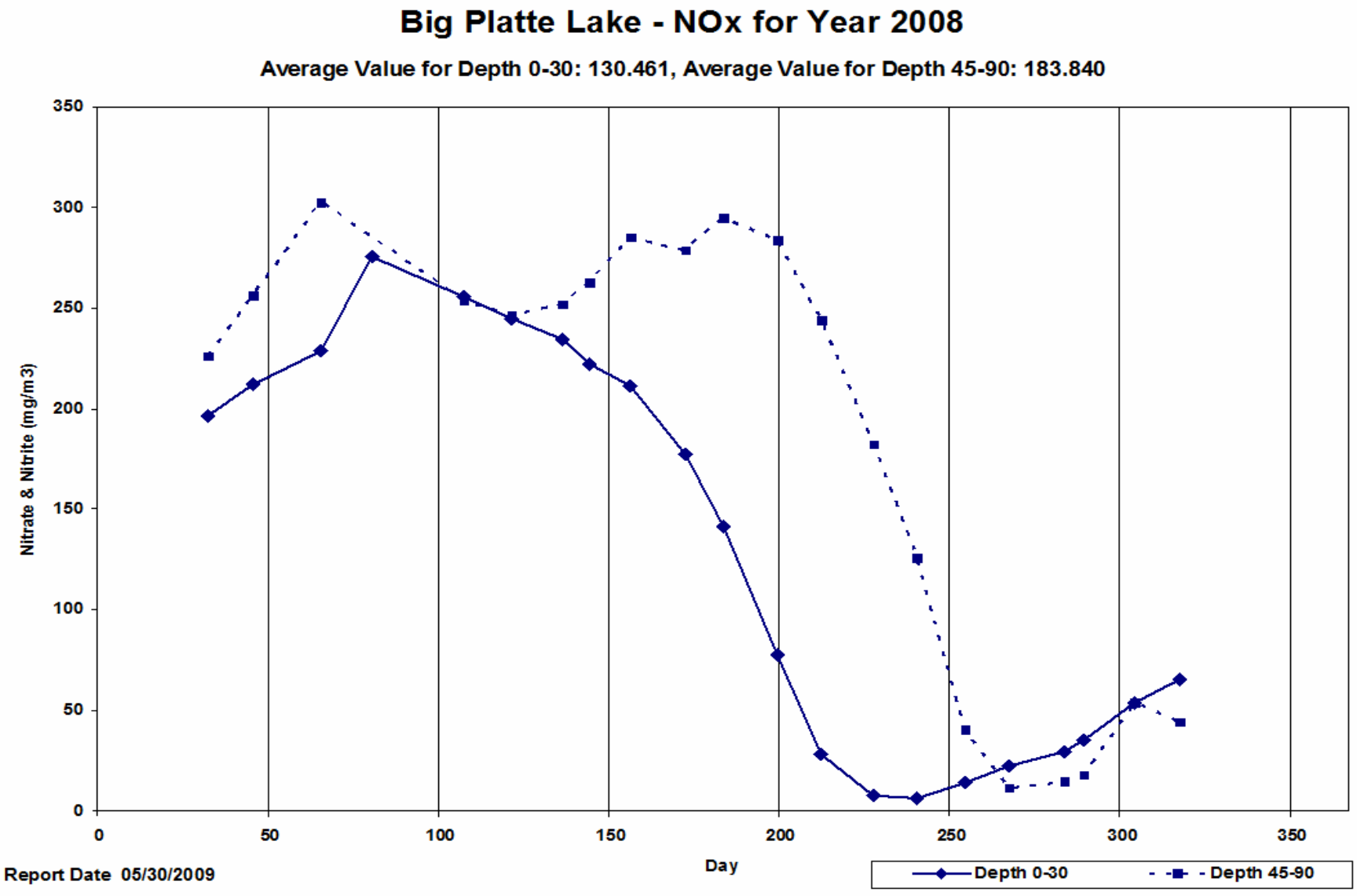


Figure 23. Nitrate concentrations at surface and bottom of Big Platte Lake for 2008.

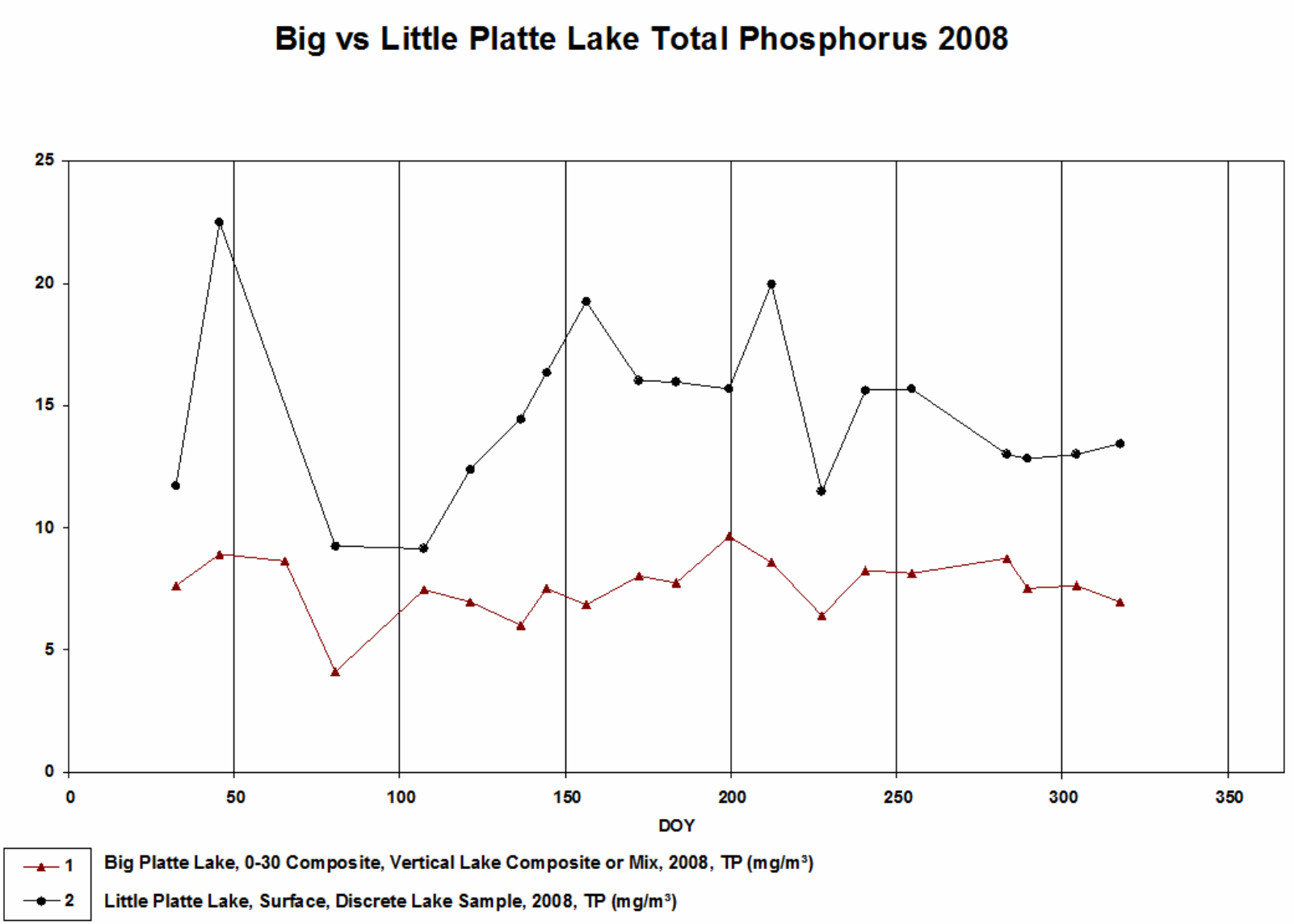


Figure 24. Comparison between total phosphorus in Big and Little Platte Lakes for 2008.

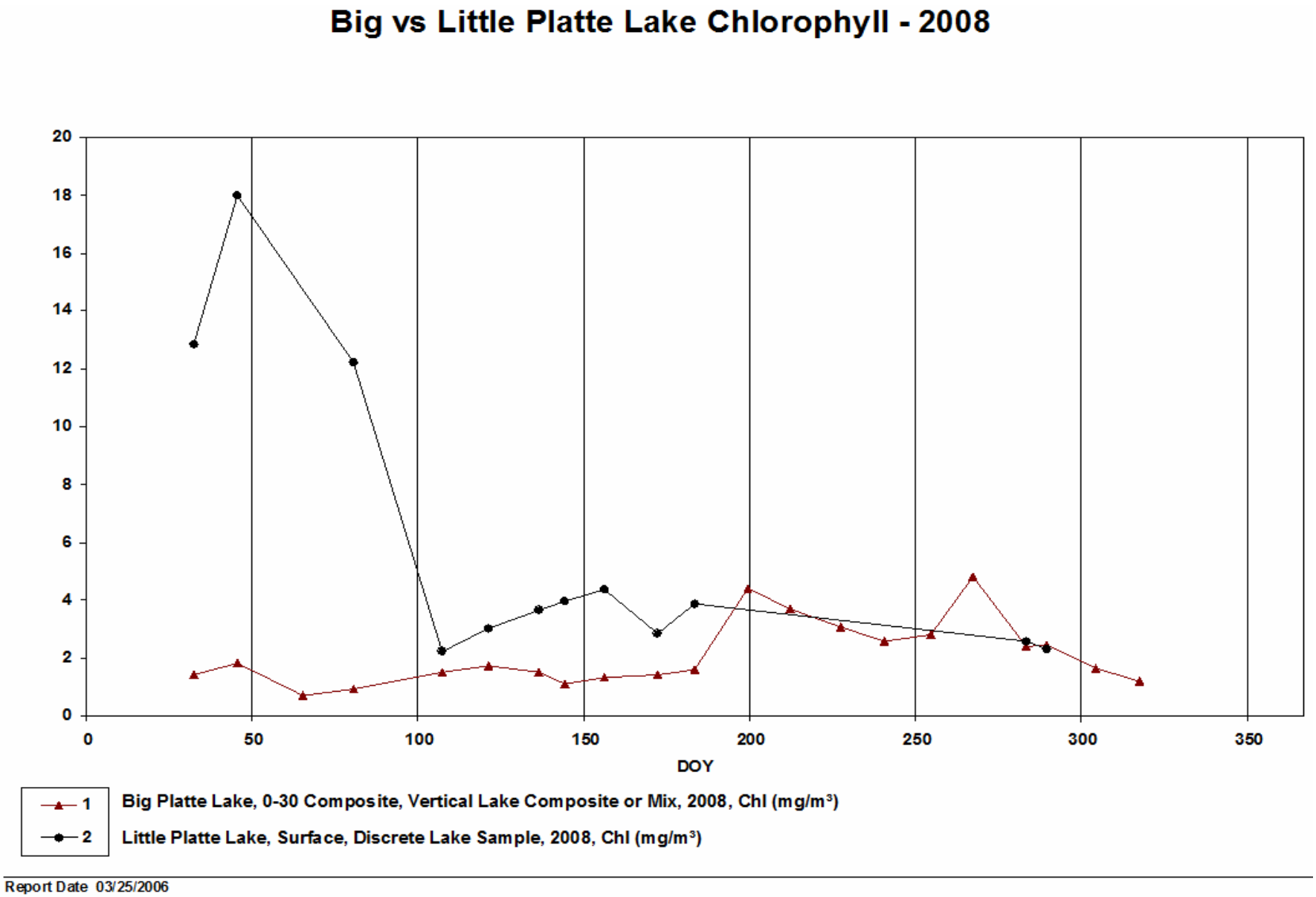


Figure 25. Comparison between chlorophyll in Big and Little Platte Lakes for 2008.

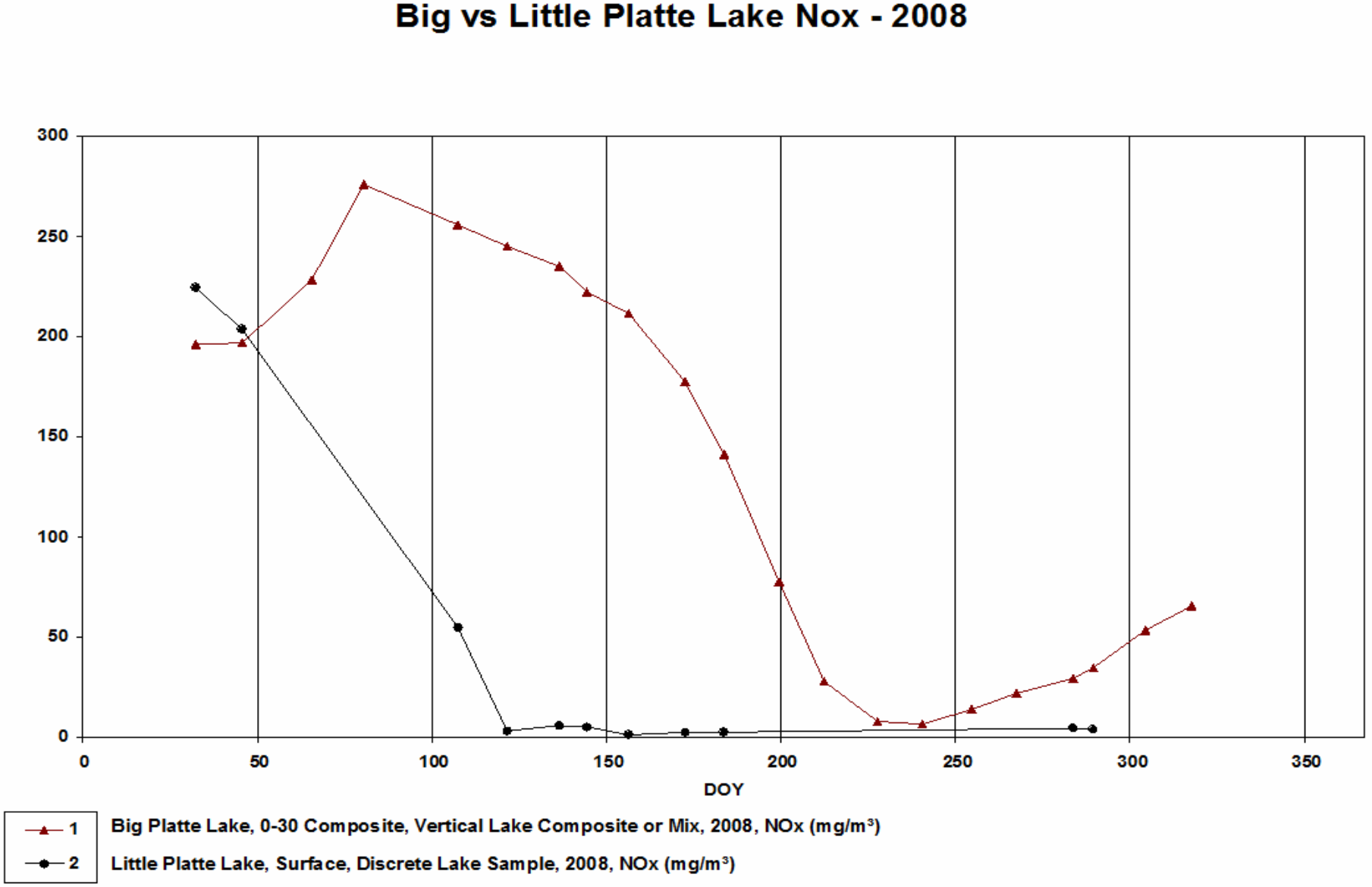


Figure 26. Comparison between nitrate + nitrite in Big and Little Platte Lakes for 2008.

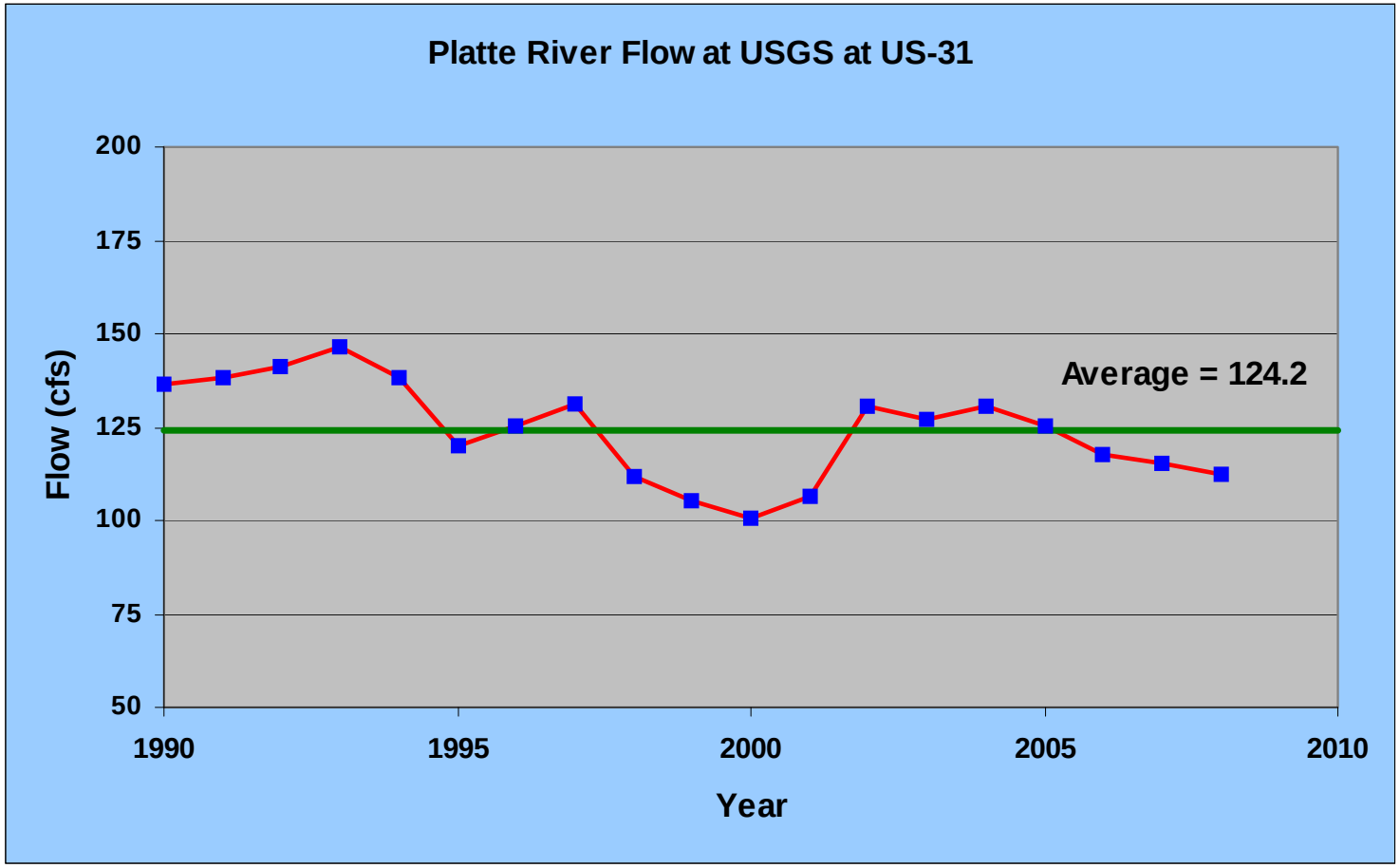


Figure 27. Historical record of annual average flows of Platte River.

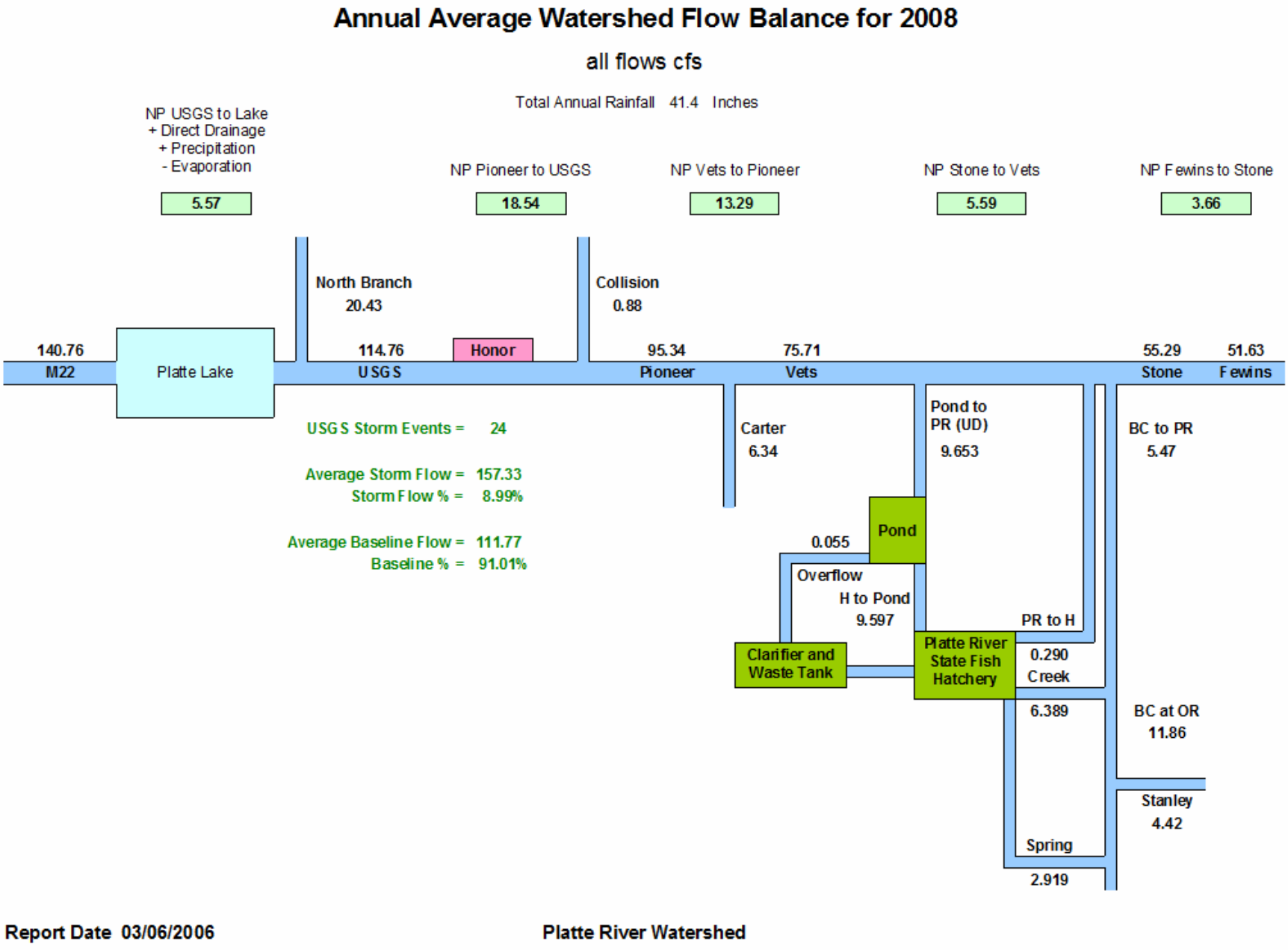


Figure 28. Watershed flow balance for 2008.

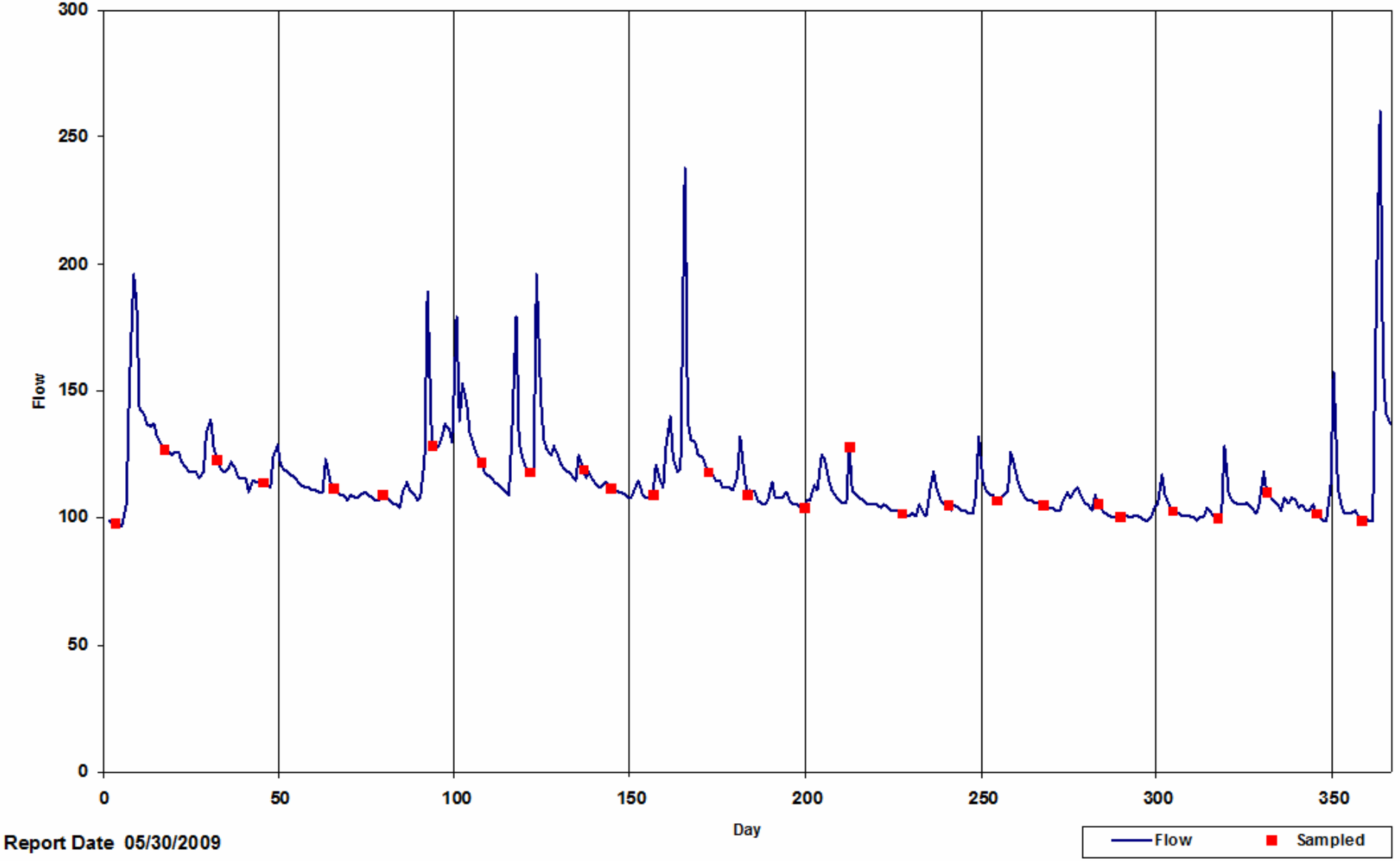


Figure 29. Daily average flows of Platte River at USGS and sampling days.

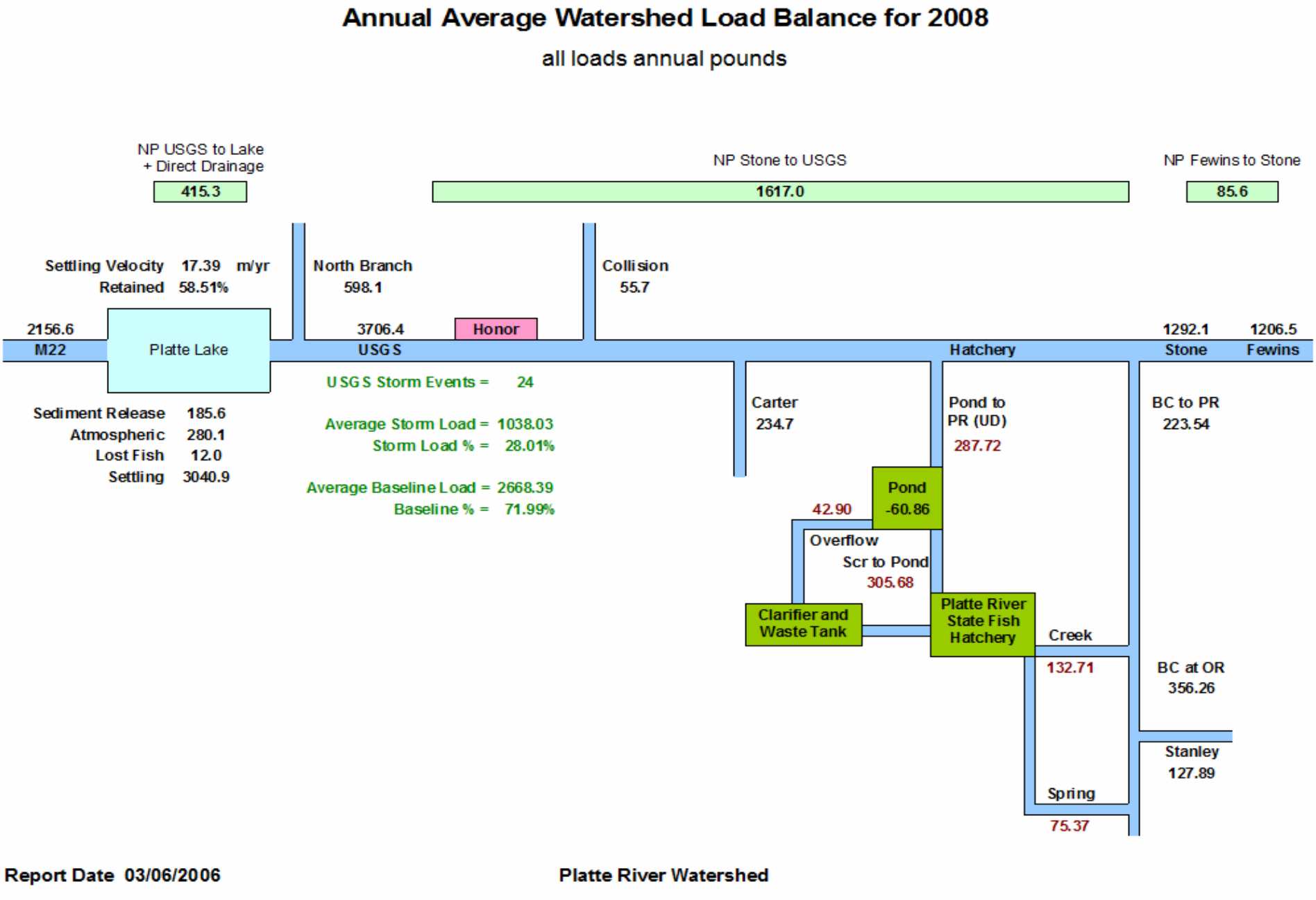


Figure 30. Watershed phosphorus balance for 2008.

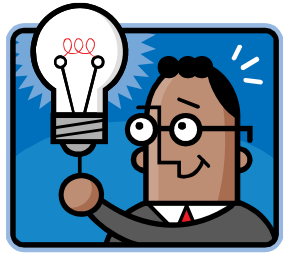
The Water Environment Federation (WEF)
and the Michigan Water Environment Association

WATERSHED 2004 INTERNATIONAL CONFERENCE
HYATT REGENCY DEARBORN
DEARBORN, MICHIGAN, USA
11-14 JULY 2004

Reduction of Total Phosphorus Loads to Big Platte Lake, MI through Point Source Reduction and Watershed Management.

By
Dr. Raymond P. Canale, Emeritus Professor, The University of Michigan.
Ron Harrison, Benzie County Conservation District.
Penelope Moskus, Limno-Tech Inc, Ann Arbor, Michigan
Troy Naperala, Limno-Tech Inc, Ann Arbor, Michigan
Wilfred Swiecki, Platte Lake Improvement Association.
Gary Whelan, Michigan Department of Natural Resources-Fisheries Division.

We need a rational, scientifically valid way to determine how much the non-point phosphorus loads must be reduced to meet water quality standards for Big Platte Lake



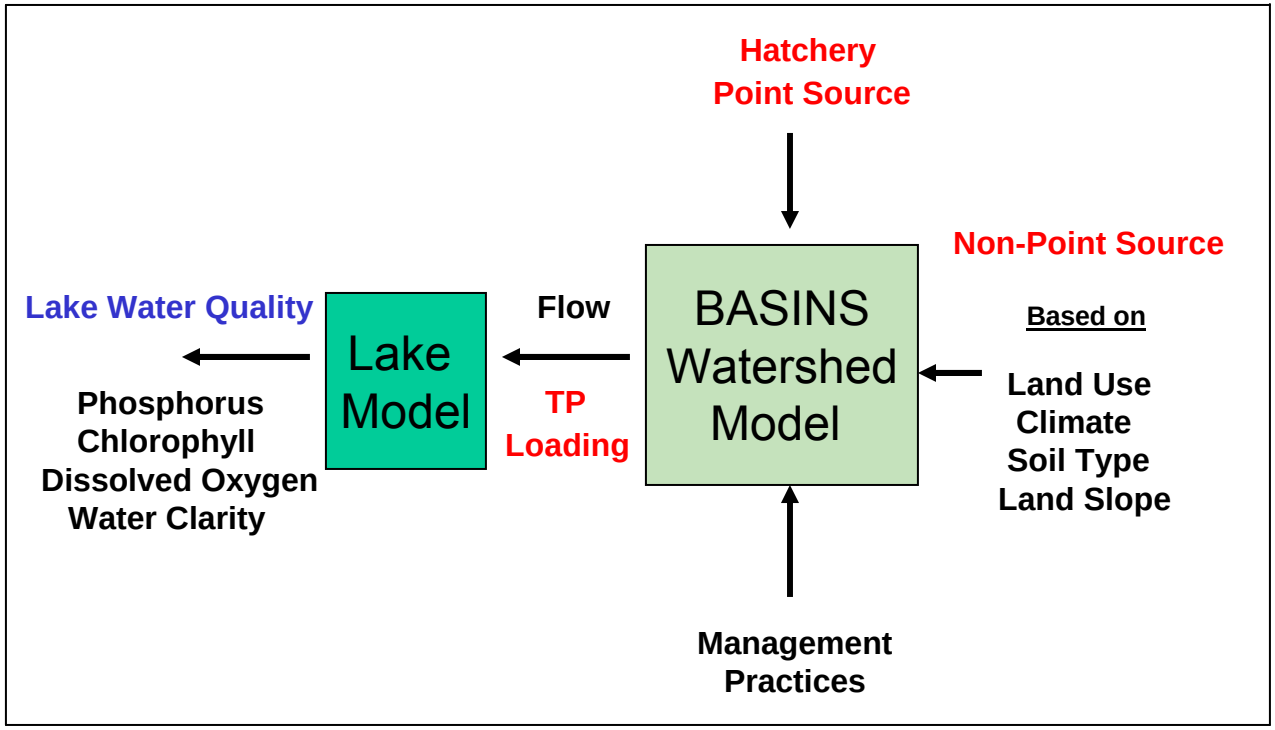
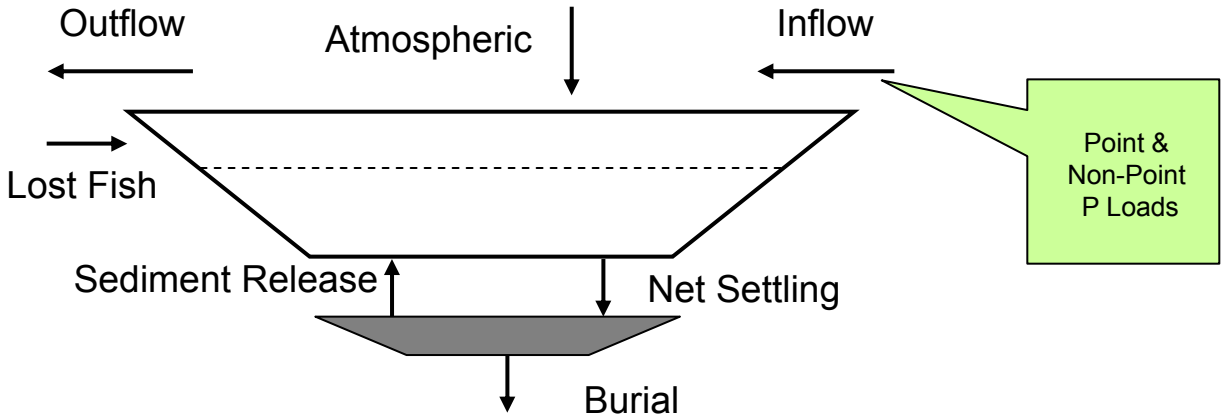


Figure 31. Components of watershed management program.

Phosphorus Action Plan for Big Platte Lake, MI.
by
Dr. Raymond P. Canale, Emeritus Professor, The University of Michigan.
Todd Redder, LimnoTech, Ann Arbor, Michigan
Wilfred Swiecki, Platte Lake Improvement Association
Gary Whelan, Michigan Department of Natural Resources-Fisheries Division

Manuscript Submitted To
Journal of Water Resources Planning and Management
American Society of Civil Engineers



$$V_w \frac{dP_w}{dt} = W - QP_w - v_s A_s P_w + v_r A_r P_s$$

$$V_s \frac{dP_s}{dt} = v_s A_s P_w - v_r A_r P_s - v_b A_r P_s$$

$$V_h \frac{dDO_h}{dt} = v_e A_r (DO_e - DO_h) - A_r (HOD)$$

Figure 32. Water and sediment model for Big Platte Lake.

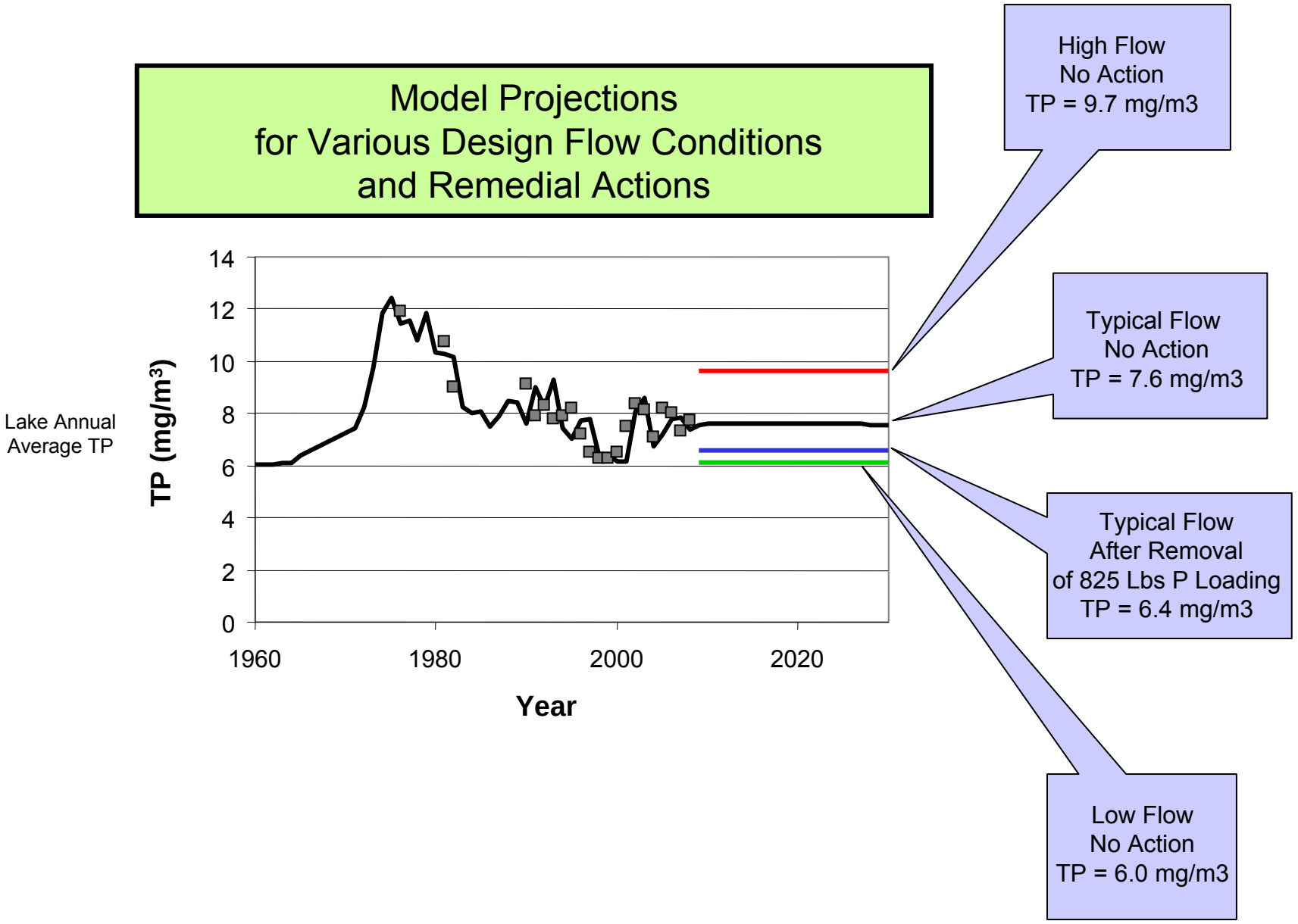


Figure 33. Model validation and projections for total phosphorus in Big Platte Lake.

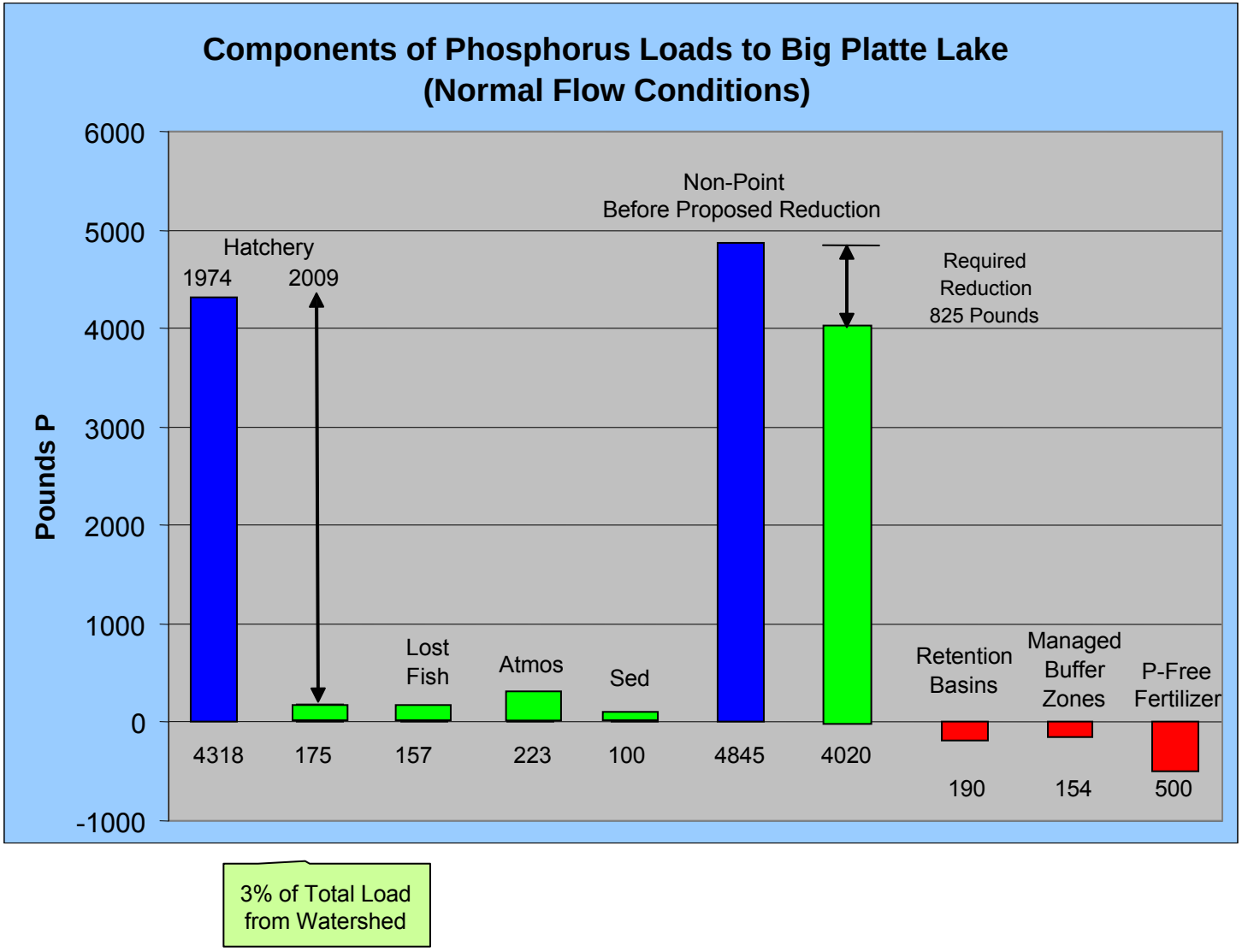


Figure 34. Summary of historical and proposed changes in the phosphorus loading to Big Platte Lake.

	BPL Dates	BPL Depths	BPL Reps	LPL Dates	LPL Depths	LPL Reps	Trib Dates	Trib Sites	Trib Reps	Count	Unit Cost	Sub Total
Alkalinity	20	1	1	0	1	0				20	$ 5.90	$ 118
Calcium	20	1	1	0	1	0				20	$ 9.44	$ 189
TDS	20	1	1	0	1	0				20	$ 5.90	$ 118
TP	20	10	3	0	1	0	20	4	3	840	$ 7.67	$ 6,443
TDP	20	2	0	0	1	0	20	0	0	0	$ 7.67	$ -
NO2 + NO2	20	2	0	0	1	0	20	0	0	0	$ 12.39	$ -
TN	20	2	0	0	1	0	20	0	0	0	$ 32.50	$ -
TDN	20	2	0	0	1	0	20	0	0	0	$ 32.50	$ -
Chlorophyll	20	2	3	0	1	0				120	$ 14.75	$ 1,770
Phytoplankton	3	1	4	0	1	0				12	$ 76.70	$ 920
Zooplankton	3	1	3							9	$ 76.70	$ 690
												$ 10,248

	H Dates	H Sites	H Reps	Tank Dates	Tank Sites	Tank Reps	Special Dates	Special Sites	Special Reps	Count	Unit Cost	Sub Total
TP	100	6	6	2	30	3	10	20	3	4380	$ 7.67	$ 33,595
mg P/mg DW	24	2	3							144	$ 17.50	$ 2,520
%water	24	2	3							144	$ 11.80	$ 1,699
												$ 37,814

Figure 35. Proposed sampling program and costs for 2009.

APPENDIX A

JUG & NEEDLE AND SIGMA RELOCATION

Jug/Needle and Sigma Relocation Project

A step toward consolidating water sampling techniques at Platte River State Fish Hatchery

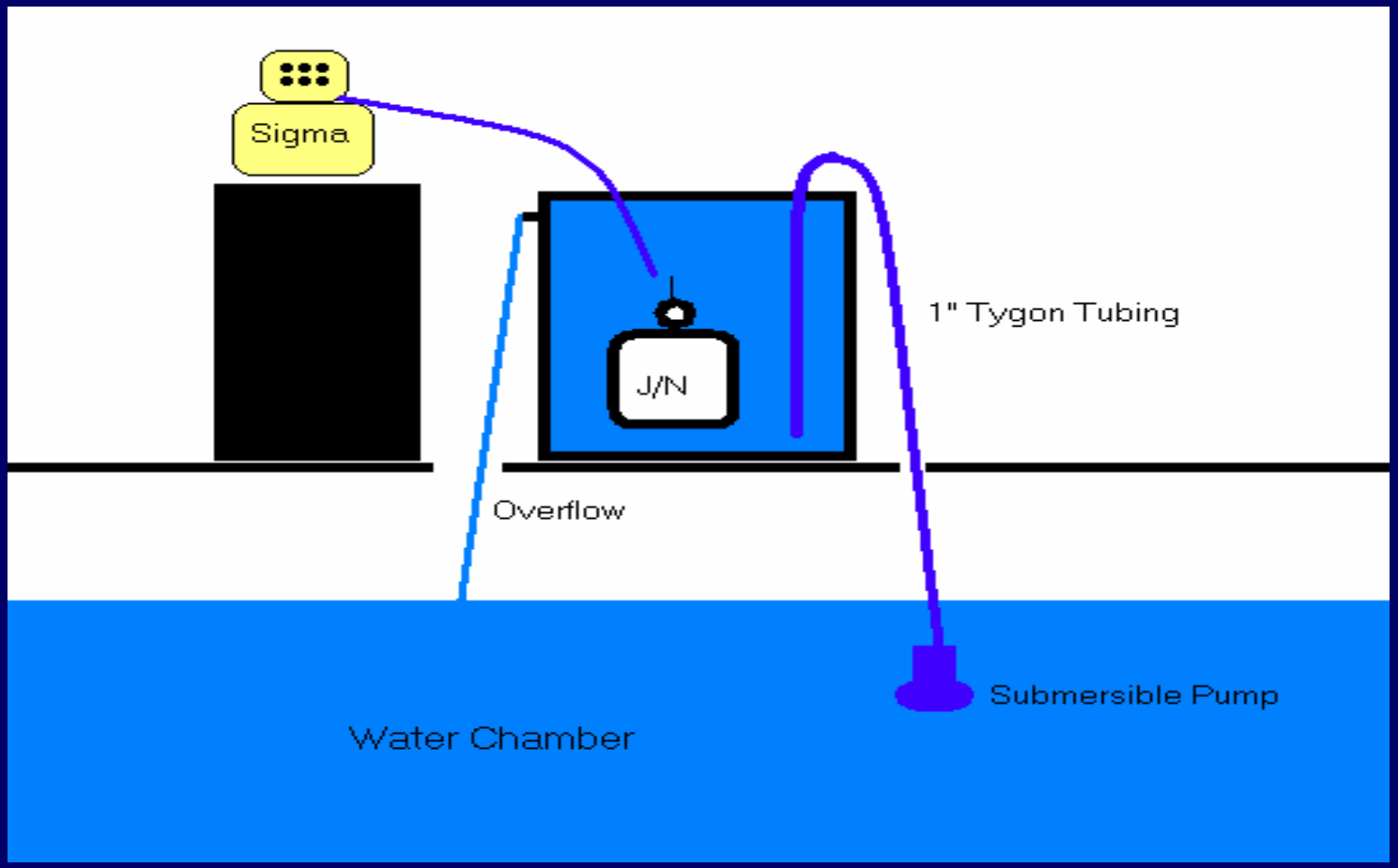
Materials

- High Density Polyethylene (HPDE) drum
- 1” Tygon tubing
- Galvanized pipe and connections
- Cast-iron submersible pump or stainless trash pump

Design

- Water is pumped from collection chamber through tygon tubing to the drum at 5 gallons per minute
- Water is forced down into the drum, up-wells through the drum and exits through top of the drum

Set-up


Sigma
J/N
1" Tygon Tubing
Overflow
Submersible Pump
Water Chamber

Brundage Creek Test Site

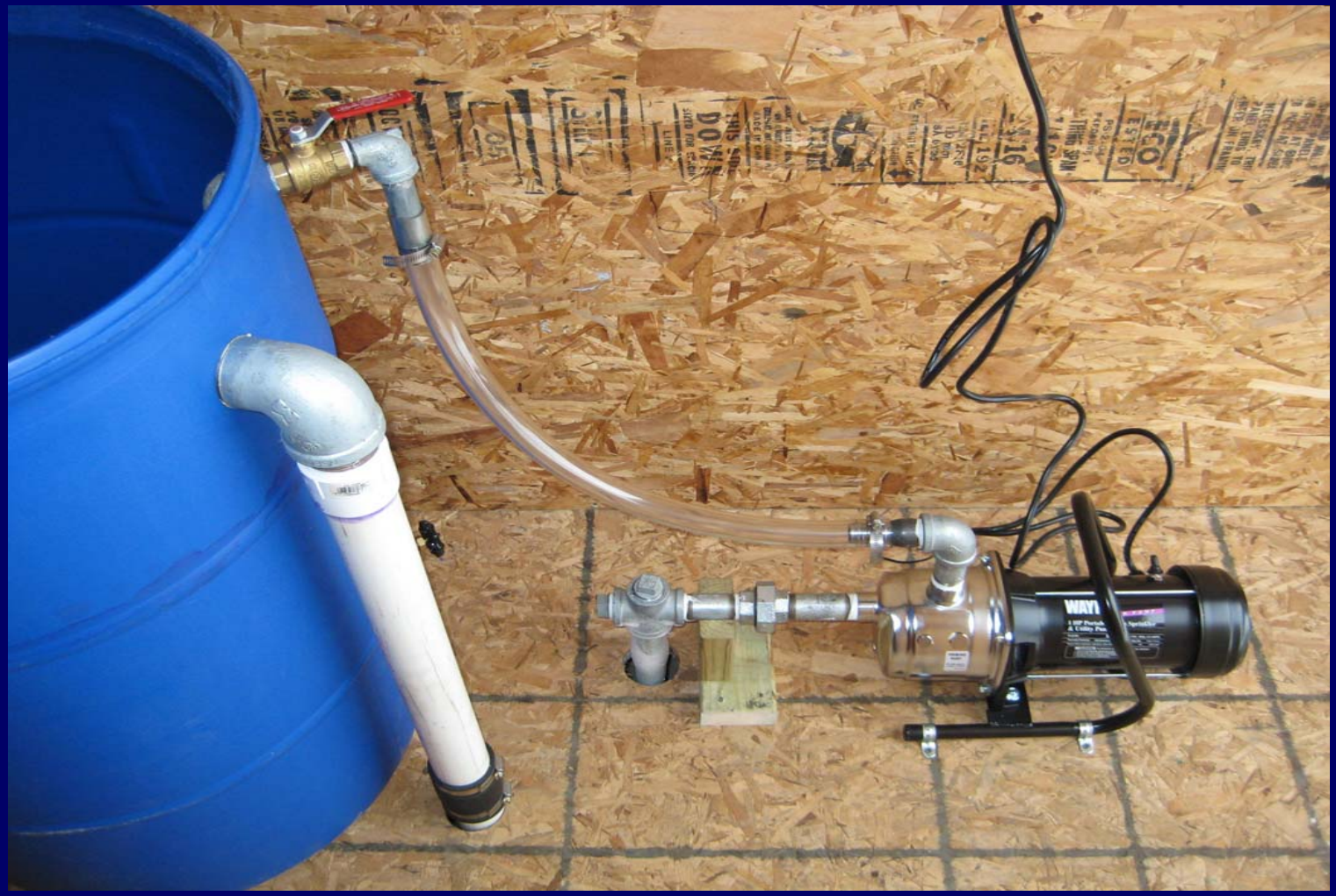
- A test site for Brundage Creek was set up and has been running 24/7 since 10/31/08
- There has been no accumulation of solids in the bottom of the drum
- This site is ready for side-by-side sampling, barring approval

Overhead view Brundage Creek drum at one week

Maintenance

- All parts are removable for cleaning
- Drums are drainable for cleaning
- Cleaning of all part shall be done monthly

All points access for cleaning



Modification

- Most sites will require some form of modification or relocation
- All site modifications are subject to approval by all parties

Brundage Spring

- No modifications necessary
- Switched to side-by-side sampling in September of 2008
- Modifications at the other sites will follow this layout

Brundage Spring Set-up

Overhead view

Brundage Creek

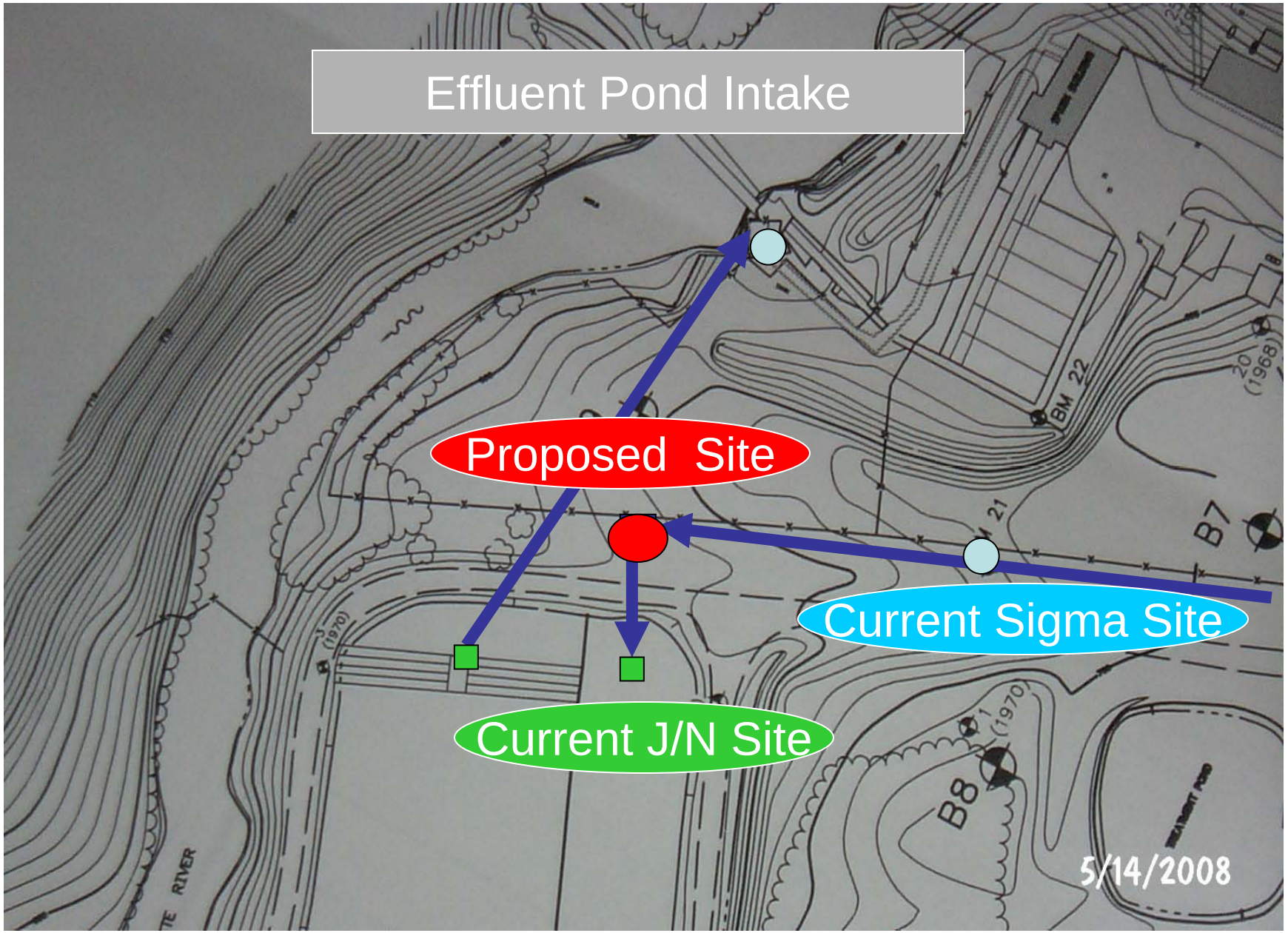
- The new design has been implemented
- The set-up is in the pump house and draws from the Brundage Creek collection chamber (current Sigma site)

Pump House

Effluent Pond Intake

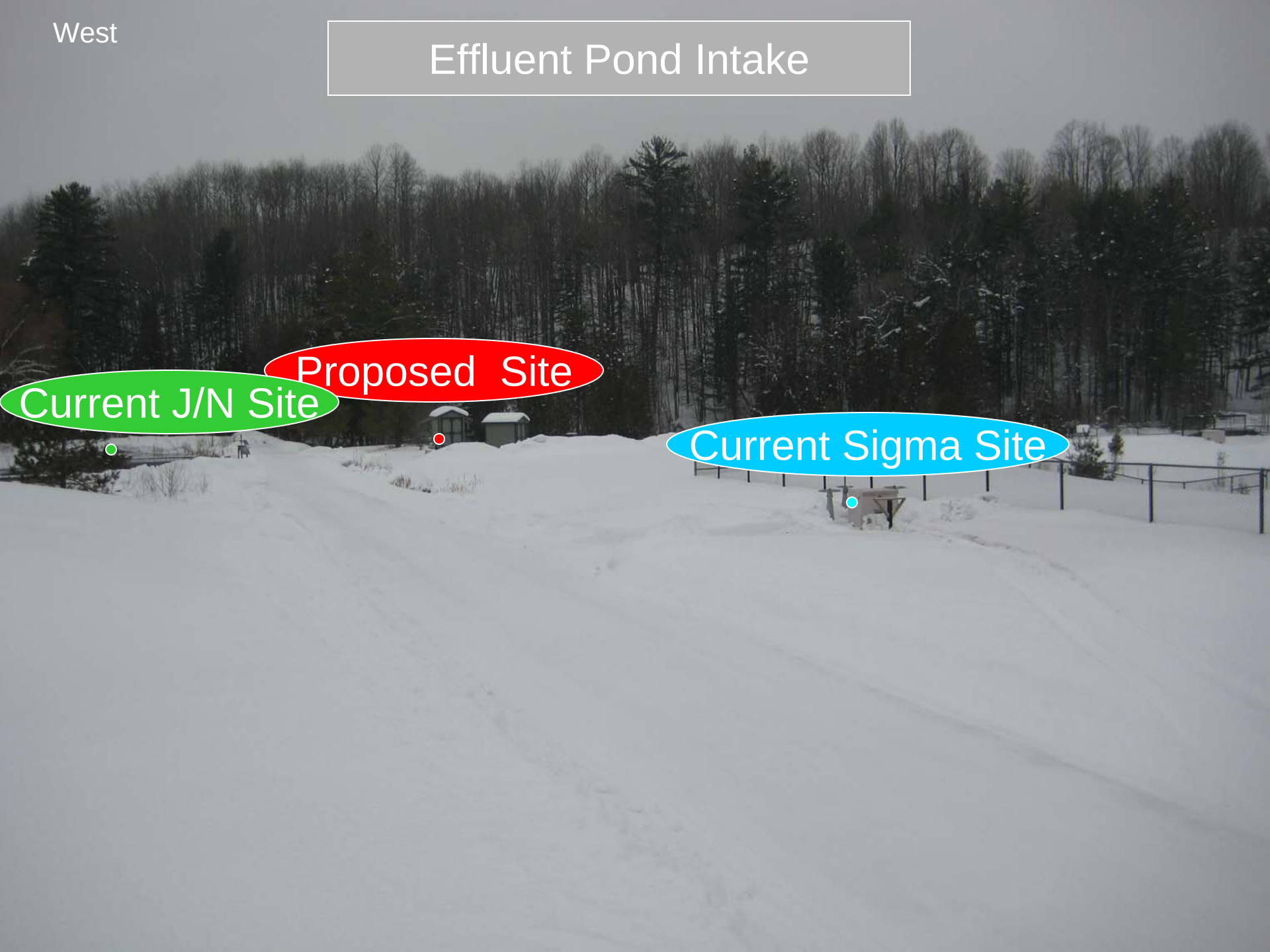
- The ideal location for this site and the new design is the pond bypass structure
- The chamber is turbulent and would provide an excellent location for side-by-side sampling
- Placing a building with electricity to accommodate the new design is a feasible option at this location

Effluent Pond Intake



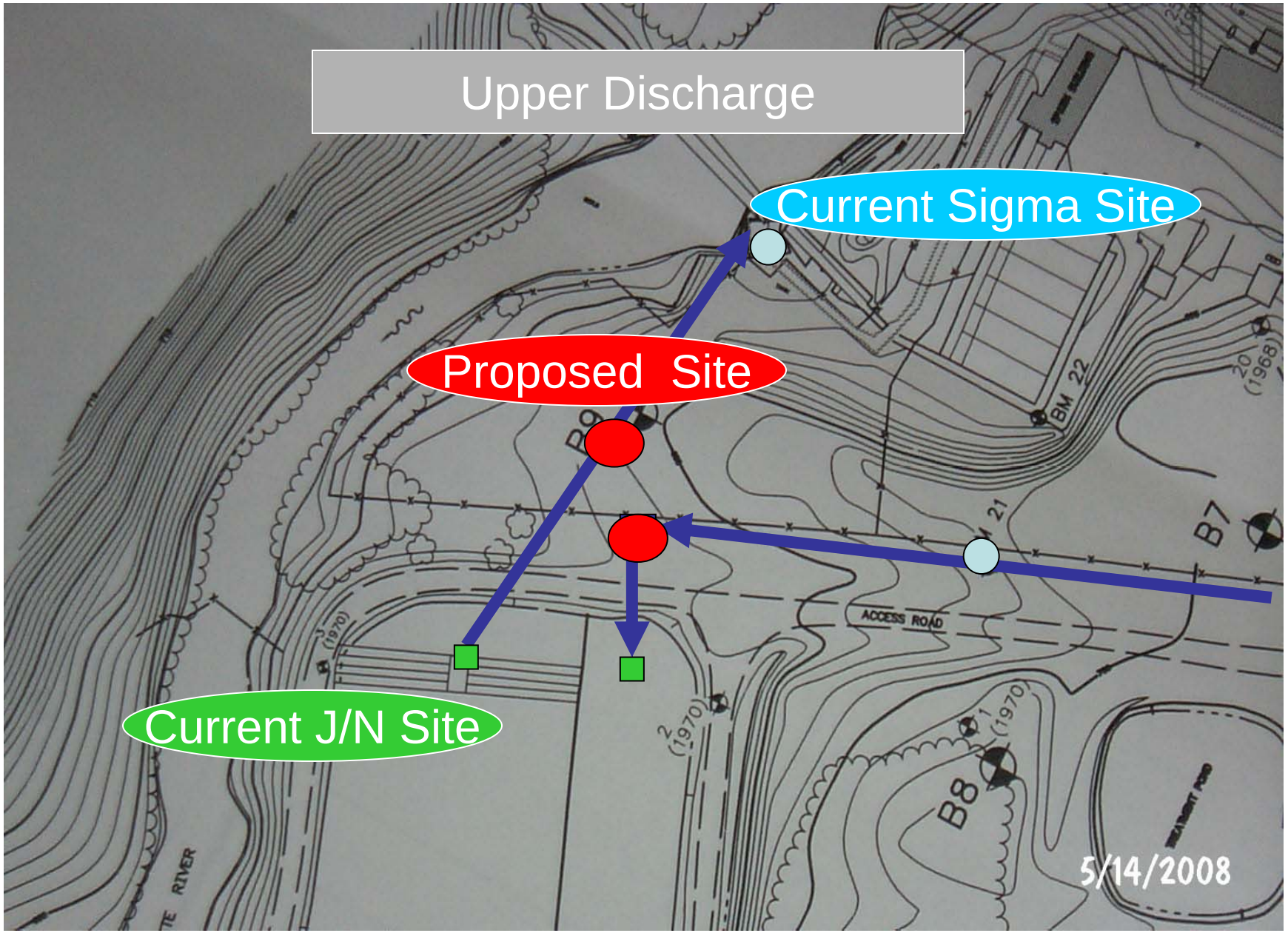
West

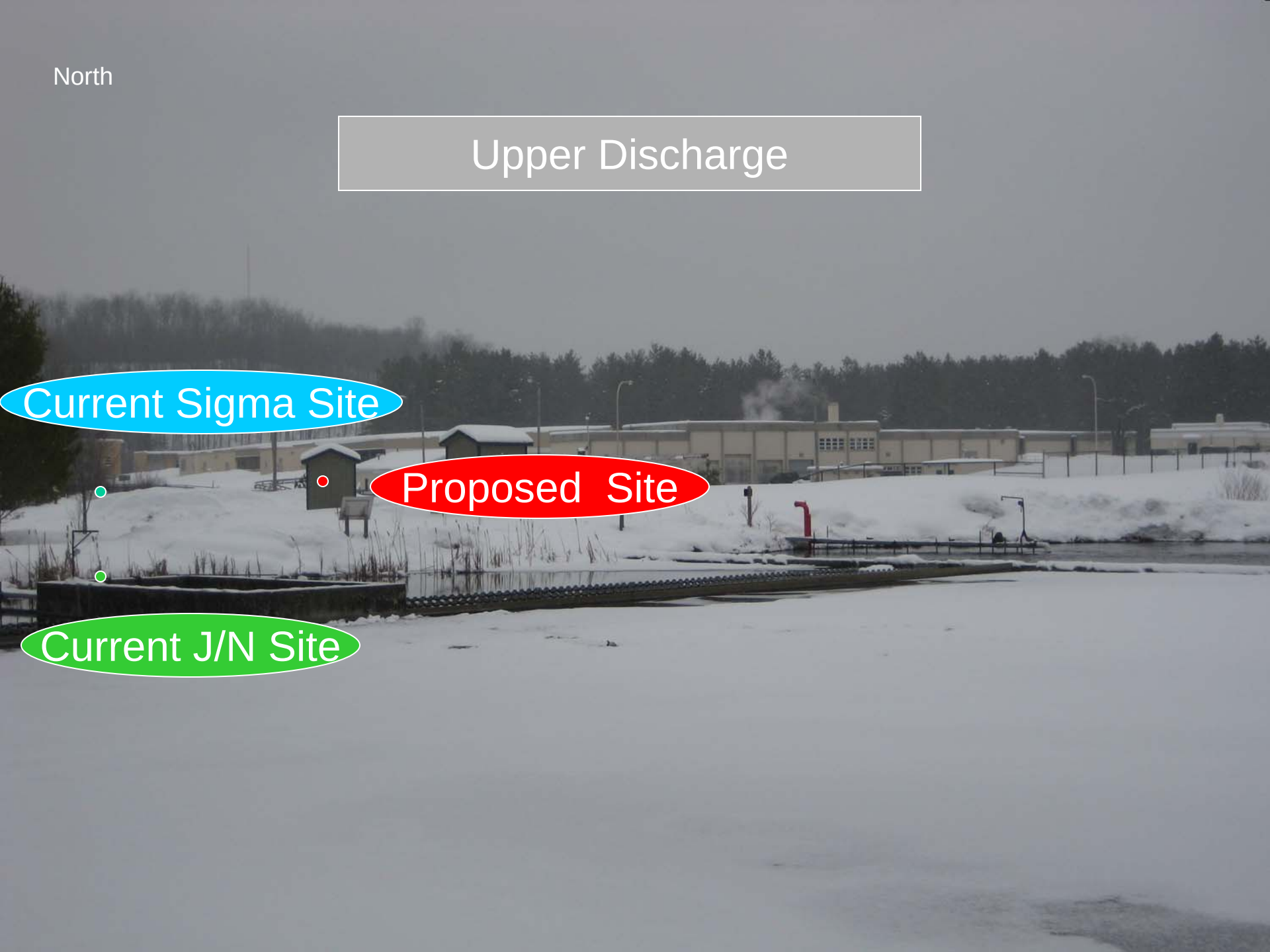
Effluent Pond Intake



Upper Discharge

- The ideal location for this site and the new design is the manhole in the line from the pond to the upper discharge
- The chamber is turbulent and would provide an excellent location for side-by-side sampling
- Placing a building with electricity to accommodate the new design is a feasible option at this location


Upper Discharge
Current Sigma Site
Proposed Site
Current J/N Site
ACCESS ROAD
B9
B8
B7
BM 22
21
5/14/2008


North
Upper Discharge
Current Sigma Site
Proposed Site
Current J/N Site

Highlights

- Side-by-side sampling at each site
- All sample sites are set up the same
- J/N fill rates easily monitored
- HDPE drum is same material as the 250ml sample bottles
- Relatively low cost modifications

APPENDIX B

JUG & NEEDLE AND SIGMA COMPARISON

Evaluation of 24 Hour Composite Water Sampling Techniques at Platte River State Fish Hatchery

Aaron Switzer
Platte River State Fish Hatchery
15210 US Hwy 31
Beulah, MI 49617

Introduction

Platte River State Fish Hatchery (PRSFH) currently monitors total phosphorus (TP) loading of all influent and effluent water sources. The monitoring is done for National Pollution Discharge Elimination System (NPDES) reporting and to comply with the Consent Judgment of 2000. The Consent Judgment is the document outlining the Court ordered settlement between PRSFH and Platte Lake Improvement Association (PLIA). The Consent Judgment specifically states, "Standard composite samples (24 hour) shall be utilized for the collection of all water samples."

For the past five years, PRSFH has collected 24 hour composite water samples twice weekly using both Sigma and Jug and Needle J/N samplers. This process allows PRSFH to examine the amount of phosphorus entering and exiting the facility over the 24 hour period. The water samples are collected using two different water sampling systems. The Sigma sampler is an automated sampling system which collects water samples at calibrated volumes, at programmed time intervals. The J/N sampler collects water samples using the slow release of air through a needle. The water samples are theoretically collected continuously over a 24 hour period.

The original method of collection is J/N sampling and was the only method of collection being used at PRSFH at the time of the Consent Judgment. The Sigma samplers are a major advancement in composite sampling technology and were installed during Phase I of a major hatchery renovation completed in 2004. The intent was to switch over from J/N samplers to Sigma samplers because running both sampling systems results in twice the expense for sample analysis. However, the data collected from the two sampling methods often showed very different results.

The objective of this study was to compare TP concentrations between samples collected using Sigma and J/N samplers. A confounding factor in making the comparison was that the two samplers were set in different physical locations at each site, yet they were assumed to be collecting samples from the "same" water. Therefore, a secondary objective of this study was to evaluate sampling locations and modify them as necessary so the samplers are indeed sampling the "same" water at a given sampling site. Another confounding factor was that the J/N samplers are known to have erratic fill rates. Therefore, shortened sampling periods were necessary to ensure that the samples being collected were actually collected during the same time periods. Once the sampling sites were modified so that they were sampling the "same" water and shortened sampling periods were applied, the TP concentrations for both sampling systems at their specific sites should be statistically equivalent.

Methods

Sampler Relocation

In the fall of 2008 PRSFH began a project to consolidate sampling sites. This effort would relocate or modify sampling sites to accommodate side-by-side sampling. All sampling sites were carefully examined to determine the best possible location. Factors considered in determining the best location included the ability to accommodate side-by-side Sigma and J/N sampling, water flow and accessibility.

The modification of these sites required a new physical sampling design for accessibility and side-by-side sampling. Each site required a common sampling vessel, an irrigation pump and a network of plumbing. All parts in the design are accessible for cleaning.

PRSFH has four sampling sites that are applicable to this project. Brundage Spring (Site 11) and Brundage Creek (Site 12) sites are influent water sources. The Effluent Pond Intake (Site 14) and Upper Discharge (Site 15) are sites related to effluent hatchery water.

Sampling Period

The sampling period for this phase of the project needed to be shortened. J/N samplers fill erratically and commonly overfill before the end of a 24 hour sampling period. Many times they fill within the first few hours. Shortened sampling periods will ensure the J/N sampler will not over fill in the allotted sampling period.

It was determined that a 1.5 hour sampling period would be ample, allowing both methods to collect enough water to analyze TP concentrations and turbidity. Sigma samplers were programmed to collect 200 ml of water every minute. If the J/N samples were overfull at the end of that time period or if they were judged to be not actively sampling, they were not used in the data analysis.

Data Collection

Water samples were analyzed for TP concentration and turbidity. TP samples were sent to Central Michigan University's Water Resources Laboratory for analysis. Turbidity readings were taken in the laboratory at PRSFH. Comparing these two parameters between the two sampling methods will determine if the samples are the same or different.

Once the data was collected it was analyzed using a linear regression. Ideally each site will yield an R^2 value of greater than 0.9 for TP concentration, indicating that water being sampled by each method is statistically equivalent.

Results

Sampler Relocation and Modification

All relocation and modification of sampling sites at PRSFH was completed in early 2009. All sampling sites now accommodate both sampling techniques, both of which sample from the same vessel. Theoretically, TP concentrations and turbidity values of samples collected in this manner should be identical.

Two 8x10 storage sheds where purchased and outfitted with electrical service to house the new sampling locations at Site 14 and 15. Other materials need for relocation and modification included irrigation pumps, galvanized pipe and connections, one inch Tygon tubing, and 55 gallon High Density Polyethylene (HDPE) drums. HDPE is the same material as the 10L carboys and 250ml sample bottles used for water sample collection.

Sites 12, 14 and 15 all employ the following set up. Water is pumped from each collection camber though a 14 foot piece of 1.5 inch galvanized pipe to a one horsepower irrigation pump. That pump connects to a 2 foot section of 1.5 inch Tygon tubing which is connected to galvanized pipe which directs the water flow straight to the bottom of the drum, thereby forcing the water to up-well through the drum and exit through an overflow spout at the top of the drum (Figure 1). This up-welling flow avoids the possibility that solids will settle out in the drum and not be captured in the samples. All parts are removable and the drums are drainable for weekly cleaning (Figure 2).

The following details changes at each sampling location (please refer to the J/N and Sigma Relocation Project section of the 2008 Annual Report for detailed photos and figures):

- Site 11 - The Brundage Spring sampling area required no relocation and very little modification. The site is located in the Mechanical Room in the Hatchery Building. There is a three inch valved line coming off of the main Spring Water line. The line empties into a 55 gallon HDPE drum with an overflow spout. The set up provides constant flow though the drum. This site layout provided the concept for the design at the other sampling sites. Side by side sampling began December 17, 2008.
- Site 12 - The Brundage Creek sampling location was relocated to the Pump House, near the original Sigma site. Creek water is easily accessed in the pump collection chamber. This location was chosen for excellent water flow and accessibility. Side by side sampling began December 17, 2008.
- Site 14 - The Effluent Pond Intake sampling location was relocated to the pond bypass structure. The relocated site is between the original J/N site and the original Sigma site. This site was moved because the original J/N site lacked electricity and the chamber at the original Sigma site was fairly stagnant. The pond bypass structure chamber is turbulent and provides an excellent location for the new storage shed. Side by side sampling began January 27, 2009.
- Site 15 - The Upper Discharge sampling location was relocated to a manhole in the line from the pond to the upper discharge. The relocated site is between the original J/N site and the original Sigma site. The original J/N site lacked

electricity and the new storage shed would block weir viewing area at the original Sigma site. The manhole in the discharge line is turbulent and provides an excellent location for the new storage shed. Side by side sampling began January 27, 2009.

Comparison

The site relocation and modification phase provided locations that allowed J/N and Sigma sampling to occur side-by-side at each sampling site. The water is forced into the bottom of the drum at a minimum of 5 gallons per minute and up-wells through the drum. That flow rate equals approximately 5.5 exchanges per hour, providing adequate flow for water sampling.

The drum houses the J/N sampler and the intake tubing for the Sigma sampler. The water intakes for both methods of sampling are within six inches of one another. The water collected and analyzed should essentially be the same.

Sampling Period

A 1.5 hour sampling period was used during this phase of the project. Shortening the sample period and the side-by-side sampling set-up provided an opportunity to carefully monitor fill rates for both sampling methods.

Sigma samplers at all sites collected and filled in the appropriate time frame. J/N samplers collected and filled in the 1.5 hour sampling period 68% of the time. Twenty percent of the time they were overfull and 12% of the time they were partially full and not sampling.

Data Collection

Samples were collected twice weekly at the 1.5 hour interval during the study period. Data collected from any J/N samples that were overfull or not sampling at the time of collected were marked. These marked samples were not used for comparison or data analysis.

Samples were collected twice weekly at Site 11 and 12 for twelve weeks and at Sites 14 and 15 for nine weeks. Sites 14 and 15 were not completed when this phase began.

The following summarizes data collected at each site:

- Site 11 had a total of 24 sampling periods; fifteen of which were usable samples. The J/N samplers were overfull a total of nine times, rendering these samples unusable for this study. Linear regression analysis of data was performed forcing the line of best fit through zero. The results from the fifteen usable samples yielded an $R^2 = 0.92$ and Slope = 0.96 (Figure 3). That is to say, 92% of the total variance in J/N and Sigma TP concentration data can be accounted for by the linear regression. Turbidity comparison yielded an $R^2 = 0.79$ and Slope = 1.02.
- Site 12 had a total of 24 sampling periods; eighteen of which were usable samples. The J/N samplers were overfull a total of four times and not sampling twice, rendering these samples unusable for this study. Linear regression analysis of data was performed forcing the line of best fit

through zero. The results from the eighteen usable samples yielded an R^2 = 0.92 and Slope = 0.96 (Figure 4). That is to say, 92% of the total variance in J/N and Sigma TP concentration data can be accounted for by the linear regression. Turbidity comparison yielded an R^2 = 0.87 and Slope = 1.04.

- Site 14 had a total of eighteen sampling periods; ten of which were usable samples. The J/N samplers were overfull a total of three times and not sampling five times, rendering these samples unusable for this study. Linear regression analysis of data was performed forcing the line of best fit through zero. The results from the ten usable samples yielded an R^2 = 0.91 and Slope = 0.99 (Figure 5). That is to say, 91% of the total variance in J/N and Sigma TP concentration data can be accounted for by the linear regression. Turbidity comparison yielded an R^2 = 0.56 and Slope = 0.97.
- Site 15 had a total of eighteen sampling periods; fourteen of which were usable samples. The J/N samplers were overfull once and were not sampling a total of three times, rendering these samples unusable for this study. Linear regression analysis of data was performed forcing the line of best fit through zero. The results from the fourteen usable samples yielded an R^2 = 0.92 and Slope = 0.96 (Figure 6). That is to say, 92% of the total variance in J/N and Sigma TP concentration data can be accounted for by the linear regression. Turbidity comparison yielded an R^2 = 0.95 and Slope = 0.95.

All sites have R^2 values of greater than 0.9 for TP concentrations and slopes within 4% of one. The turbidity data R^2 values were not as high as the TP concentration values; however slopes were also within 4% of one. Turbidity data from Site 14 had the highest variability, but the scatter was approximately evenly distributed about the one on one slope line.

Recommendations and Conclusions

Data from the two sampling methods have been carefully evaluated. Sampling sites were relocated, modified, and set up identically to accommodate side-by-side sampling. Samples were collected and monitored over shortened sampling time periods. The results from this project clearly indicate that when J/N sampler and the Sigma sampler are collecting similar water samples, similar results will be obtained for TP and turbidity at all sampling sites.

Because of the erratic nature of J/N samplers and the automated sampling of the technologically advanced Sigma samplers, Sigma sampling is the superior method of sampling and should be employed by PRSFH. It is recommended that PRSFH drop J/N sampling. J/N sampling should only be used as a back up method of sampling in the future. Switching to Sigma sampling provides two significant benefits:

1. The total number of TP samples is cut in half, resulting in significant costing savings to the sampling budget, and
2. Samples will be collected over a true 24 hour sampling period.

All members of the Consent Judgment Implementation Team agreed, beginning July 1st 2009 PRSFH made the transition to sampling with Sigma samplers. The 2009 TP data collected prior to July 1st with the J/N sampler will be interpolated to meet the Sigma data collected in the future.

Figure 1. – A schematic of the barrel set up used for site consolidation.

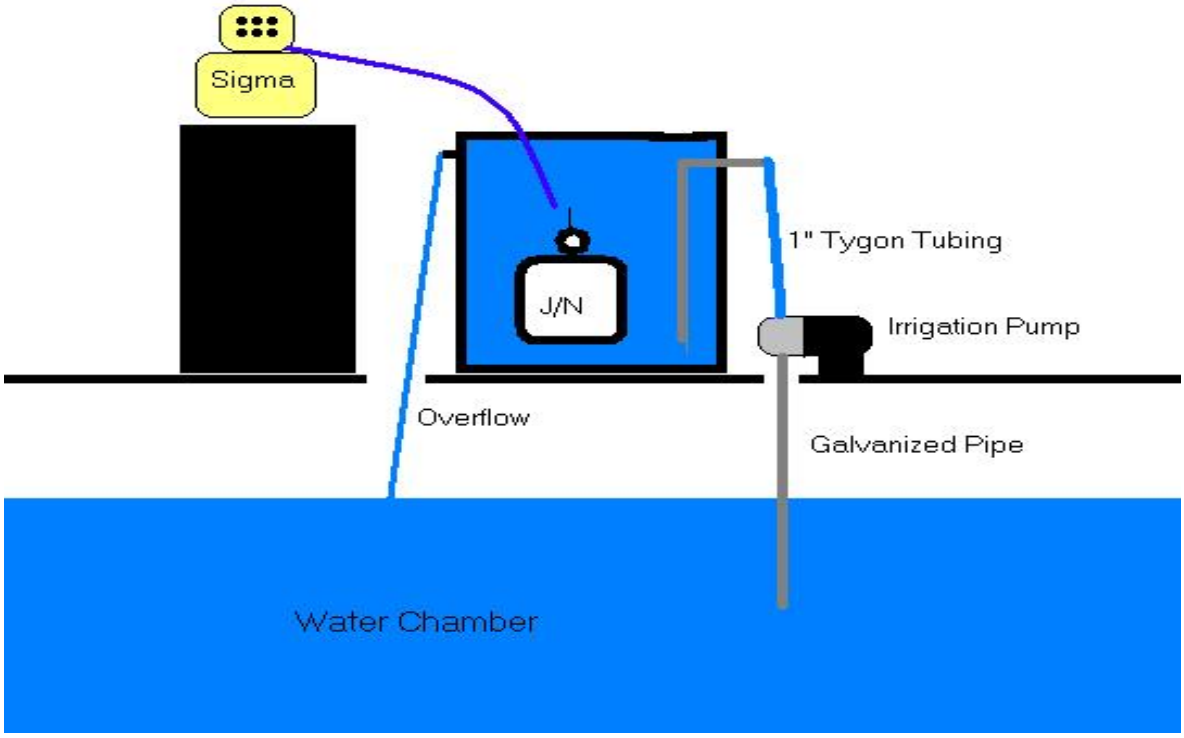


Figure 2. – All points access for weekly cleaning.

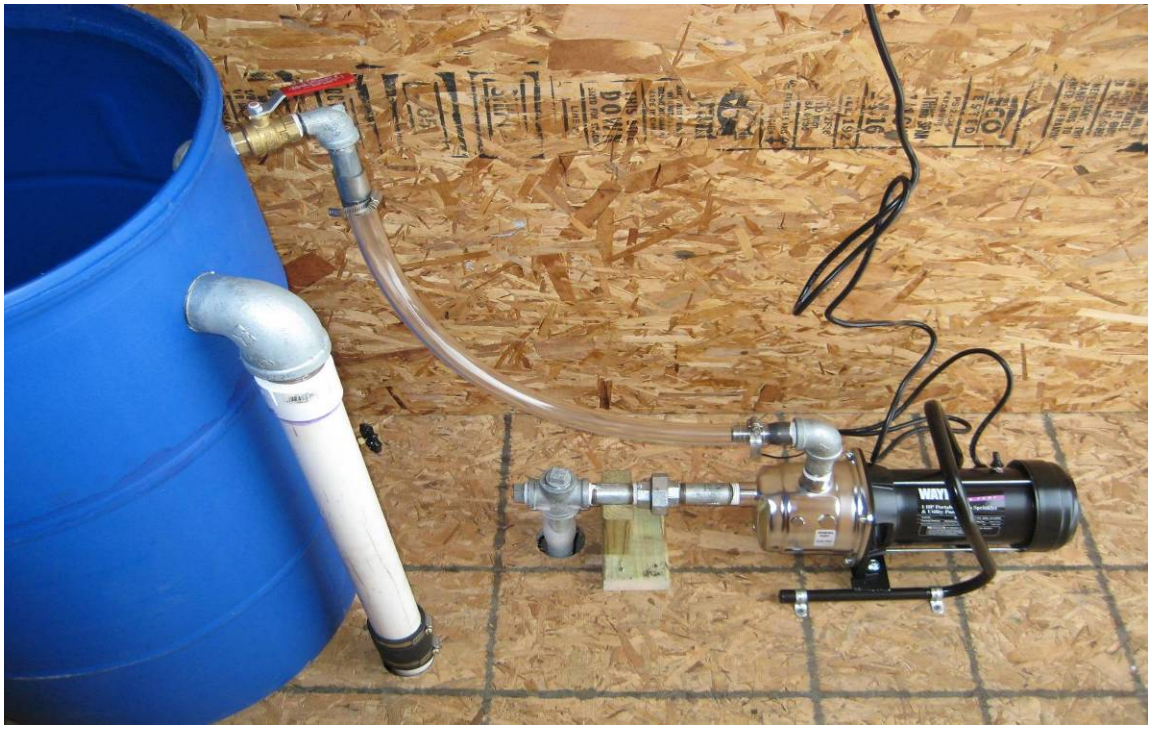


Figure 3. – Linear regression analysis of Site 11 data collected during this study.

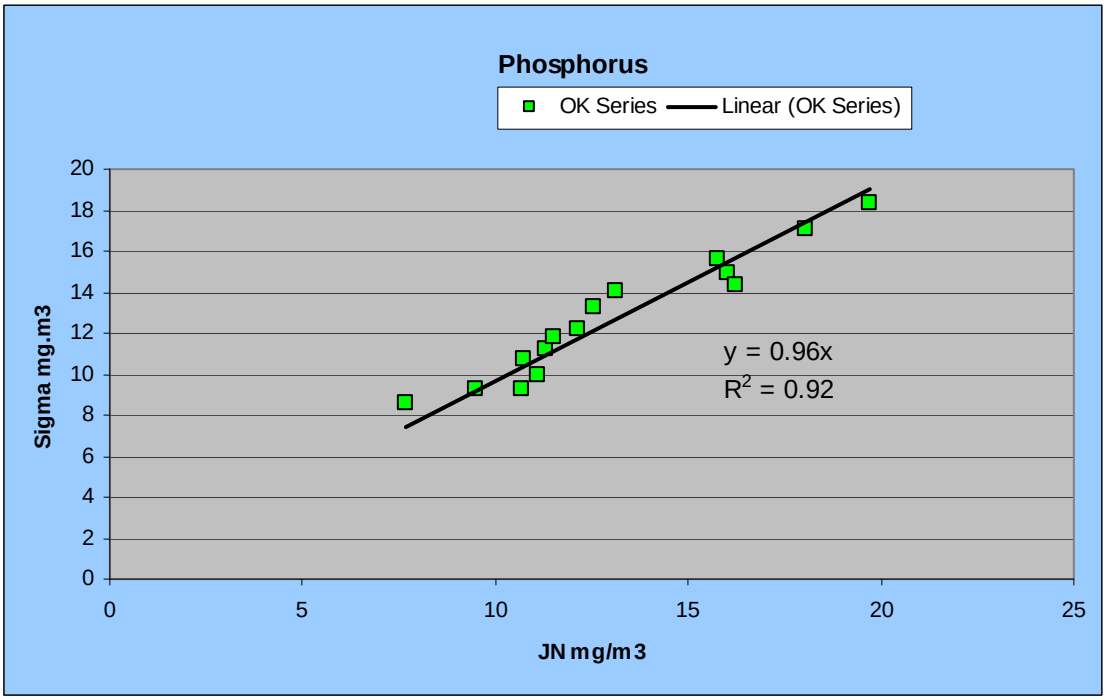


Figure 4. – Linear regression analysis of Site 12 data collected during this study.

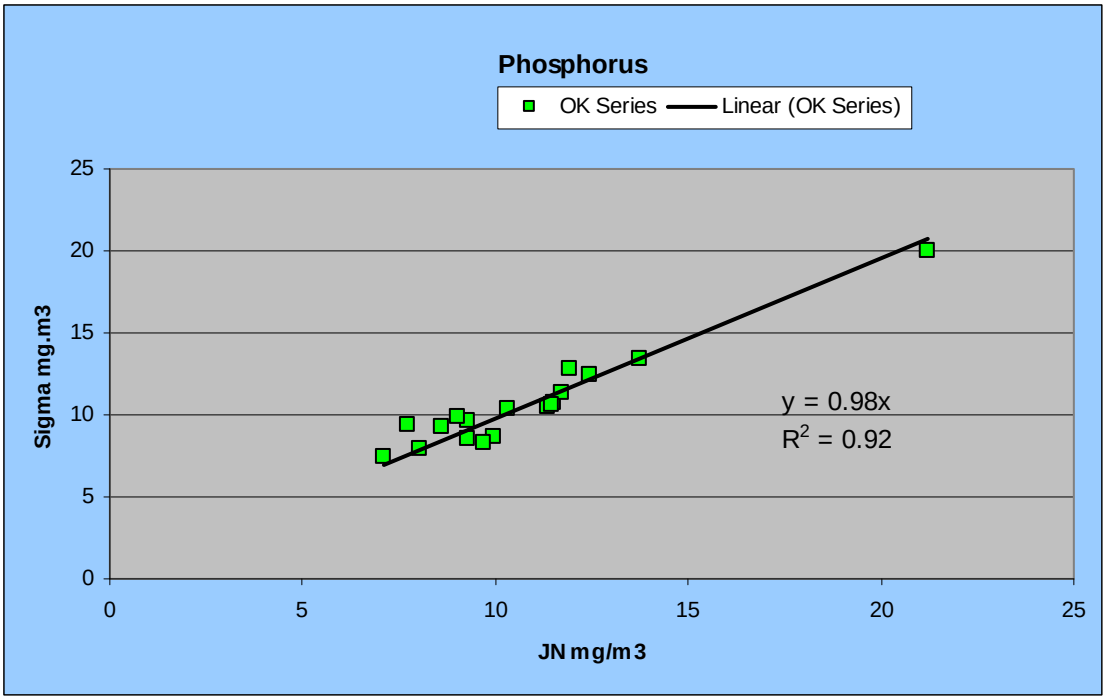


Figure 5. – Linear regression analysis of Site 14 data collected during this study.

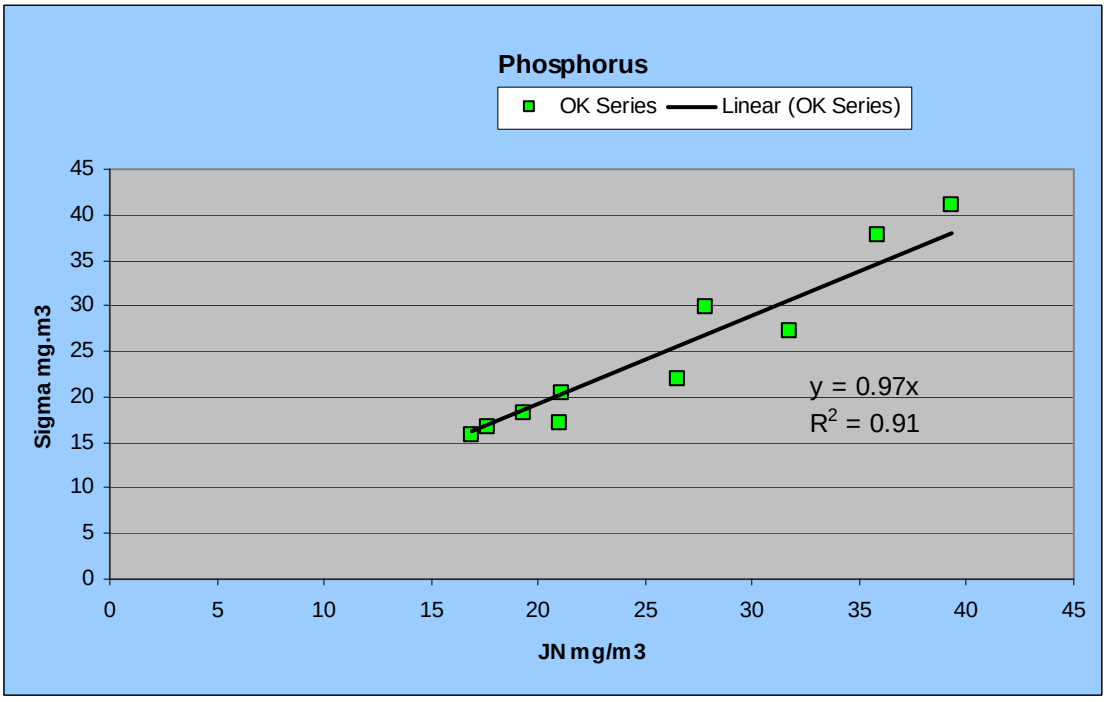
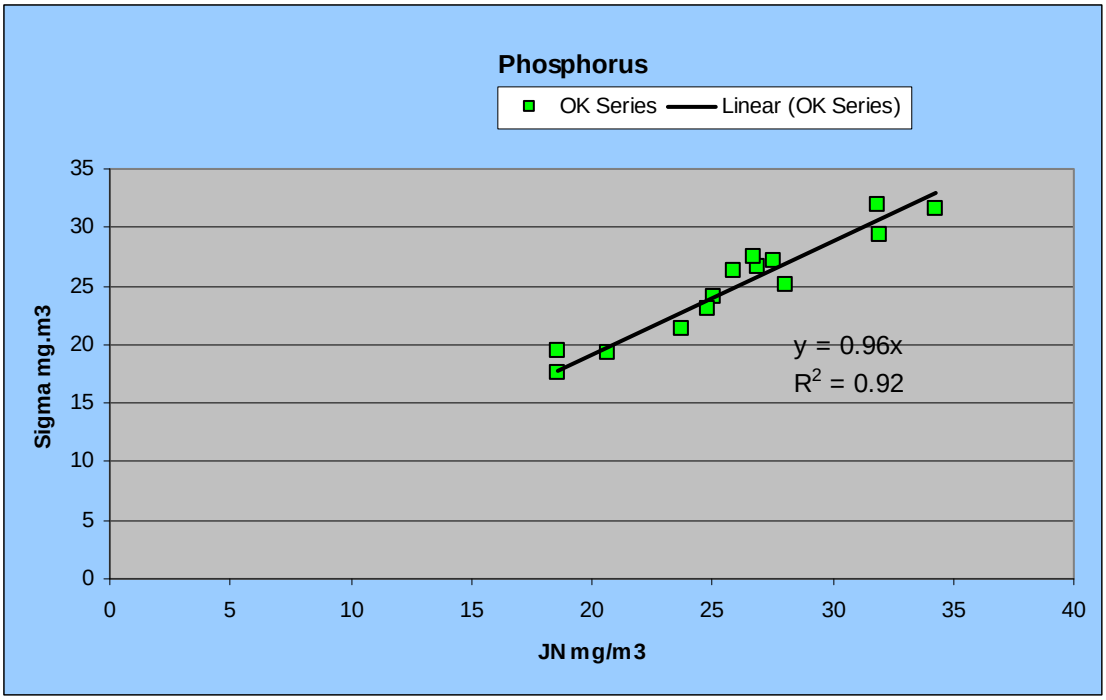


Figure 6. – Linear regression analysis of Site 15 data collected during this study.



APPENDIX D

HATCHERY LOADING CALCULATIONS FOR 2008

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load		Interpolated Net Load	accum
12/28/2007	2.314	4.038	0.000	0.039	0.011	6.401	12.79	7.886667		18.35000038	0.4675151	0.46751511		0.467515	
12/29/2007	2.346	4.038	0.000	0.042	0.011	6.437								0.471632	
12/30/2007	2.346	4.039	0.000	0.045	0.011	6.440								0.475749	
12/31/2007	2.346	4.039	0.000	0.048	0.011	6.444								0.479865	
1/1/2008	2.346	4.040	0.000	0.051	0.011	6.448								0.483982	0.483982
1/2/2008	2.346	4.040	0.000	0.053	0.011	6.451								0.488099	0.972081
1/3/2008	2.322	4.041	0.000	0.056	0.012	6.431	10.85	8.446667		18.39666748	0.4922153	0.4922153		0.492215	1.464296
1/4/2008	1.846	4.042	0.000	0.059	0.012	5.959	13.083333	9.316667		17.33666611	0.3463116	0.34631158		0.346312	1.810607
1/5/2008	1.846	4.042	0.000	0.032	0.012	5.933								0.259734	2.070341
1/6/2008	1.846	4.043	0.000	0.048	0.010	5.948								0.173156	2.243497
1/7/2008	1.846	4.043	0.000	0.069	0.010	5.969								0.086578	2.330075
1/8/2008	1.856	4.044	0.000	0.069	0.011	5.980	14.11	35.69667		25.21666718	-0.1647484	0	*	0	2.330075
1/9/2008	1.867	4.045	0.000	0.056	0.015	5.982	14.273334	16.64333		26.49333382	0.5384849	0.53848494		0.538485	2.86856
1/10/2008	1.878	4.045	0.000	0.049	0.015	5.986								0.544612	3.413171
1/11/2008	1.870	4.046	0.000	0.042	0.015	5.973								0.550739	3.96391
1/12/2008	1.867	4.046	0.000	0.036	0.015	5.964								0.556865	4.520775
1/13/2008	1.867	4.047	0.000	0.036	0.015	5.964								0.562992	5.083768
1/14/2008	1.867	4.047	0.000	0.043	0.015	5.972								0.569119	5.652887
1/15/2008	1.876	4.048	0.000	0.032	0.015	5.971	11.733334	9.216666		21.47999954	0.5752458	0.57524583		0.575246	6.228132
1/16/2008	1.878	4.049	0.000	0.022	0.015	5.964								0.608481	6.836613
1/17/2008	1.876	4.049	0.000	0.030	0.015	5.971	10.44	9.48		22.58666611	0.6417158	0.64171583		0.641716	7.478329
1/18/2008	1.871	4.050	0.000	0.077	0.015	6.013								0.620845	8.099174
1/19/2008	1.871	4.050	0.000	0.091	0.014	6.026								0.599975	8.699149
1/20/2008	1.871	4.051	0.000	0.090	0.014	6.026								0.579104	9.278254
1/21/2008	1.871	4.052	0.000	0.090	0.014	6.027								0.558234	9.836488
1/22/2008	1.872	4.052	0.000	0.068	0.014	6.006								0.537363	10.37385
1/23/2008	1.941	4.053	0.000	0.040	0.015	6.048	11.74	8.47		19.67666626	0.5164929	0.51649289		0.516493	10.89034
1/24/2008	1.891	4.053	0.000	0.035	0.014	5.993								0.524897	11.41524
1/25/2008	1.900	4.054	0.000	0.034	0.015	6.002	12.133333	8.35		20.12666702	0.5333012	0.53330121		0.533301	11.94854
1/26/2008	1.894	4.054	0.000	0.034	0.015	5.997								0.588071	12.53661
1/27/2008	1.894	4.055	0.000	0.031	0.015	5.995								0.642841	13.17945
1/28/2008	1.894	4.056	0.000	0.032	0.015	5.996								0.697612	13.87707
1/29/2008	1.897	4.056	0.000	0.044	0.015	6.012	10.9	14.17667		28	0.7523818	0.75238178		0.752382	14.62945
1/30/2008	1.896	4.057	0.000	0.055	0.014	6.022								0.662715	15.29216
1/31/2008	1.831	4.057	0.000	0.041	0.014	5.944	7.2066665	6.97		18.53000069	0.5730482	0.57304817		0.573048	15.86521
2/1/2008	1.957	4.058	0.000	0.040	0.014	6.070								0.590774	16.45599
2/2/2008	1.896	4.059	0.000	0.037	0.014	6.006								0.608499	17.06448
2/3/2008	1.896	4.059	0.000	0.034	0.015	6.004								0.626225	17.69071
2/4/2008	1.896	4.060	0.000	0.037	0.014	6.007								0.64395	18.33466
2/5/2008	1.900	4.060	0.000	0.045	0.015	6.020	12.54	8.913333		23.13999939	0.6616757	0.66167568		0.661676	18.99633
2/6/2008	1.887	4.061	0.000	0.053	0.014	6.015								0.573717	19.57005
2/7/2008	1.892	4.061	0.000	0.054	0.014	6.022	20.176666	9.926666		22.70000076	0.4857589	0.48575888		0.485759	20.05581
2/8/2008	1.863	4.062	0.000	0.044	0.014	5.983								0.449127	20.50494
2/9/2008	1.863	4.063	0.000	0.044	0.014	5.984								0.412495	20.91743
2/10/2008	1.863	4.063	10.339	0.044	0.014	16.323								0.375863	21.2933
2/11/2008	1.863	4.064	17.758	0.044	0.014	23.743								0.339232	21.63253
2/12/2008	1.863	4.064	11.770	0.044	0.014	17.756	16.096666	16.05667	11.44	14.98999977	0.3025997	0.30259972		0.3026	21.93513
2/13/2008	1.886	4.065	11.770	0.044	0.014	17.780								0.357665	22.29279
2/14/2008	2.346	4.066	11.770	0.044	0.014	18.240								0.412729	22.70552
2/15/2008	2.553	4.066	5.149	0.044	0.014	11.827	19.129999	9.55	11.44	17.13333321	0.4677941	0.46779411		0.467794	23.17332
2/16/2008	2.324	4.067	0.000	0.044	0.014	6.449								0.523891	23.69721
2/17/2008	2.324	4.067	0.000	0.044	0.014	6.449								0.579988	24.2772
2/18/2008	2.324	4.068	0.000	0.044	0.014	6.450								0.636085	24.91328
2/19/2008	2.324	4.068	0.000	0.044	0.014	6.451								0.692182	25.60546
2/20/2008	2.313	4.069	0.000	0.044	0.014	6.441	14.113334	8.89		24.60666656	0.748279	0.74827895		0.748279	26.35374
2/21/2008	2.306	4.070	0.000	0.044	0.014	6.434								0.606325	26.96007
2/22/2008	2.306	4.070	0.000	0.044	0.014	6.435	13.366667	9.553333		19.47999954	0.4643718	0.46437181		0.464372	27.42444
2/23/2008	2.273	4.071	0.000	0.044	0.015	6.402								0.530534	27.95497
2/24/2008	2.273	4.071	0.000	0.041	0.014	6.400								0.596696	28.55167
2/25/2008	2.272	4.072	0.000	0.053	0.015	6.412								0.662858	29.21453
2/26/2008	2.268	4.073	0.000	0.060	0.016	6.417	16.793333	9.326667		25.46999931	0.7290199	0.7290199		0.72902	29.94355
2/27/2008	2.264	4.073	0.000	0.050	0.015	6.401								0.647352	30.5909
2/28/2008	2.254	4.074	0.000	0.045	0.015	6.387								0.565685	31.15658
2/29/2008	2.257	4.074	0.000	0.051	0.015	6.397	14.81	8.77		19.87666702	0.4840173	0.48401729		0.484017	31.6406
3/1/2008	2.254	4.075	0.000	0.049	0.014	6.392								0.46493	32.10553
3/2/2008	2.254	4.075	0.000	0.044	0.014	6.387								0.445844	32.55137
3/3/2008	2.254	4.076	0.000	0.072	0.014	6.416								0.426757	32.97813
3/4/2008	2.244	4.077	0.000	0.058	0.014	6.393	14.16	18.09667		24.14999962	0.4076698	0.40766983		0.40767	33.3858

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load	Interpolated Net Load	accum
3/5/2008	2.243	4.077	0.000	0.053	0.014	6.387							0.525838	33.91164
3/6/2008	2.246	4.078	0.000	0.057	0.014	6.395	13.43	8.493333		22.20000076	0.6440072	0.64400717	0.644007	34.55565
3/7/2008	2.236	4.078	0.000	0.059	0.014	6.388							0.564241	35.11989
3/8/2008	2.198	4.079	0.000	0.062	0.014	6.353							0.484475	35.60436
3/9/2008	2.198	4.080	0.000	0.066	0.014	6.357							0.404708	36.00907
3/10/2008	2.198	4.080	0.000	0.069	0.014	6.361							0.324942	36.33401
3/11/2008	2.226	4.081	0.000	0.072	0.014	6.393	21.746666	10.47667		18.85499954	0.2451759	0.2451759	0.245176	36.57919
3/12/2008	2.219	4.081	0.000	0.076	0.014	6.390							0.4854	37.06459
3/13/2008	2.219	4.082	0.000	0.079	0.014	6.394	25.389999	8.99		28.14999962	0.7256242	0.72562417	0.725624	37.79021
3/14/2008	2.217	4.082	0.000	0.082	0.014	6.396							0.737171	38.52738
3/15/2008	2.210	4.083	0.000	0.068	0.013	6.374							0.748719	39.2761
3/16/2008	2.210	4.084	0.000	0.069	0.013	6.376							0.760266	40.03637
3/17/2008	2.210	4.084	0.000	0.067	0.013	6.374							0.771813	40.80818
3/18/2008	2.213	4.085	0.000	0.071	0.014	6.383	18.883333	9.783334		27.51333427	0.78336	0.78336005	0.78336	41.59154
3/19/2008	2.197	4.085	0.000	0.075	0.013	6.370							0.958733	42.55027
3/20/2008	2.197	4.086	0.000	0.083	0.014	6.380							1.134106	43.68438
3/21/2008	2.191	4.087	0.000	0.089	0.014	6.381	7.9299998	2.6		28.97999954	1.309479	1.30947899	1.309479	44.99386
3/22/2008	2.191	4.087	0.000	0.071	0.014	6.363							1.221442	46.2153
3/23/2008	2.191	4.088	0.000	0.068	0.013	6.360							1.133405	47.34871
3/24/2008	2.191	4.088	0.000	0.095	0.012	6.386							1.045368	48.39407
3/25/2008	2.228	4.089	0.000	0.123	0.010	6.450	15.456667	9.376667		29.06999969	0.9573313	0.95733133	0.957331	49.35141
3/26/2008	2.385	4.089	0.000	0.117	0.009	6.601							0.909092	50.2605
3/27/2008	2.355	4.090	0.000	0.122	0.010	6.577							0.860853	51.12135
3/28/2008	2.353	4.091	0.000	0.122	0.011	6.576	11.79	10.24667		25.39999962	0.8126142	0.81261417	0.812614	51.93397
3/29/2008	2.324	4.091	0.000	0.116	0.010	6.541							0.895075	52.82904
3/30/2008	2.324	4.092	0.000	0.119	0.010	6.545							0.977536	53.80658
3/31/2008	2.324	4.092	0.000	0.091	0.008	6.516							1.059997	54.86657
4/1/2008	2.313	4.093	0.000	0.054	0.006	6.465	13.38	11.16667		33.02999878	1.1424584	1.14245835	1.142458	56.00903
4/2/2008	2.288	4.094	0.000	0.076	0.011	6.469							0.975377	56.98441
4/3/2008	2.498	4.094	0.000	0.069	0.013	6.674							0.808297	57.79271
4/4/2008	2.478	4.095	0.000	0.060	0.013	6.646	19.9	19.30333		30.87333298	0.6412157	0.64121574	0.641216	58.43392
4/5/2008	2.433	4.095	0.000	0.062	0.013	6.603							0.584114	59.01804
4/6/2008	2.433	4.096	0.000	0.053	0.013	6.595							0.527011	59.54505
4/7/2008	2.433	4.096	0.000	0.063	0.013	6.606							0.469909	60.01496
4/8/2008	2.419	4.097	0.000	0.075	0.012	6.603	10.953333	37.26		34.62333298	0.4128069	0.41280691	0.412807	60.42776
4/9/2008	2.417	4.098	0.000	0.086	0.012	6.613							0.443166	60.87093
4/10/2008	2.408	4.098	0.000	0.044	0.012	6.561	27.73	18.4		30.31666756	0.4735243	0.47352426	0.473524	61.34445
4/11/2008	2.388	4.099	0.000	0.000	0.000	6.487							0.537992	61.88244
4/12/2008	2.122	4.099	0.000	0.000	0.000	6.221							0.602459	62.4849
4/13/2008	2.122	4.100	0.000	0.000	0.000	6.222							0.666927	63.15183
4/14/2008	2.122	4.101	0.000	0.000	0.000	6.223							0.731394	63.88323
4/15/2008	2.107	4.101	0.000	0.000	0.000	6.208	12.22	5.74		23.29999924	0.7958616	0.79586164	0.795862	64.67909
4/16/2008	2.099	4.102	0.000	0.000	0.000	6.200							0.749091	65.42818
4/17/2008	2.066	4.102	0.000	0.000	0.000	6.169							0.70232	66.1305
4/18/2008	2.299	4.103	0.000	0.000	0.000	6.402							0.65555	66.78605
4/19/2008	2.359	4.103	0.000	0.000	0.000	6.462							0.608779	67.39483
4/20/2008	2.359	4.104	0.000	0.000	0.000	6.463							0.562009	67.95684
4/21/2008	2.359	4.105	0.000	0.000	0.000	6.464	15.453333	8.973333		20.88999939	0.5152381	0.51523814	0.515238	68.47207
4/22/2008	2.338	4.105	0.000	0.000	0.000	6.443							0.753122	69.2252
4/23/2008	2.345	4.106	0.000	0.000	0.000	6.451	6.3166666	5.01		23.89333344	0.9910051	0.9910051	0.991005	70.2162
4/24/2008	2.672	7.265	0.000	0.000	0.000	9.937							0.884807	71.10101
4/25/2008	2.686	8.470	0.000	0.000	0.000	11.157	14.233334	6.186666		16.48666573	0.7786092	0.77860924	0.778609	71.87962
4/26/2008	2.471	8.471	0.000	0.000	0.000	10.941							0.836231	72.71585
4/27/2008	2.471	8.471	0.000	0.000	0.000	10.942							0.893853	73.6097
4/28/2008	2.471	8.471	0.000	0.000	0.000	10.942							0.951475	74.56118
4/29/2008	2.455	8.471	0.000	0.000	0.000	10.926							1.009097	75.57027
4/30/2008	2.437	8.471	0.000	0.000	0.000	10.908	17.083334	7.48		21.3433342	1.066719	1.06671898	1.066719	76.63699
5/1/2008	2.425	8.472	0.000	0.000	0.000	10.897							0.724538	77.36153
5/2/2008	2.427	8.472	0.000	0.000	0.000	10.898	11.653334	8.946667		13.75333309	0.3823561	0.38235609	0.382356	77.74389
5/3/2008	2.414	8.472	0.000	0.000	0.000	10.886							0.508598	78.25248
5/4/2008	2.414	8.472	0.000	0.000	0.000	10.886							0.63484	78.88733
5/5/2008	2.414	8.472	0.000	0.000	0.000	10.886							0.761082	79.64841
5/6/2008	2.403	8.472	0.000	0.000	0.000	10.875							0.887325	80.53573
5/7/2008	2.396	8.473	0.000	0.000	0.000	10.869	9.7433329	7.57		19.22333336	1.0135667	1.01356675	1.013567	81.5493
5/8/2008	2.376	8.473	0.000	0.000	0.000	10.848							0.759303	82.3086
5/9/2008	2.375	8.473	0.000	0.000	0.000	10.848	9.8366671	8.11		14.0666666	0.5050394	0.50503945	0.505039	82.81364
5/10/2008	2.379	8.473	0.000	0.000	0.000	10.852							0.521915	83.33556
5/11/2008	2.379	8.473	0.000	0.000	0.000	10.852							0.538791	83.87435

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load		Interpolated Net Load	accum
5/12/2008	2.379	8.474	0.000	0.000	0.000	10.852								0.555666	84.43001
5/13/2008	2.381	6.281	0.000	0.000	0.000	8.662	7.8333335	6.463333		14.76000023	0.5725419	0.57254193		0.572542	85.00256
5/14/2008	2.367	4.118	0.000	0.000	0.000	6.485								0.384228	85.38678
5/15/2008	2.393	1.974	0.000	0.000	0.000	4.366								0.195915	85.5827
5/16/2008	2.817	0.000	0.000	0.000	0.000	2.817	13.223333	4.74		13.5466671	0.0076009	0.00760092		0.007601	85.5903
5/17/2008	2.785	0.000	0.000	0.000	0.000	2.785								0.041741	85.63204
5/18/2008	2.785	0.000	0.000	0.000	0.000	2.785								0.075881	85.70792
5/19/2008	2.785	0.000	0.000	0.000	0.000	2.785								0.110021	85.81794
5/20/2008	2.779	0.000	0.000	0.000	0.000	2.779	10.266666	7.003334		16.48333359	0.1441608	0.14416076		0.144161	85.9621
5/21/2008	2.770	0.000	0.000	0.000	0.000	2.770								0.073814	86.03592
5/22/2008	2.770	0.000	0.000	0.000	0.000	2.770	14.976666	6.16		15.12666702	0.0034677	0.00346771		0.003468	86.03938
5/23/2008	2.770	0.000	0.000	0.000	0.000	2.770								0.058535	86.09792
5/24/2008	2.405	0.000	0.000	0.000	0.000	2.405								0.113603	86.21152
5/25/2008	2.405	0.000	0.000	0.000	0.000	2.405								0.168671	86.38019
5/26/2008	2.405	0.000	0.000	0.000	0.000	2.405								0.223738	86.60393
5/27/2008	2.405	0.000	0.000	0.000	0.000	2.405	9.7233334	6.35		23.61333275	0.2788062	0.27880615		0.278806	86.88274
5/28/2008	2.361	0.000	0.000	0.000	0.000	2.361								0.217212	87.09995
5/29/2008	2.373	0.000	0.000	0.000	0.000	2.373								0.155618	87.25557
5/30/2008	2.350	0.000	0.000	0.000	0.000	2.350	12.453333	5.945		17.24666595	0.0940235	0.09402348		0.094023	87.34959
5/31/2008	2.329	0.000	0.000	0.000	0.000	2.329								0.109316	87.45891
6/1/2008	2.329	0.000	0.000	0.000	0.000	2.329								0.124608	87.58351
6/2/2008	2.330	0.000	0.000	0.000	0.000	2.330								0.1399	87.72341
6/3/2008	2.333	0.000	0.000	0.000	0.000	2.333	13.22	7.23		21.19000053	0.1551921	0.15519211		0.155192	87.87861
6/4/2008	2.333	0.000	0.000	0.000	0.000	2.333								0.198841	88.07745
6/5/2008	2.325	0.000	0.000	0.000	0.000	2.325	10.946667	7.373333		23.44333267	0.24249	0.24249002		0.24249	88.31994
6/6/2008	2.324	0.000	0.000	0.000	0.000	2.324								0.209941	88.52988
6/7/2008	2.312	0.000	0.000	0.000	0.000	2.312								0.177391	88.70727
6/8/2008	2.312	0.000	0.000	0.000	0.000	2.312								0.144842	88.85211
6/9/2008	2.312	0.000	0.000	0.000	0.000	2.312								0.112293	88.9644
6/10/2008	2.310	0.000	0.000	0.000	0.000	2.310	20.65	17.24		24.78666687	0.0797433	0.07974326		0.079743	89.04415
6/11/2008	2.317	0.000	0.000	0.000	0.000	2.317								0.13817	89.18232
6/12/2008	2.763	0.000	0.000	0.000	0.000	2.763								0.196597	89.37892
6/13/2008	2.763	0.000	0.000	0.000	0.000	2.763	11.12	18.22333		22.18000031	0.2550242	0.25502416		0.255024	89.63394
6/14/2008	2.747	0.000	0.000	0.000	0.000	2.747								0.298691	89.93263
6/15/2008	2.747	0.000	0.000	0.000	0.000	2.747								0.342358	90.27499
6/16/2008	2.747	0.000	0.000	0.000	0.000	2.747								0.386025	90.66101
6/17/2008	2.745	0.000	0.000	0.000	0.000	2.745	10.31	10.01333		29.06666756	0.4296926	0.4296926		0.429693	91.09071
6/18/2008	2.743	0.000	0.000	0.000	0.000	2.743								0.337812	91.42852
6/19/2008	2.760	0.000	0.000	0.000	0.000	2.760	9.5200005	11.37333		20.19666672	0.2459318	0.24593182		0.245932	91.67445
6/20/2008	2.752	0.000	0.000	0.000	0.000	2.752								0.206802	91.88125
6/21/2008	2.749	0.000	0.000	0.000	0.000	2.749								0.167673	92.04893
6/22/2008	2.749	0.000	0.000	0.000	0.000	2.749								0.128543	92.17747
6/23/2008	2.750	0.000	0.000	0.000	0.000	2.750	12.836667	0		16.73333359	0.0894136	0.08941357		0.089414	92.26688
6/24/2008	2.745	0.000	0.000	0.000	0.000	2.745								0.169144	92.43603
6/25/2008	2.740	0.000	0.000	0.000	0.000	2.740								0.248875	92.6849
6/26/2008	2.747	0.000	0.000	0.000	0.000	2.747	6.8666668	0		21.20000076	0.3286056	0.32860564		0.328606	93.01351
6/27/2008	2.747	0.000	0.000	0.000	0.000	2.747								0.295814	93.30932
6/28/2008	2.739	0.000	0.000	0.000	0.000	2.739								0.263022	93.57234
6/29/2008	2.740	0.000	0.000	0.000	0.000	2.740	15.2	0		25.27000046	0.2302302	0.2302302		0.23023	93.80257
6/30/2008	2.740	0.000	0.000	0.000	0.000	2.740								0.568847	94.37142
7/1/2008	2.734	2.159	0.000	0.000	0.000	4.893								0.907464	95.27889
7/2/2008	2.736	4.147	0.000	0.000	0.000	6.883	9.1850004	8.373333		30.38999939	1.2460814	1.24608137		1.246081	96.52497
7/3/2008	2.733	4.147	0.000	0.000	0.000	6.880								1.11549	97.64046
7/4/2008	2.729	4.148	0.000	0.000	0.000	6.877								0.984898	98.62535
7/5/2008	2.729	4.148	0.000	0.000	0.000	6.877								0.854306	99.47966
7/6/2008	2.729	4.149	0.000	0.000	0.000	6.878								0.723714	100.2034
7/7/2008	2.729	4.150	0.000	0.000	0.000	6.879								0.593123	100.7965
7/8/2008	2.375	4.150	0.000	0.000	0.000	6.526	9.0799999	9.02		17.53499985	0.462531	0.46253096		0.462531	101.259
7/9/2008	2.238	4.151	0.000	0.000	0.000	6.389								0.308354	101.5674
7/10/2008	2.234	4.151	0.000	0.000	0.000	6.386								0.154177	101.7216
7/11/2008	2.088	4.152	0.000	0.000	0.000	6.240	26.686666	27.16667		16.88999939	-0.5268112	0	*	0	101.7216
7/12/2008	2.039	4.152	0.000	0.000	0.000	6.191								0	101.7216
7/13/2008	2.038	4.153	0.000	0.000	0.000	6.191								0	101.7216
7/14/2008	2.038	4.154	0.000	0.000	0.000	6.192								0	101.7216
7/15/2008	2.036	4.154	0.000	0.000	0.000	6.190	32.673332	8.563334		14.15666676	-0.1206886	0	*	0	101.7216
7/16/2008	2.025	4.155	0.000	0.000	0.000	6.180								0.097629	101.8192
7/17/2008	2.000	4.155	0.000	0.000	0.000	6.156								0.195257	102.0144
7/18/2008	2.038	4.156	0.000	0.000	0.000	6.194	11.686666	9.576667		15.93666649	0.2928856	0.29288556		0.292886	102.3073

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load	Interpolated Net Load	accum
7/19/2008	2.014	4.156	0.000	0.000	0.000	6.170							0.331361	102.6387
7/20/2008	2.014	4.156	0.000	0.000	0.000	6.170							0.369837	103.0085
7/21/2008	2.014	4.649	0.000	0.000	0.000	6.663							0.408312	103.4168
7/22/2008	1.638	7.191	0.000	0.000	0.000	8.829	11.956667	7.986667		14.78666687	0.4467875	0.44678745	0.446787	103.8636
7/23/2008	1.357	7.115	0.000	0.000	0.000	8.472							0.374752	104.2384
7/24/2008	1.357	4.156	0.000	0.000	0.000	5.513	8.0299997	9.49		15.71000004	0.3027158	0.30271577	0.302716	104.5411
7/25/2008	1.081	4.156	0.000	0.000	0.000	5.237							0.298683	104.8398
7/26/2008	1.081	4.156	0.000	0.000	0.000	5.237							0.294651	105.1344
7/27/2008	1.081	4.156	0.000	0.000	0.000	5.237							0.290619	105.425
7/28/2008	1.080	4.156	0.000	0.000	0.000	5.236							0.286587	105.7116
7/29/2008	1.075	4.156	0.000	0.000	0.000	5.231	7.9333334	8.56		14.90333366	0.2825542	0.28255424	0.282554	105.9942
7/30/2008	1.078	4.156	0.000	0.000	0.000	5.234							0.274113	106.2683
7/31/2008	1.221	4.156	0.000	0.000	0.000	5.377	6.7633333	5.24		11.50666714	0.2656715	0.26567147	0.265671	106.534
8/1/2008	1.220	4.156	0.000	0.000	0.000	5.376							0.263389	106.7974
8/2/2008	0.979	4.156	0.000	0.000	0.000	5.135							0.261106	107.0585
8/3/2008	0.979	4.156	0.000	0.000	0.000	5.135							0.258823	107.3173
8/4/2008	0.979	4.156	0.000	0.000	0.000	5.135							0.25654	107.5738
8/5/2008	1.072	4.156	0.000	0.000	0.000	5.228	7.4133334	6.59		12.58666706	0.254257	0.25425698	0.254257	107.8281
8/6/2008	1.074	4.156	0.000	0.000	0.000	5.230							0.224396	108.0525
8/7/2008	1.072	4.156	0.000	0.000	0.000	5.228							0.194536	108.247
8/8/2008	1.070	4.156	0.000	0.000	0.000	5.226	6.6866665	6.453333		10.27666664	0.1646753	0.16467528	0.164675	108.4117
8/9/2008	1.069	4.156	0.000	0.000	0.000	5.225							0.19835	108.61
8/10/2008	1.069	4.156	0.000	0.000	0.000	5.225							0.232024	108.8421
8/11/2008	1.069	4.503	0.000	0.004	0.008	5.585							0.265699	109.1078
8/12/2008	1.066	4.897	0.000	0.008	0.017	5.987	6.75	4.406667		10.7966671	0.2993736	0.29937363	0.299374	109.4071
8/13/2008	1.067	4.897	0.000	0.011	0.016	5.991							0.310367	109.7175
8/14/2008	1.067	4.897	0.000	0.012	0.015	5.991							0.321361	110.0389
8/15/2008	1.066	4.897	0.000	0.011	0.017	5.991	7.9666667	5.136667		12.26333332	0.3323546	0.33235458	0.332355	110.3712
8/16/2008	1.067	4.897	0.000	0.013	0.017	5.994							0.288389	110.6596
8/17/2008	1.067	4.897	0.000	0.009	0.017	5.990							0.244424	110.904
8/18/2008	1.066	4.897	0.000	0.010	0.017	5.991							0.200458	111.1045
8/19/2008	1.067	4.897	0.000	0.012	0.017	5.993	7.4133334	8.506667		11.39999962	0.1564927	0.15649273	0.156493	111.261
8/20/2008	1.063	4.897	0.000	0.044	0.018	6.022							0.193164	111.4542
8/21/2008	1.071	4.897	0.000	0.061	0.017	6.045	9.0699997	6.546667		11.46500015	0.2298351	0.22983514	0.229835	111.684
8/22/2008	1.173	4.897	0.000	0.078	0.016	6.163							0.20499	111.889
8/23/2008	1.026	4.897	0.000	0.055	0.016	5.995							0.180144	112.0691
8/24/2008	1.026	4.897	0.000	0.022	0.017	5.962							0.155299	112.2244
8/25/2008	1.026	4.897	0.000	0.015	0.017	5.954							0.130454	112.3549
8/26/2008	1.055	4.897	0.000	0.012	0.017	5.982	7.0533333	7.663333		9.633333206	0.1056083	0.10560826	0.105608	112.4605
8/27/2008	1.014	4.897	0.000	0.052	0.018	5.982							0.154368	112.6149
8/28/2008	2.742	4.897	0.000	0.012	0.017	7.668	7.4200001	7.285		10.47999954	0.2031283	0.20312834	0.203128	112.818
8/29/2008	1.026	4.897	0.000	0.017	0.017	5.957							0.205043	113.023
8/30/2008	1.025	4.897	0.000	0.015	0.017	5.954							0.206958	113.23
8/31/2008	1.025	4.897	0.000	0.015	0.017	5.955							0.208873	113.4389
9/1/2008	1.025	4.897	0.000	0.012	0.017	5.951							0.210788	113.6496
9/2/2008	1.025	4.897	0.000	0.020	0.018	5.960							0.212703	113.8623
9/3/2008	1.025	4.897	0.000	0.023	0.017	5.962	8.1733332	9.73		13.71000004	0.2146179	0.21461789	0.214618	114.077
9/4/2008	1.025	4.897	0.000	0.026	0.017	5.965							0.261608	114.3386
9/5/2008	1.026	4.897	0.000	0.047	0.017	5.987	8.6199999	8.083333		14.26500034	0.308599	0.30859904	0.308599	114.6472
9/6/2008	1.024	4.897	0.000	0.018	0.017	5.956							0.337321	114.9845
9/7/2008	1.024	4.897	0.000	0.019	0.017	5.957							0.366042	115.3505
9/8/2008	1.024	4.897	0.000	0.030	0.018	5.969							0.394763	115.7453
9/9/2008	1.115	4.897	0.000	0.028	0.018	6.057	7.3899999	7.263333		15.60999966	0.4234849	0.42348491	0.423485	116.1688
9/10/2008	1.115	4.897	0.000	0.038	0.019	6.068							0.428934	116.5977
9/11/2008	1.122	4.897	0.000	0.037	0.019	6.074	7	7.18		15.64999962	0.4343831	0.43438307	0.434383	117.0321
9/12/2008	1.117	4.897	0.000	0.022	0.017	6.053							0.452195	117.4843
9/13/2008	1.117	4.897	0.000	0.021	0.017	6.052							0.470007	117.9543
9/14/2008	1.117	4.897	0.000	0.042	0.017	6.074							0.487819	118.4421
9/15/2008	1.117	4.897	0.000	0.031	0.017	6.062							0.505631	118.9478
9/16/2008	1.113	4.897	0.000	0.032	0.018	6.059	8.6000004	8.89		19.11666679	0.5234435	0.52344347	0.523443	119.4712
9/17/2008	1.111	4.897	0.000	0.075	0.017	6.101							0.615796	120.087
9/18/2008	1.109	4.897	0.000	0.067	0.017	6.091	9.4333334	7.65		21.79999924	0.708148	0.70814797	0.708148	120.7951
9/19/2008	1.117	4.897	0.000	0.059	0.017	6.091							0.679992	121.4751
9/20/2008	1.115	4.897	0.000	0.052	0.017	6.081							0.651836	122.127
9/21/2008	1.115	4.897	0.000	0.044	0.018	6.073							0.62368	122.7506
9/22/2008	1.115	4.897	0.000	0.036	0.018	6.065							0.595524	123.3462
9/23/2008	1.109	4.897	0.000	0.028	0.018	6.052							0.567369	123.9135
9/24/2008	1.108	4.897	0.000	0.030	0.016	6.051	9.7799997	7.633333		18.64666748	0.5392127	0.53921274	0.539213	124.4528

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load	Interpolated Net Load	accum
9/25/2008	1.112	4.897	0.000	0.026	0.017	6.052							0.520566	124.9733
9/26/2008	1.109	4.897	0.000	0.021	0.017	6.043	8.4033337	6.033333		16.38333321	0.5019189	0.50191889	0.501919	125.4752
9/27/2008	1.109	4.897	0.000	0.019	0.017	6.042							0.511296	125.9865
9/28/2008	1.109	4.897	0.000	0.017	0.017	6.041							0.520672	126.5072
9/29/2008	1.109	4.897	0.000	0.027	0.018	6.051							0.530049	127.0373
9/30/2008	1.111	4.897	0.000	0.024	0.015	6.047							0.539426	127.5767
10/1/2008	1.110	4.897	0.000	0.035	0.016	6.058							0.548803	128.1255
10/2/2008	1.663	4.897	0.000	0.108	0.015	6.683	7.0566669	6.236667		16.33499908	0.5581792	0.55817924	0.558179	128.6837
10/3/2008	1.650	4.897	0.000	0.003	0.014	6.564	7.0966668	6.816667		19.63333321	0.6991814	0.69918136	0.699181	129.3828
10/4/2008	1.627	4.897	0.000	0.002	0.014	6.539							0.628492	130.0113
10/5/2008	1.627	4.897	0.000	0.000	0.000	6.524							0.557803	130.5691
10/6/2008	1.627	4.897	0.000	0.000	0.000	6.524							0.487114	131.0563
10/7/2008	1.624	4.897	0.000	0.000	0.000	6.521	7.2566667	7.666667		15.21666622	0.4164253	0.41642527	0.416425	131.4727
10/8/2008	1.621	4.897	0.000	0.022	0.017	6.557	7.1433334	5.46		15.11666679	0.5074473	0.50744728	0.507447	131.9801
10/9/2008	1.617	4.897	0.000	0.022	0.017	6.554							0.545363	132.5255
10/10/2008	1.609	4.897	0.000	0.018	0.016	6.540							0.583279	133.1088
10/11/2008	1.613	4.897	0.000	0.012	0.017	6.540							0.621195	133.73
10/12/2008	1.613	4.897	0.000	0.011	0.017	6.538							0.659111	134.3891
10/13/2008	1.613	4.897	0.000	0.008	0.017	6.535							0.697027	135.0861
10/14/2008	1.614	4.897	0.000	0.002	0.014	6.527	11.563334	7.023334		21.62000084	0.7349433	0.73494329	0.734943	135.821
10/15/2008	1.614	4.897	0.000	0.002	0.015	6.528							0.744405	136.5655
10/16/2008	1.612	4.897	0.000	0.005	0.016	6.530							0.753866	137.3193
10/17/2008	1.611	4.897	0.000	0.005	0.016	6.529	10.44	7.583333		22.2733326	0.763328	0.76332801	0.763328	138.0826
10/18/2008	1.612	4.897	0.000	0.007	0.017	6.533							0.808261	138.8909
10/19/2008	1.612	4.897	0.000	0.006	0.017	6.532							0.853194	139.7441
10/20/2008	1.612	4.897	0.000	0.006	0.017	6.531							0.898127	140.6422
10/21/2008	1.606	4.897	0.000	0.005	0.017	6.526	6.4200001	4.903333		22.57666588	0.9430606	0.94306062	0.943061	141.5853
10/22/2008	1.609	4.897	0.000	0.005	0.017	6.528							0.859401	142.4447
10/23/2008	1.609	4.897	0.000	0.009	0.015	6.531							0.775741	143.2204
10/24/2008	1.607	4.897	0.000	0.012	0.016	6.532	6.6700001	5.1		18.15999985	0.6920819	0.69208186	0.692082	143.9125
10/25/2008	1.606	4.897	0.000	0.013	0.017	6.532							0.690673	144.6032
10/26/2008	1.606	4.897	0.000	0.011	0.017	6.531							0.689264	145.2924
10/27/2008	1.606	4.897	0.000	0.019	0.017	6.539							0.687855	145.9803
10/28/2008	1.604	4.897	0.000	0.005	0.017	6.522	6.5733333	5.646667		18.46666718	0.6864461	0.68644612	0.686446	146.6668
10/29/2008	1.602	4.897	0.000	0.007	0.016	6.521							0.649248	147.316
10/30/2008	1.600	4.897	0.000	0.024	0.018	6.539							0.612049	147.928
10/31/2008	1.609	4.897	0.000	0.011	0.017	6.534	8.25	6.106667		17.14999962	0.5748509	0.57485086	0.574851	148.5029
11/1/2008	1.624	4.897	0.000	0.004	0.015	6.540							0.569663	149.0726
11/2/2008	1.624	4.897	0.000	0.005	0.016	6.541							0.564474	149.637
11/3/2008	1.624	4.897	0.000	0.006	0.016	6.543							0.559286	150.1963
11/4/2008	1.604	4.897	0.000	0.007	0.017	6.524							0.554098	150.7504
11/5/2008	1.604	4.897	0.000	0.013	0.017	6.532	6.5533333	7.136667		17.03000069	0.5489096	0.54890961	0.54891	151.2993
11/6/2008	1.599	4.897	0.000	0.010	0.017	6.522							0.6226	151.9219
11/7/2008	1.602	4.897	0.000	0.015	0.017	6.532	6.3766665	5.413333		18.39666748	0.6962905	0.69629046	0.69629	152.6182
11/8/2008	1.598	4.897	0.000	0.008	0.016	6.519							0.66799	153.2862
11/9/2008	1.598	4.897	0.000	0.011	0.017	6.523							0.639689	153.9259
11/10/2008	1.598	4.897	0.000	0.012	0.017	6.523							0.611389	154.5373
11/11/2008	1.597	4.897	0.000	0.006	0.017	6.516							0.583088	155.1204
11/12/2008	1.597	4.897	0.000	0.011	0.017	6.521							0.554787	155.6752
11/13/2008	1.598	4.897	0.000	0.015	0.017	6.528	6.0966668	4.913333		14.84333324	0.5264866	0.5264866	0.526487	156.2016
11/14/2008	1.591	4.897	0.000	0.051	0.017	6.557	6.3266668	3.293333		15.76000023	0.6437526	0.64375259	0.643753	156.8454
11/15/2008	1.598	4.897	0.000	0.012	0.017	6.523							0.558419	157.4038
11/16/2008	1.598	4.897	0.000	0.012	0.017	6.523							0.473086	157.8769
11/17/2008	1.598	4.897	0.000	0.021	0.018	6.533							0.387752	158.2647
11/18/2008	1.605	4.897	0.000	0.018	0.017	6.538	10.65	8.386666		14.43999958	0.302419	0.30241896	0.302419	158.5671
11/19/2008	1.601	4.897	0.000	0.015	0.017	6.530							0.500995	159.0681
11/20/2008	1.592	4.897	0.000	0.013	0.017	6.519	14.483334	9.406667		23.46333313	0.6995711	0.69957105	0.699571	159.7676
11/21/2008	1.590	4.897	0.000	0.010	0.016	6.514							0.652318	160.42
11/22/2008	1.594	4.897	0.000	0.009	0.016	6.516							0.605065	161.025
11/23/2008	1.594	4.897	0.000	0.006	0.016	6.513							0.557812	161.5828
11/24/2008	1.594	4.897	0.000	0.005	0.016	6.513							0.510558	162.0934
11/25/2008	1.590	4.897	0.000	0.012	0.016	6.515	14.98	18.08		25.76666641	0.4633053	0.46330532	0.463305	162.5567
11/26/2008	1.599	4.897	0.000	0.011	0.016	6.523							0.439366	162.9961
11/27/2008	1.592	4.897	0.000	0.004	0.016	6.508							0.415427	163.4115
11/28/2008	1.592	4.897	0.000	0.007	0.016	6.512							0.391488	163.803
11/29/2008	1.592	4.897	0.000	0.008	0.016	6.513							0.367548	164.1705
11/30/2008	1.592	4.897	0.000	0.008	0.016	6.513							0.343609	164.5141
12/1/2008	1.592	4.897	0.000	0.015	0.016	6.520							0.31967	164.8338

JN SampDate	mgd Spring11	mgd Creek12	mgd River13	mgd Clarifier28	mgd Tank27	mgd DischgC15	TP mg/m3 Spring11	TP mg/m3 Creek12	TP mg/m3 River13	TP mg/m3 DischgC15	Net Load	Adjusted Net Load		Interpolated Net Load	accum
12/2/2008	1.562	4.897	0.000	0.008	0.016	6.484	8.1866665	6.896667		12.64666653	0.2957309	0.29573086		0.295731	165.1295
12/3/2008	1.629	4.897	0.000	0.012	0.016	6.554								0.342666	165.4722
12/4/2008	1.497	4.897	0.000	0.009	0.016	6.419								0.3896	165.8618
12/5/2008	1.560	4.897	0.000	0.011	0.016	6.485	10.146667	8.04		16.57999992	0.4365348	0.43653479		0.436535	166.2983
12/6/2008	1.554	4.897	0.000	0.014	0.016	6.481								0.442735	166.7411
12/7/2008	1.554	4.897	0.000	0.016	0.016	6.483								0.448936	167.19
12/8/2008	1.554	4.897	0.000	0.018	0.016	6.486								0.455136	167.6451
12/9/2008	1.552	4.897	0.000	0.021	0.016	6.485	11.853333	5.213333		15.2966671	0.4613369	0.46133693		0.461337	168.1065
12/10/2008	1.556	4.897	0.000	0.015	0.015	6.483								0.395432	168.5019
12/11/2008	1.548	4.897	0.000	0.018	0.016	6.479								0.329526	168.8314
12/12/2008	1.597	4.897	0.000	0.013	0.016	6.522		8.63		18.37999916	0.6477101	0.64771006		0.263621	169.0951
12/13/2008	1.575	4.897	0.000	0.012	0.016	6.499								0.197716	169.2928
12/14/2008	1.575	4.897	0.000	0.024	0.016	6.511								0.131811	169.4246
12/15/2008	1.575	4.897	0.000	0.081	0.015	6.567								0.065905	169.4905
12/16/2008	1.600	4.897	0.000	0.076	0.015	6.589	17.35	27.34		23.28000069	-0.0690261	0	*	0	169.4905
12/17/2008	1.585	4.897	0.000	0.066	0.015	6.564								0.016112	169.5066
12/18/2008	1.588	4.897	0.000	0.066	0.015	6.566	32.573334	9.983334		15.91333294	0.0322235	0.03222345		0.032223	169.5388
12/19/2008	1.580	4.897	0.000	0.069	0.015	6.562								0.10642	169.6453
12/20/2008	1.577	4.897	0.000	0.066	0.015	6.555								0.180617	169.8259
12/21/2008	1.577	4.897	0.000	0.065	0.015	6.554								0.254813	170.0807
12/22/2008	1.577	4.897	0.000	0.063	0.015	6.553								0.32901	170.4097
12/23/2008	1.596	4.897	0.000	0.061	0.016	6.570	13.753333	8.053333		16.69666672	0.4032067	0.40320674		0.403207	170.8129
12/24/2008	1.587	4.897	0.000	0.066	0.016	6.566								0.426647	171.2395
12/25/2008	1.587	4.897	0.000	0.066	0.015	6.566								0.450086	171.6896
12/26/2008	1.587	4.897	0.000	0.062	0.015	6.561								0.473526	172.1632
12/27/2008	1.596	4.897	0.000	0.089	0.014	6.596								0.496966	172.6601
12/28/2008	1.596	4.897	0.000	0.094	0.015	6.602								0.520406	173.1805
12/29/2008	1.596	4.897	0.000	0.060	0.015	6.568								0.543846	173.7244
12/30/2008	1.596	4.897	0.000	0.029	0.015	6.537	15.79	11.53667		22.89666748	0.5672859	0.56728586		0.567286	174.2917
12/31/2008	1.596	4.897	0.000	0.018	0.015	6.526								0.473887	**174.7656**
1/1/2009	1.594	4.897	0	0.0130	0.0155	6.5195								0.380488	
1/2/2009	1.594	4.897	0	0.0168	0.0152	6.5229	17.943333	9.943334		17.12333298	0.2870895	0.28708946		0.287089	

APPENDIX E

CMU PLANKTON REPORT

Seasonal Dynamics and Food Web Interactions of Planktonic Organisms in Big and Little Platte Lake, Benzie Co., Michigan.

Scott McNaught, Ph.D.
Central Michigan University

Report to the Michigan Department of Natural Resources and the Platte Lake Improvement Association

17 July 2009

Objectives:

- Describe the plankton composition and seasonal dynamics of plankton populations in Big and Little Platte Lake, MI during 2008.
- Compare plankton composition and seasonal dynamics in 2008 with composition and dynamics in 2003- 2007.
- Describe the planktonic food web of Big Platte Lake, MI, including major feeding pathways.
- Relate phytoplankton composition and diversity to physical and chemical characteristics of Big and Little Platte Lake during 2008.

Methods:

Phytoplankton and zooplankton samples were collected from Big Platte Lake every two weeks in 2008 (February-November) unless ice conditions made sampling unsafe. Only one set of samples was collected in November. Phytoplankton samples were collected from Little Platte Lake every two weeks in 2008 (February-November) except in March and November when sampling conditions were unsafe.

MDNR personnel sampled epilimnetic phytoplankton at 3 locations near the deep hole in Big Platte Lake by dropping a 2-cm diameter silicone tube sampler vertically through the water column (0-30 ft.). The tube sampler was outfitted with a one-way foot valve on the lower end to facilitate sample collection. As the tube sampler was withdrawn from the water, its contents were released into a clean container. One 250-mL bottle was filled with well-mixed tube sampler water from each sample location. MDNR personnel also collected discrete samples from 45, 60, 75 and 90 feet at one location using a Van Dorn bottle sampler. Samples from individual depths were combined in a single container to produce an integrated 45-90 foot sample. One 250-mL sample bottle was filled with well-mixed hypolimnetic water. Little Platte Lake is shallow and well-mixed, so MDNR personnel sampled phytoplankton by filling three 250-mL bottles just below the surface. All algal samples were preserved with Lugol's solution.

MDNR personnel collected zooplankton samples from Big Platte Lake using a 30-cm diameter, 64-μm mesh net. Three vertical net tows were collected from 1 m above the sediments to the surface at separate locations near the deep hole. The net was hauled no faster than 1 m/sec. The contents of each net tow was washed into separate, labeled 250-mL bottles and preserved with formalin.

Phytoplankton samples were examined by placing 5 ml of well-mixed sample into a settling chamber for 24 hours. Algal species were enumerated at 200-400x magnification using a Zeiss inverted compound microscope. All colonial and large solitary algal species in the sampling chamber were enumerated at 200x magnification (Table 1). Cell counts for large algal species were multiplied by 200 to get cells/liter. Small algal species in the sampling chamber were enumerated at 400x magnification using a sub-sampling technique (Table 1). All algae along a single transect through the middle of the counting chamber (38 rectangular fields of view) were counted. Cell counts for small algal species were divided by the proportion of rectangular field examined in the chamber (38/1663)

and multiplied by 200 to get cells/liter. For some colonial and filamentous species (Table 1), it was easier to measure colony length or area and apply a correction formula to estimate the number of cells.

Table 1: Counting procedures used for algal types and genera found in Big Platte Lake, Benzie Co., Michigan.

Algae type	**Counting Procedure**	**Algal Genera**
Large/Colonial	magnification = 200 count entire chamber cells/L = counts * 200	*Stephanodiscus, Cyclotella, Cocsinodiscus, Cymatopleura, Amphipora, Asterionella, Diploneis, Pleuro/Gyrosigma, Rhizosolenia, Cymbella, Tabellaria, Pediastrum, Coelastrum, Mugeotia, Zygnema, Spirogyra, Gymnodinium, Peridinium, Chrysophaerella, Ceratium*
Small	magnification = 400 count fields cells/L = counts ÷ prop. chamber * 200	*Synedra, Achnanthes, Navicula Hantschia, Nitschia, Pinnularia, Mastigloia, Scenedesmus, microgreens, Golenkinia, Closterium, Mallamonas, Cryptomonas, Dinobryon, Epipyxis*
Filament	magnification = 200 count entire chamber counts = length * 5.5 cells/L = counts * 200	*Fragilaria*
Filament	magnification = 200 count entire chamber counts = length * 1.0 cells/L = counts * 200	*Melosira*
Colony	magnification = 200 count entire chamber counts = area * cells/area cells/L = counts * 200	*Microcystis*

Table 2: Shapes and geometric formulas for the volume of select algal taxa found in Big Platte Lake, Benzie Co., Michigan. Symbols: D = diameter, L = length, W = width, H = height.

	Fragilaria	*Melosira*	*Scenedesmus*	*Microcystis*	*Dinobryon*
Cell shape	elliptic prism	cylinder	prolate spheroid	sphere	ellipsoid
Volume	$L*W^{*}H*\pi/4$	$H*D^2*\pi/4$	$L*W^2*\pi/6$	$D^3*\pi/6$	$\frac{1}{2}(\frac{2}{3}L*W*T)*\pi/6 + \frac{1}{2}(\frac{1}{3}L*W*T)*\pi/6$

Algal biomass was calculated as the product of cell density and average cell volume. Average cell volume was determined by measuring length, width, and depth of 20 randomly selected cells from 2003 Big Platte Lake samples and applying a published geometric formula that closely approximated the shape of each taxon (Table 2). The volume of colonial green algae was calculated as the product of colony density and average colony volume. Cell volumes (μm^3) were multiplied by 10^{-9} to give biovolume (μl). If one assumes that algal cell density is approximately 1.0 g/ml, biovolume (μl) is equivalent to dry biomass (mg). This assumption is good for green algae and cyanobacteria. It severely underestimates diatom biomass.

Zooplankton species were enumerated by counting 5-ml sub-samples in a Bogorov tray at 25x magnification using a Leica stereomicroscope. Zooplankton biomass was calculated as the product of species density and average individual dry weight. Average individual dry weights of copepod (calanoid, cyclopoid) and cladoceran (*Bosmina*, *Daphnia*, and *Holopedium*) species was determined by measuring 30 individuals of each taxon from 2004 Big Platte Lake samples and applying a published length-weight regression to the average length (Culver et al. 1985). Average individual dry weights of rotifer species (*Polyarthra*, *Keratella*) found in Lake Michigan (Makarewicz et al. 1994) were used to estimate average individual dry weights in Big Platte Lake. Average individual dry weights of *Alona* and *Chydorus* in Lake Michigan (M. Edwards, unpublished data) were used estimate dry weight of animals found in Big Platte Lake. Average individual dry weight of *Leptodora* in Big Platte Lake was estimated by applying a published length-weight regression (Manca et al. 2000) to a 6 mm animal.

Results:

Physical and chemical environment of Big and Little Platte Lakes:

The abundance and seasonal succession of planktonic organisms depends to a large degree on the physical and chemical characteristics of a lake. In 2008, temperature profiles indicate that Big Platte Lake was well mixed until April 30 when stratification began (Fig.1a). Big Platte Lake reached a maximum temperature of 24ºC on July 30. Separation of warm surface water from cold bottom water continued until October 30 when the lake once again became mixed. Turbidity was moderate during spring and fall mixing events (Fig. 1b), but was high in early August 2008 suggesting a summer mixing event. Because shallow water (< 30 ft.) dominates the surface area of Big Platte Lake, sediments are easily mixed into the surface water by the wind.

Unlike Big Platte Lake, Little Platte Lake is shallow and well-mixed when ice-free. Little Platte Lake was 2-3ºC warmer than Big Platte Lake during late winter and spring 2008 (Fig. 1a). Little Platte Lake reached a maximum temperature of 25ºC on July 30. Little Platte Lake cooled quickly during 2 wind induced mixing events in fall 2008. As a result of frequent wind mixing, Little Platte Lake was consistently more turbid than Big Platte Lake in 2008. Highest turbidity was in the spring and late summer (Fig. 1b).

Nutrient concentrations govern the abundance and composition of phytoplankton populations. In 2008, total phosphorus (TP) concentration in the epilimnion varied between 4.1 and 9.6 μg/L (Fig. 2a). Mean TP in Big Platte Lake was 7.60 μg/L. Most phosphorus during spring mixing (especially March 20 and April 30) was dissolved and available to phytoplankton. Nitrate concentrations in the epilimnion were highest during spring mixing and dropped to very low levels (< 2 μg/L) in late July.

In 2008, TP concentrations in Little Platte Lake varied between 9.1 and 22.5 (Fig. 2b). Mean TP in Little Platte Lake was 14.62 μg/L. TP was lowest in the spring and highest in late winter and summer. Most phosphorus during spring mixing (April) was dissolved and available to phytoplankton. TP in Little Platte Lake was twice as high as TP in Big Platte Lake. The peak nitrate concentration in Little Platte Lake was similar to that in Big Platte Lake. Nitrate concentrations in Little Platte Lake were highest during the winter, dropped to very low levels (< 2 μg/L) in early May and remained low through November (Fig. 2b).

Algal biomass, as estimated by chlorophyll a concentration, was more closely related to total phosphorus concentrations than nitrate concentrations in Big Platte Lake during 2008 (Fig. 2a). Chlorophyll *a* was highest during mid-July and late September when nitrate was lowest. During 2003-2008, chlorophyll *a* concentrations were always higher in the summer and lower in the winter in Big Platte Lake (Fig. 3). Mean annual chlorophyll *a* concentrations have changed over time. Chlorophyll *a* concentration increased from 1.85 μg/L in 2004 to 2.87 μg/L in 2006. In 2007, mean chlorophyll *a* concentration decreased to 2.31 μg/L. In 2008, mean chlorophyll *a* concentration decreased further to 2.11 μg/L. Mean annual chlorophyll *a* concentration was usually related to algal density. Mean epilimnetic phytoplankton density increased from 0.6 million cells per liter in 2004 to 2.5 million cells per liter in 2006 but decreased to 1.9

million cells per liter in 2007. Phytoplankton density increased to 2.4 million cells per liter in 2008 even though chlorophyll a concentration had decreased.

Little Platte Lake algal biomass, as estimated by chlorophyll a concentration, was closely related to nitrate concentration during winter and early spring 2008 and total dissolved phosphorus concentration in the summer (Fig. 2b). Chlorophyll *a* decreased from 18.0 μg/L to 2.2 μg/L during the winter months and remained low (≤5.0 μg/L) during the summer and fall. Mean chlorophyll *a* concentration in Little Platte Lake was 5.1 μg/L in 2008. During 2004-2008, chlorophyll *a* concentrations were always higher in Little Platte Lake than in Big Platte Lake (Fig. 4). Mean annual chlorophyll *a* concentrations have not changed much over time.

Phytoplankton in Big Platte Lake:

Planktonic algae were most abundant in spring and summer 2008 when peak cell counts were 3.4 and 4.9 million cells per liter, respectively (Fig. 4). Spring and summer phytoplankton abundance maxima have been a consistent feature of Big Platte Lake since 2003, even though the dates of peak abundance have varied slightly from year to year. In 2003 and 2005, the spring abundance peak occurred in June; whereas in 2004 and 2006-2008 the spring abundance peak occurred in April (Fig. 4). The summer abundance peak occurred in late July-early August during all years except 2007 when it occurred in early September.

Small green algae, flagellates, diatom species, and blue-green bacteria were co-dominant in the epilimnion of Big Platte Lake in 2008 (Fig. 4). The most common green algae were *Scenedesmus, Coelastrum* and other colonial species, and single-celled micro-greens. The most common flagellates were *Dinobryon*, a colonial chrysophyte, and two cryptomonads (*Cryptomonas*, *Chroomonas*). In past years, the large *Cryptomonas* was referred to as a "Euglenoid." Common diatoms included colonial species such as *Fragilaria*, *Melosira,* and *Asterionella*; pennates such as *Navicula, Cymbella* and *Synedra*; and small centrics. Blue-green bacteria were dominated by the colonial genera *Chroococcus, Merismopedium,* and *Microcystis*.

There was a distinct seasonal shift in phytoplankton composition in Big Platte Lake during 2008. Small flagellates, green algae, and blue-green bacteria were numerically co-dominant under the ice in the winter and early summer (Fig. 4). Diatoms were abundant during mixing events in the spring and mid-summer. Blue-green bacteria were numerically dominant in the late summer and fall. The compositional changes in 2008 were similar to those in past years except that blue-green algae were more prominently represented throughout the year.

Although flagellates, small green algae, and blue-green bacteria were abundant in Big Platte Lake during 2008, diatoms contributed the most algal biomass (Fig. 5). Diatom cells are much larger than the cells of most other algal taxa in Big Platte Lake. Only the dinoflagellate *Ceratium* has larger cells. Diatom biomass may be underestimated because mass of the glass frustule (cell wall) is not included in the biomass calculation. Diatoms comprised the majority of algal biomass (≥50%) in the epilimnion (0-30 ft.) of Big Platte Lake during spring and summer 2008, particularly during mixing events (Fig. 5). Mixing events are less important for other phytoplankton taxa.

In 2008, algal biomass in Big Platte Lake ranged from 0.32 to 2.88 mg/L, and mean annual algal biomass was 0.94 mg/L. Algal biomass was low (< 1.0 mg/L) during winter, late spring, and fall 2008 (Fig. 8). A *Fragilaria* bloom was responsible for the large biomass peak in late July. Mean algal biomass in 2008 was lower than that in 2005-2007 (1.2-2.2 mg/L) but slightly higher than that in 2004 (0.2 mg/L). During 2003-2008, diatoms have dominated algal biomass in Big Platte Lake, particularly during spring, summer and fall mixing periods. Only during August and early September are diatoms not an important contributor to algal biomass (Fig. 5).

The distribution of algal biomass with depth reflects the mixing status and thermal properties of Big Platte Lake in 2008. In February, algal biomass was greatest deep in the lake (Fig. 6). A layer of ice and snow most likely covered Big Platte Lake restricting mixing such that immobile algae settled to the bottom. In March, algal biomass was greatest near the surface. This may have been a response to increased light levels following snow melt or ice break-up. In April, Big Platte Lake underwent a period of mixing such that algal biomass was similar at all depths (Fig. 6). Heavy diatoms and nutrients from the bottom were brought to the surface by the moving water. The diatom biomass increased in response to available light and nutrients. When the wind stopped in May, diatoms sank into the bottom waters (Fig. 6). Between July and October, algal biomass was greatest near the surface indicating that the lake was stratified. Green algae, flagellates and blue-green algae grew well in the warm surface waters. Diatom biomass in surface water decreased as heavy species sank toward the bottom. In late July, there was a *tremendous* centric diatom bloom in the epilimnion, possibly in response to a strong wind event. In November, algal biomass was similar at all depths, indicating that Big Platte Lake had once again become mixed (Fig. 6).

Zooplankton in Big Platte Lake:

The zooplankton community of Big Platte Lake includes 5 copepod taxa (*Diacyclops thomasi*, *Mesocyclops edax*, *Diaptomus* spp., *Epischura lacustris*, and harpacticoids), 9 cladoceran taxa (*Bosmina*, *Eubosmina*, *Ceriodaphnia*, *Diaphanosoma*, *Daphnia*, *Holopedium*, *Sida*, *Chydorus*, *Leptodora*) and many rotifer species. The copepods *Diacyclops* and *Diaptomus* (both naupliar and copepodid stages) and the cladocerans *Bosmina* and *Daphnia* were the most common microcrustaceans in 2008. *Polyarthra* and *Keratella* were the most common rotifers.

Planktonic crustaceans were most abundant during summer 2008, and rotifers were most abundant during the late summer and fall (Fig. 7). Crustaceans exhibited peak abundance in early July (37 animals per liter) and rotifers exhibited peak abundance in August (46 animals per liter) and October (48 animals per liter). Larval and adult copepods dominated the crustacean plankton and cladoceran densities were low in 2008 (Fig. 7). Rotifers were slightly more abundant than crustaceans in 2008.

Zooplankton abundance and seasonal dynamics have changed during the past 5 years. Crustaceans were most abundant in 2003 (peak = 142 per liter) and 2006 (peak = 94 per liter) and least abundant in 2004 (peak = 35 per liter) and 2008 (37 animals per liter). Crustaceans typically exhibit 2-3 abundance peaks per year depending on the number of copepod cohorts (nauplii abundance peaks) and cladoceran blooms (Fig. 7). There were 3 distinct copepod cohorts in 2004 and 2005 and 2 distinct cohorts in 2006. A single large

cladoceran bloom was evident in 2003 and 2005. Rotifers were also most abundant in 2003 (peak = 552 per liter) and least abundant in 2008 (peak = 48 per liter). Rotifers typically exhibited one large early-summer abundance peak and smaller abundance peaks in spring and fall. In 2004, 2007, and 2008, the summer abundance peak was delayed until August-September.

There was a distinct seasonal succession of zooplankton taxa in Big Platte Lake during 2008. Rotifers dominated the plankton during spring mixing. Cyclopoid copepods (nauplii and copepodids) dominated the plankton in the summer, but were replaced by rotifers again in the fall (Fig. 7). Cladocerans were never dominant; however they were most prominent in late June.

In 2008, zooplankton biomass in Big Platte Lake ranged from 3.8 to 84 μg/L, and mean annual zooplankton biomass was 20 μg/L. Zooplankton biomass was highest in late June (Fig. 8). Although rotifers were numerically dominant during most of the year, they only comprised a small portion of total zooplankton biomass in 2008. Juvenile and adult copepods dominated zooplankton biomass throughout the year (Fig. 8).

Mean and peak zooplankton biomass in Big Platte Lake has decreased between 2003 and 2008. Mean zooplankton biomass was 64 mg/L in 2003 and 34 mg/L in 2004 but only 20 in 2008. Biomass peaks were large in 2003-2005 but much smaller in 2006-2008 (Fig. 8). Cladocerans were responsible for summertime biomass peaks except during 2007 and 2008 when cladocerans were low in abundance. Low cladoceran biomass in recent years may be caused by increased fish predation or zebra mussel filtering.

Phytoplankton in Little Platte Lake:

During the past 4 years, colonial blue-green species have been a prominent feature of the summer and fall phytoplankton assemblage in Little Platte Lake (Fig. 9). Common blue-green genera in Little Platte Lake during 2008 included *Chroococcus, Merismopedium,* and *Microcystis*. Nitrogen-fixing *Anabaena* was present in low numbers. Green algae, flagellates and diatoms were also present in Little Platte Lake during 2008. The most common green algae were *Scenedesmus, Ankistrodesmus,* and single-celled microgreens. Common flagellates included *Dinobryon* and two cryptomonads (*Cryptomonas*, *Chroomonas*). Centric and small pennate diatoms and the genus *Fragilaria* were abundant throughout the year.

Planktonic algae in Little Platte Lake were most abundant in winter 2008 when the peak cell count was 10.7 million cells per liter (Fig. 9). Phytoplankton abundance peaks occurred repeatedly throughout the spring and summer 2008, likely in response to wind mixing. Mean phytoplankton density in 2008 (6.1 million cells per liter) was intermediate between that in 2007 (6.7 million cells per liter) and 2006 (5.4 million cells per liter). During the past 3 years, phytoplankton densities in Little Platte Lake were 2-3 times greater than in Big Platte Lake.

The seasonal succession of phytoplankton taxa in Little Platte Lake during 2008 was similar to that in Big Platte Lake except that diatoms did not play a prominent role. Diatoms were present in low numbers throughout the year in Little Platte Lake (Fig. 9). Flagellates were dominant in the winter and small green algae were dominant in the early

spring. Colonial blue-green bacteria were most abundant during the summer and fall. The seasonal succession in 2008 was similar to that in 2006 when green algae exhibited a large springtime bloom (Fig. 9).

Although colonial blue-greens were numerically dominant in Little Platte Lake during 2008, diatoms frequently contributed the most algal biomass (Fig. 10). Diatom cells are much larger than the cells of most other algal taxa in Little Platte Lake. Diatoms dominated algal biomass during late April and September. High turbidity in early April and September (Fig. 1b) indicates wind mixing which may have re-suspended bottom-dwelling diatoms.

In 2008, algal biomass in Little Platte Lake ranged from 0.75 to 3.6 mg/L, and mean annual algal biomass was 2.1 mg/L. Algal biomass was low (< 2.0 mg/L) during spring and late fall 2008 (Fig. 10). As in 2007, blue-green bacteria represented a large proportion of total algal biomass. Mean algal biomass was slightly lower in 2008 than in 2007 (2.5 mg/L). Mean algal biomass in Little Platte Lake was approximately twice that in Big Platte Lake.

Discussion:

Big Platte Lake Food Web

Planktonic organisms in Big Platte Lake include bacteria, protozoans, algae, rotifers, and crustaceans. Bacteria and protozoans interact closely in a "microbial food web". Bacteria ingest organic molecules dissolved in lake water and protozoans eat the bacteria. Algae, rotifers, and crustacean plankton interact with one another, and with larger invertebrates and fish, in a traditional grazing food web (Fig. 11). The Big Platte Lake food web has remained unchanged since 2002. No unique or exotic plankton species were discovered in 2008.

Algae (phytoplankton) constitute the basis for the grazing food web in Big Platte Lake (Fig. 11). Algae use photosynthetic pigments to acquire energy from the sun. They use this energy to create sugars, which are eventually stored as starch or oil. Heavy algal taxa such as the diatoms are abundant during spring and fall overturn when the lake is mixed, top to bottom, by the wind. Diatom biomass can also be high in the epilimnion following strong wind events during the summer. Strong winds can re-suspend diatoms that have settled to the bottom in shallow water.

When Big Platte Lake is not mixed, it stratifies into warm surface and cool deep-water layers. Heavy diatoms sink into the hypolimnion and lighter phytoplankton taxa such as green algae and flagellates become abundant. Small green algae and flagellates thrive during the spring and early summer when epilimnetic nutrients (nitrogen and phosphorus) are plentiful. During calm periods in late summer, epilimnetic nitrogen concentrations become low. Colonial blue-green algae become abundant because they can tolerate low nitrogen concentrations and have gas vacuoles that allow them to float near the surface. Added phosphorus during the late summer can enhance the growth of blue-green algae.

When diatoms, flagellates and green algae are abundant in Big Platte Lake, populations of herbivorous zooplankton (rotifers, copepod nauplii, and cladocerans) increase. Nauplii and rotifers are small (80-300 μm) and can only ingest single celled or small colonial green algae and flagellates (Fig. 11). Cladocerans such as *Bosmina* and *Daphnia* are large (300-2500 μm) and can ingest diatoms as well as small green algae and flagellates. Because they can eat a wider range of food sizes, cladocerans may out-compete rotifers and nauplii for food in June when all algal types are abundant.

Planktonic herbivores in Big Platte Lake are most abundant when densities of green algae and flagellates are high. Peak rotifer abundance coincided with green algae densities during each year of this study (compare Figs. 4 and 7). Peak cladoceran abundance coincided green algae peaks in 2003 and 2005 but also with a June flagellate peak in 2004. Rotifers and cladocerans reproduce asexually and their populations can increase quickly when food is abundant. Copepods reproduce sexually and rarely produce more than three sets of nauplii in a year. The copepods in Big Platte Lake produced nauplii in late May and August when edible algae were most abundant.

Among the cladocerans, the temporary replacement of *Bosmina* by *Daphnia* in July can be explained by species-specific growth rates and feeding ability. *Bosmina* is smaller than *Daphnia* and grows more quickly in the cool epilimnion early in the summer. As

water temperature increases, so do *Daphnia* populations. By July, the large herbivore is abundant and feed heavily on green algae thereby reducing its abundance. In August, the blue-green alga *Microcystis* becomes abundant. *Microcystis* can be toxic to *Daphnia* and is difficult to ingest. *Bosmina*, however, can avoid the blue-green colonies and feed on green algae and flagellates. A growing *Bosmina* population soon surpasses the stagnant *Daphnia* population.

Abundance of planktonic crustaceans was lower in 2004, 2007 and 2008 than in other years because the density of edible green algae was low during the summer. Abundant green algae fuel fast-growing populations of nauplii and cladocerans. Without abundant green algae, crustacean plankton cannot be abundant. Cladoceran abundance was low in 2006-2008 even though the density of green algae was sometimes high (e.g. 2006). Low cladoceran biomass in recent years may be caused by increased fish predation or competition from zebra mussels that filter algae from the water (Fig. 11).

Predators in Platte Lake include cyclopoid copepods and planktivorous fish (Fig. 11). Cyclopoid copepods feed on protozoans and rotifers during all juvenile and adult (copepodid) life stages. Larval and juvenile fish are visual predators that actively select large prey such as adult copepods and cladocerans. Some fish species such as alewife, yellow perch, and sunfish also feed on plankton as adults. If fish predation is intense, small-bodied taxa (ex: rotifers, nauplii) will dominate the zooplankton.

Phytoplankton Growth in Big and Little Platte Lake

The growth of algal populations in Big and Little Platte Lake appears to be governed by mixing events, regional climate, and phosphorus concentrations. High turbidity and high diatom biomass during April and November are consistent with overturn events in a dimictic lake. During overturn, inorganic sediment and diatom frustules are re-suspended in the lake. Turbidity and diatom biomass data also indicate that Little Platte Lake and the epilimnion of Big Platte Lake are mixed by a prolonged wind events July and August. In Big Platte Lake, inorganic sediment and diatom frustules from shallow depths were re-suspended throughout the epilimnion as the wind blew. Multiple turbidity and diatom biomass peaks during summer 2008 suggest that Little Platte Lake is frequently mixed by the wind.

Regional climate may be an important factor governing the growth of phytoplankton in Big Platte Lake. The spring diatom biomass peak occurred later each year between 2003 and 2006 (Fig. 5), but appeared early once again in 2007. A multi-year cycle of warming and cooling may correspond to the appearance of the spring diatom bloom. Spring diatom peaks in Little Platte Lake show a similar pattern; however, additional peaks make interpretation difficult.

Mean TP and chlorophyll concentrations indicate that Big Platte Lake is meso-oligotrophic and Little Platte Lake is mesotrophic. In Big Platte Lake, mean TP concentration was below the cut-off for a mesotrophic lake (10 μg/L) but mean chlorophyll concentration was above the cut-off (2 μg/L). In Little Platte Lake, mean TP and chlorophyll concentrations were well within the range for a mesotrophic lake (TP: 10-30 μg/L, Chl: 2-9 μg/L).

Phytoplankton grow particularly well in Little Platte Lake during the summer. Algal biomass and chlorophyll a concentrations were twice as high in Little Platte Lake than in Big Platte Lake. High pH in Little Platte Lake during the summer is consistent with high algal photosynthetic rates. As algae use CO_2, the carbonic acid equilibrium shifts and hydrogen ions are no longer produced.

Close correspondence between chlorophyll a and phosphorus concentration indicates that phytoplankton growth in Big and Little Platte Lake may be limited by phosphorus, not nitrate. Although nitrate concentrations are inversely correlated with blue-green biomass in Big and Little Platte Lake, it is unlikely that there is a cause-effect relationship. The dominant blue-green bacterium in both lakes, the colonial genus *Merismopedium*, is not a nitrogen fixer and must obtain inorganic nitrogen (nitrate and ammonium) directly from the water. Moderate ammonium concentrations in Big and Little Platte Lake would permit the growth of *Merismopedium*. More likely, physical factors such as light, temperature or mixing are responsible for high biomass of *Merismopedium* during the summer.

APPENDIX F

CMU PLANKTON CHARTS AND GRAPHS

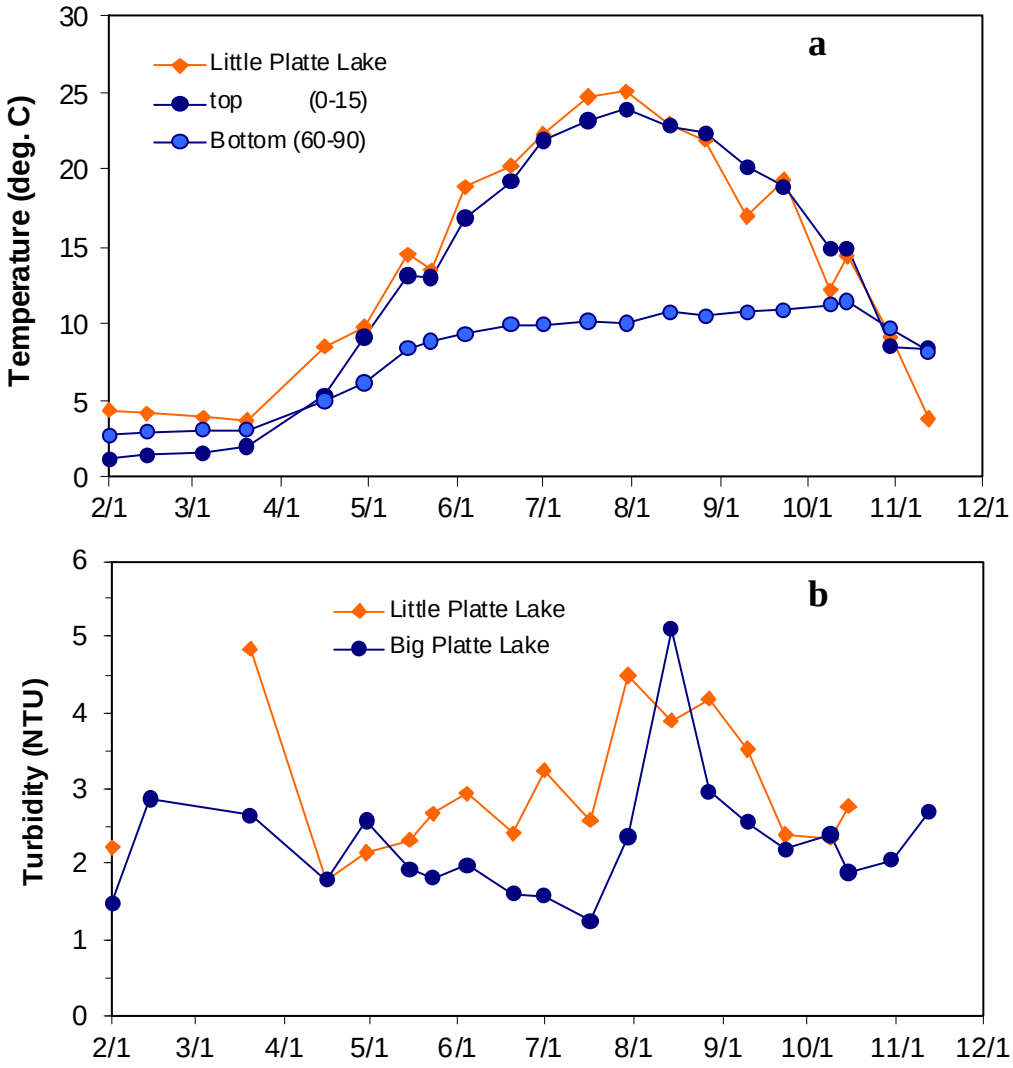


Figure 1: Temperature (a) and turbidity (b) in Little and Big Platte Lake, MI during 2008.

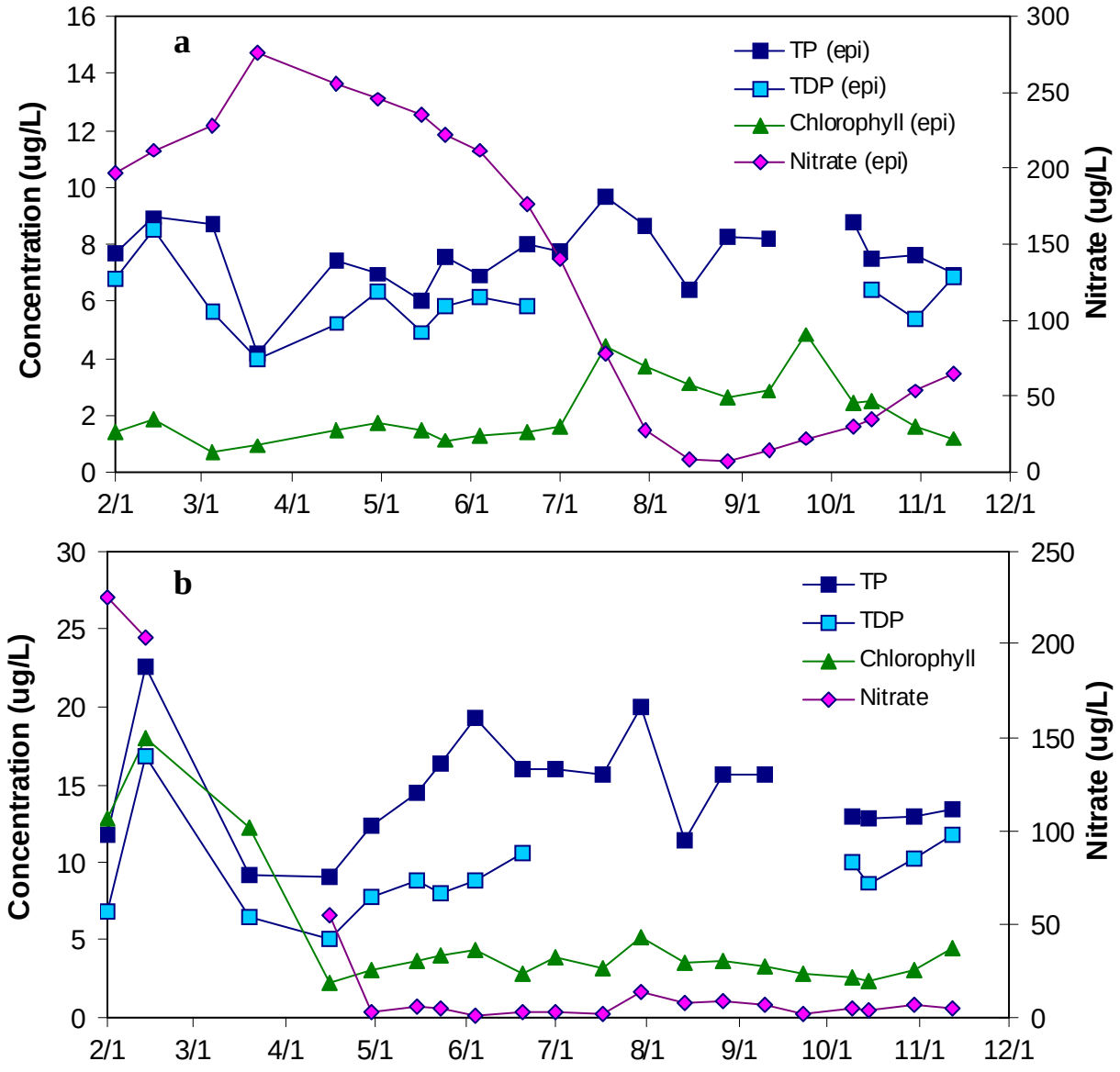


Figure 2: Epilimnetic phosphorus (total and total dissolved), nitrate, and chlorophyll *a* in Big Platte Lake (a) and Little Platte Lake (b), Benzie Co., MI during 2008.

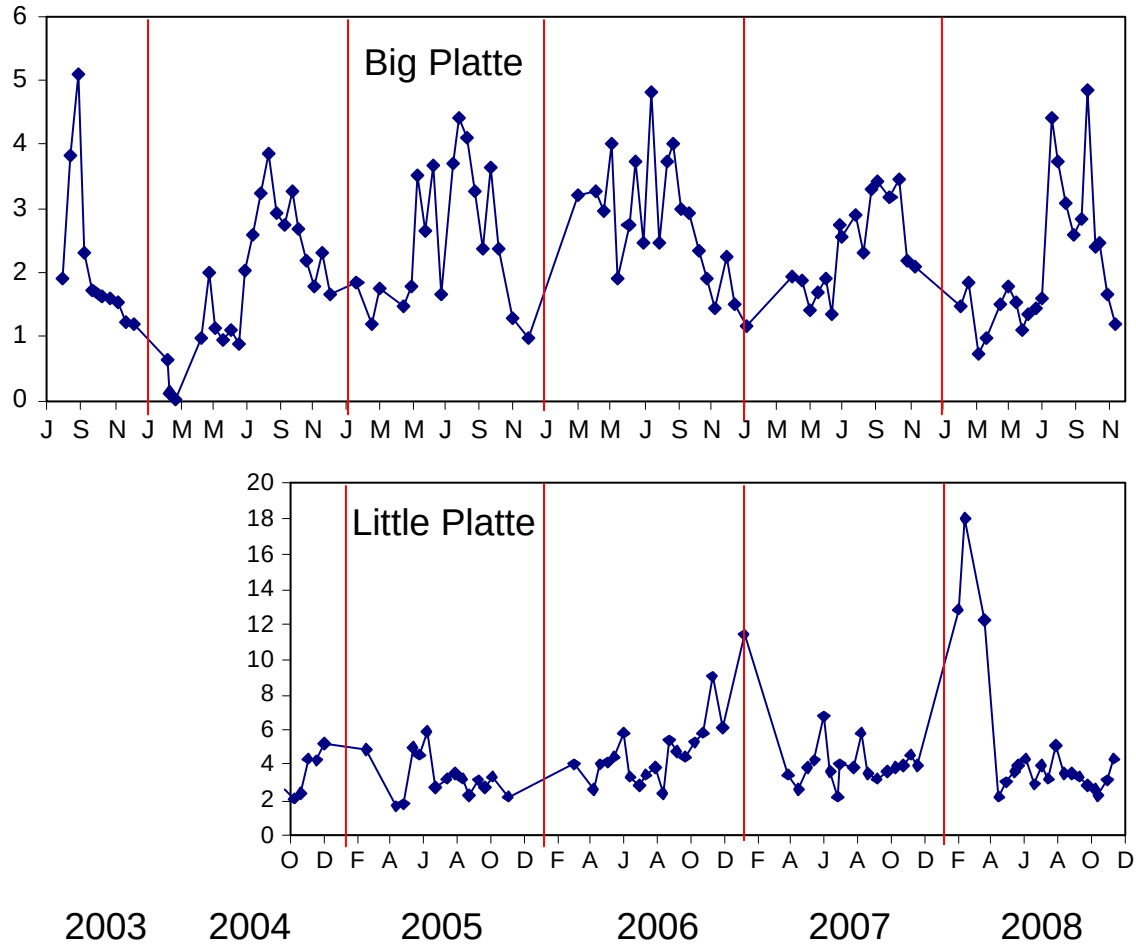


Figure 3: Epilimnetic chlorophyll a concentration in Big and Little Platte Lake, MI 2003-2008. Mean concentrations in Big Platte Lake during 2003-2008 were 2.19, 1.85, 2.53, 2.87, 2.31 and 2.11 µg/L, respectively.

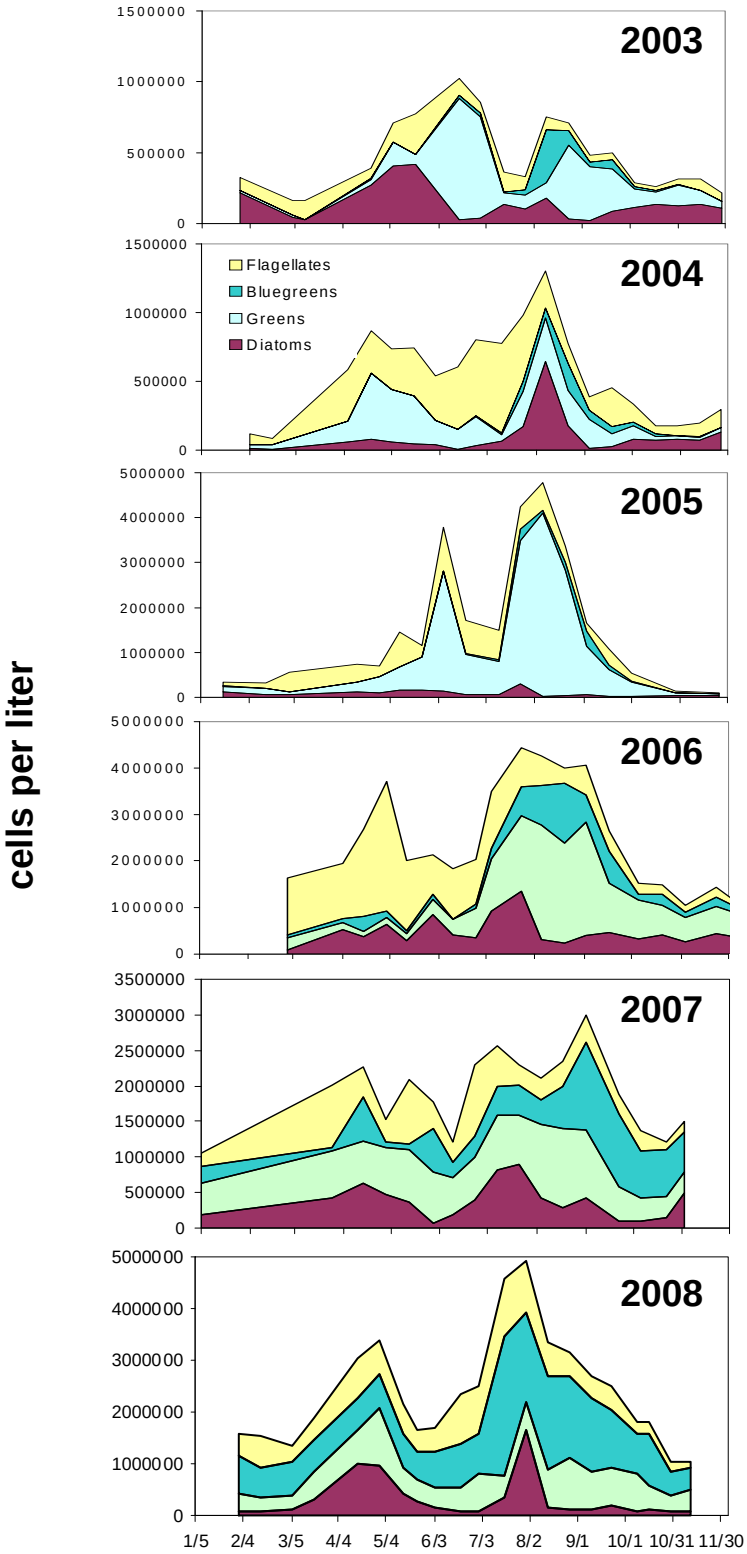


Figure 4: Epilimnetic phytoplankton density in Big Platte Lake, MI during 2003-2008. Note change of scale in 2005.

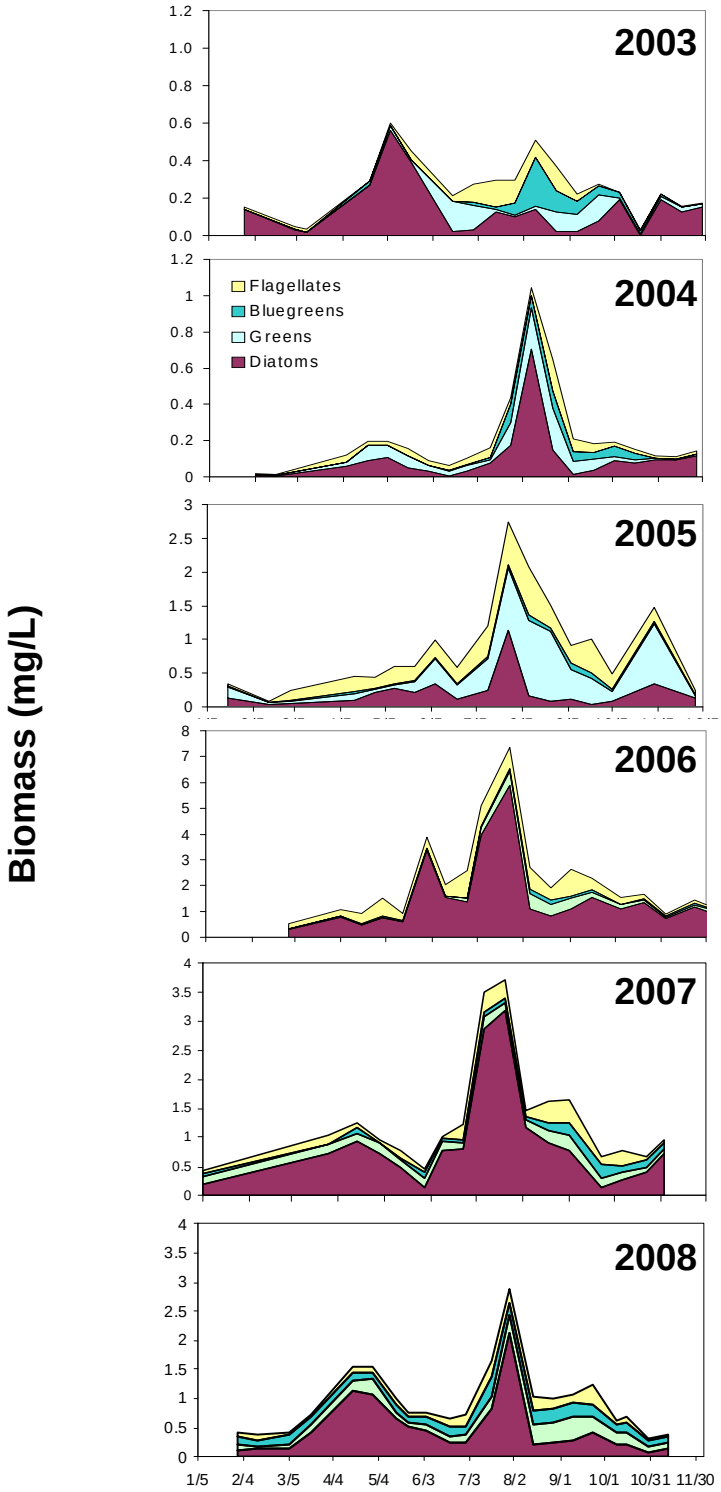


Figure 5: Epilimnetic phytoplankton biomass (wet wt.) in Big Platte Lake, MI during 2003-2008. Note change of scale in 2005, 2006, and 2007.

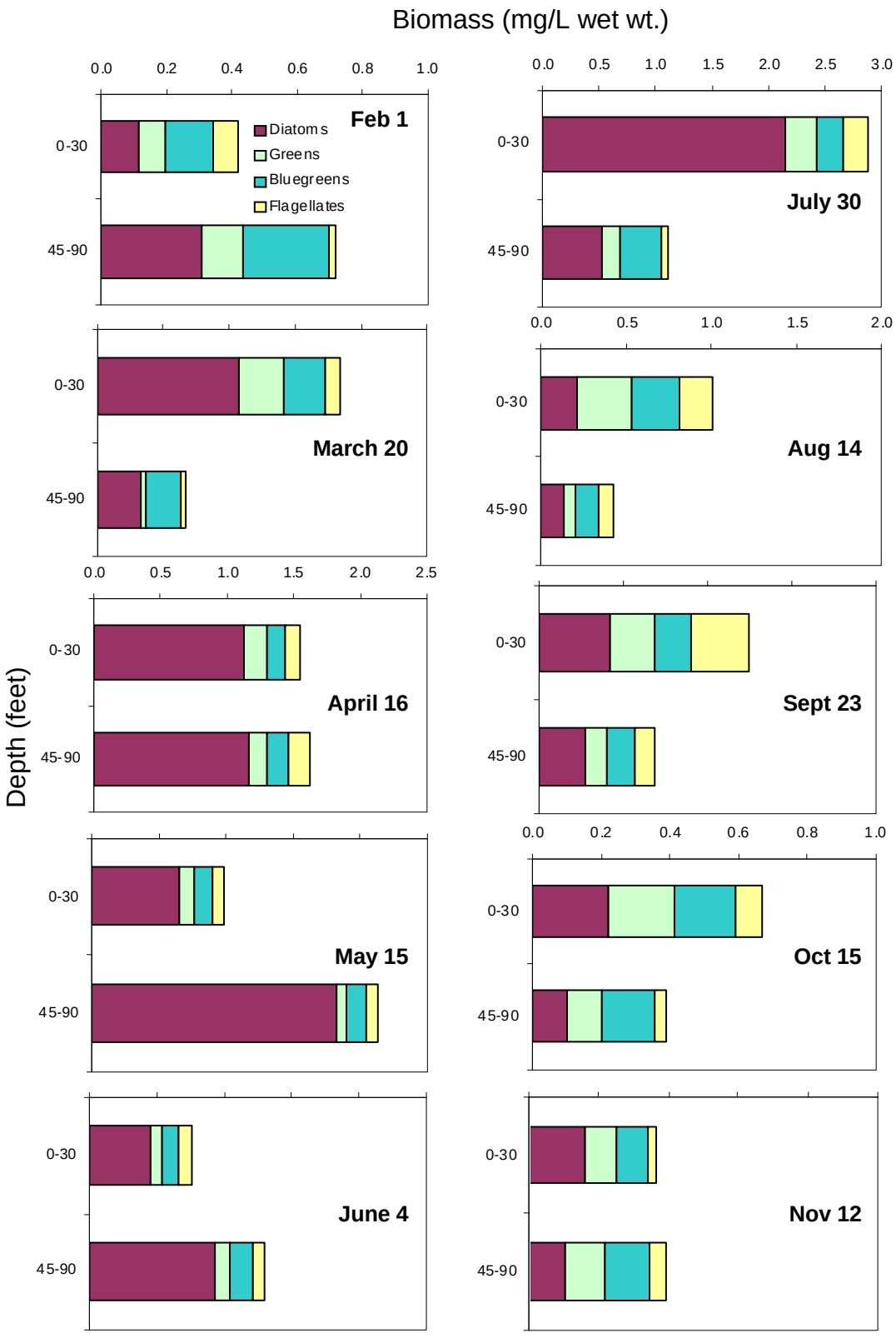


Figure 6: Phytoplankton biomass in the epilimnion (0-30 ft.) and hypolimnion (45-90 ft.) of Big Platte Lake, MI, 2008. Note changes in biomass scale.

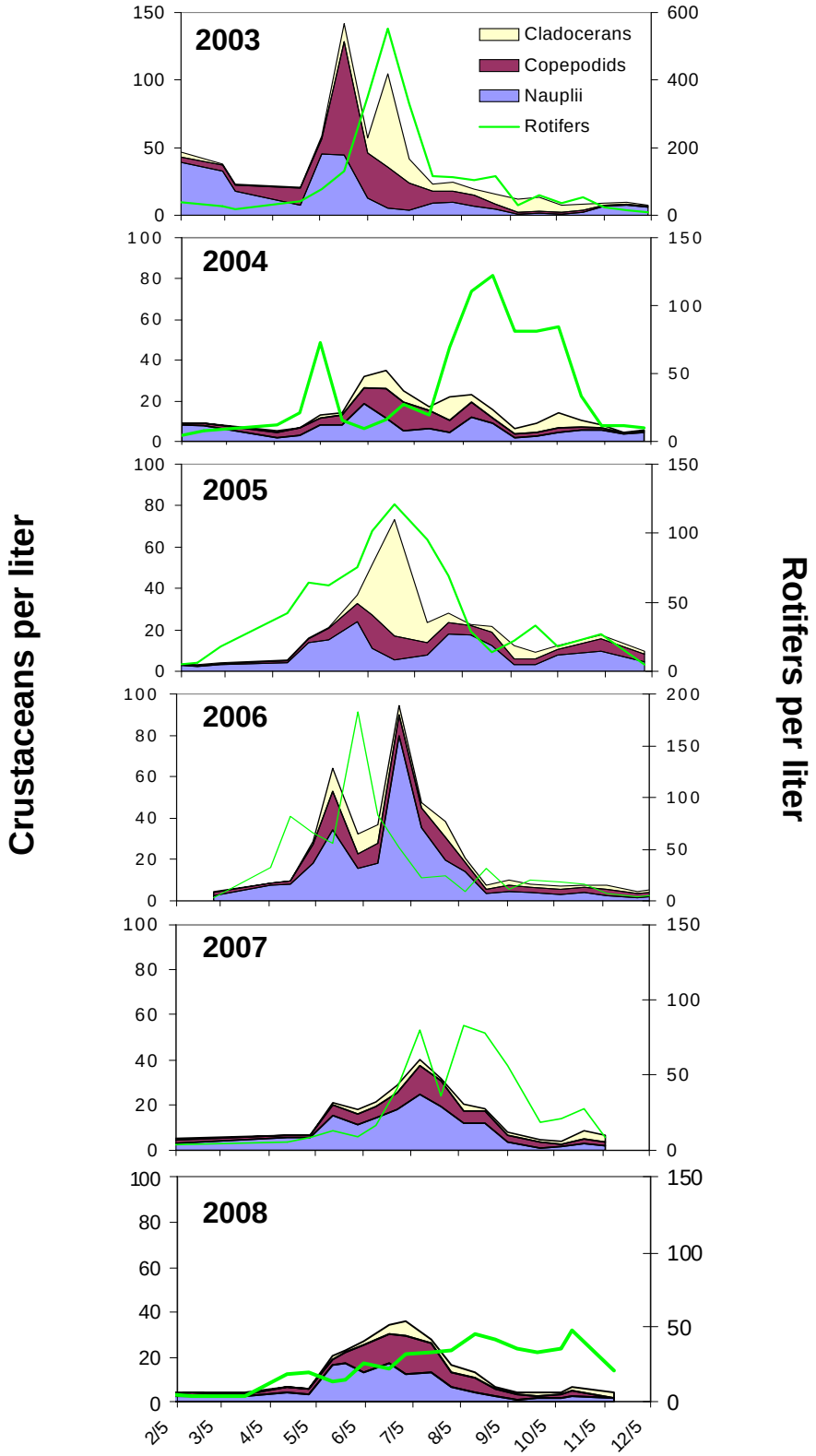


Figure 7: Average zooplankton density in Big Platte Lake, MI during the years 2003-2008. Note change in scales.

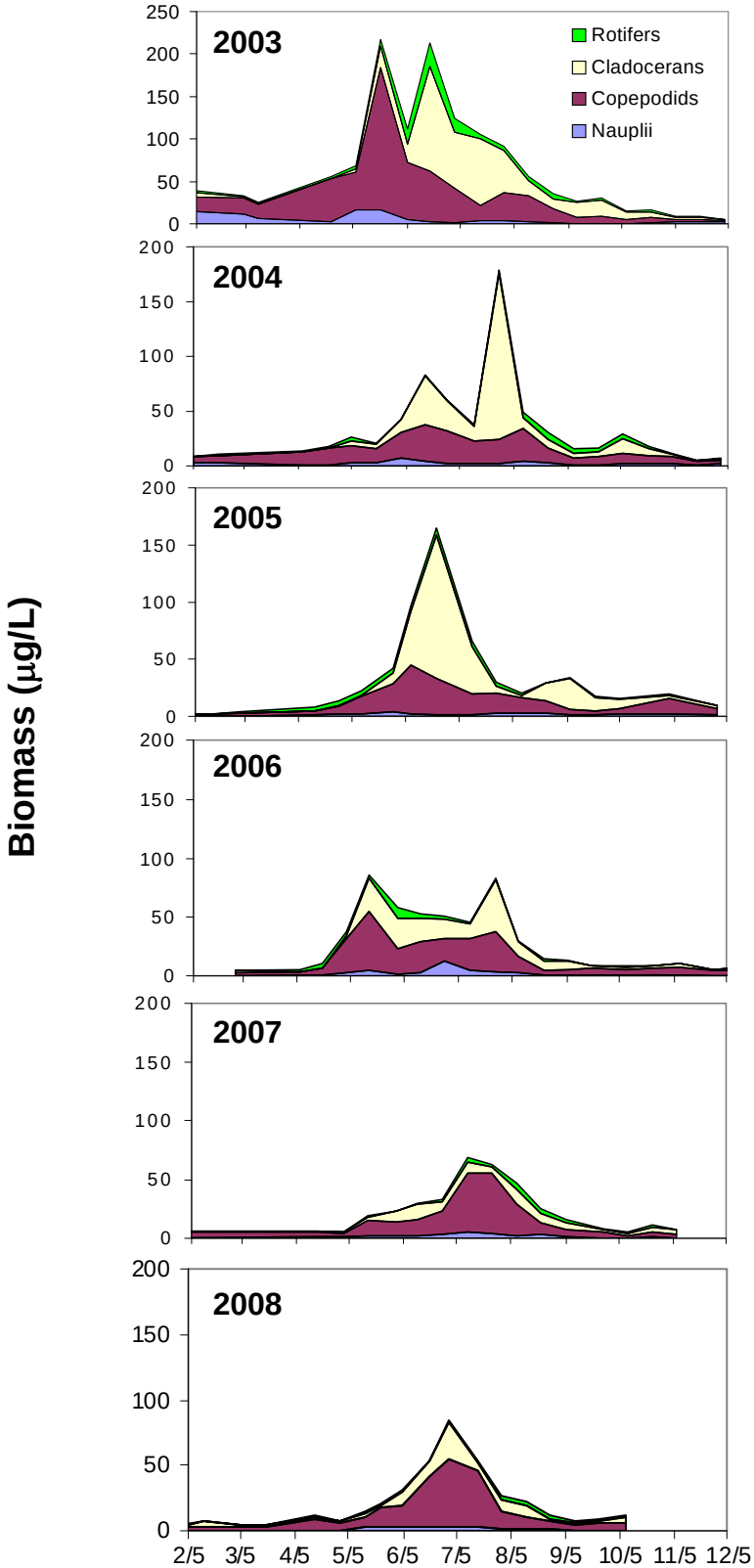


Figure 8: Average zooplankton biomass (dry wt.) in Big Platte Lake, MI during the years 2003-2008.

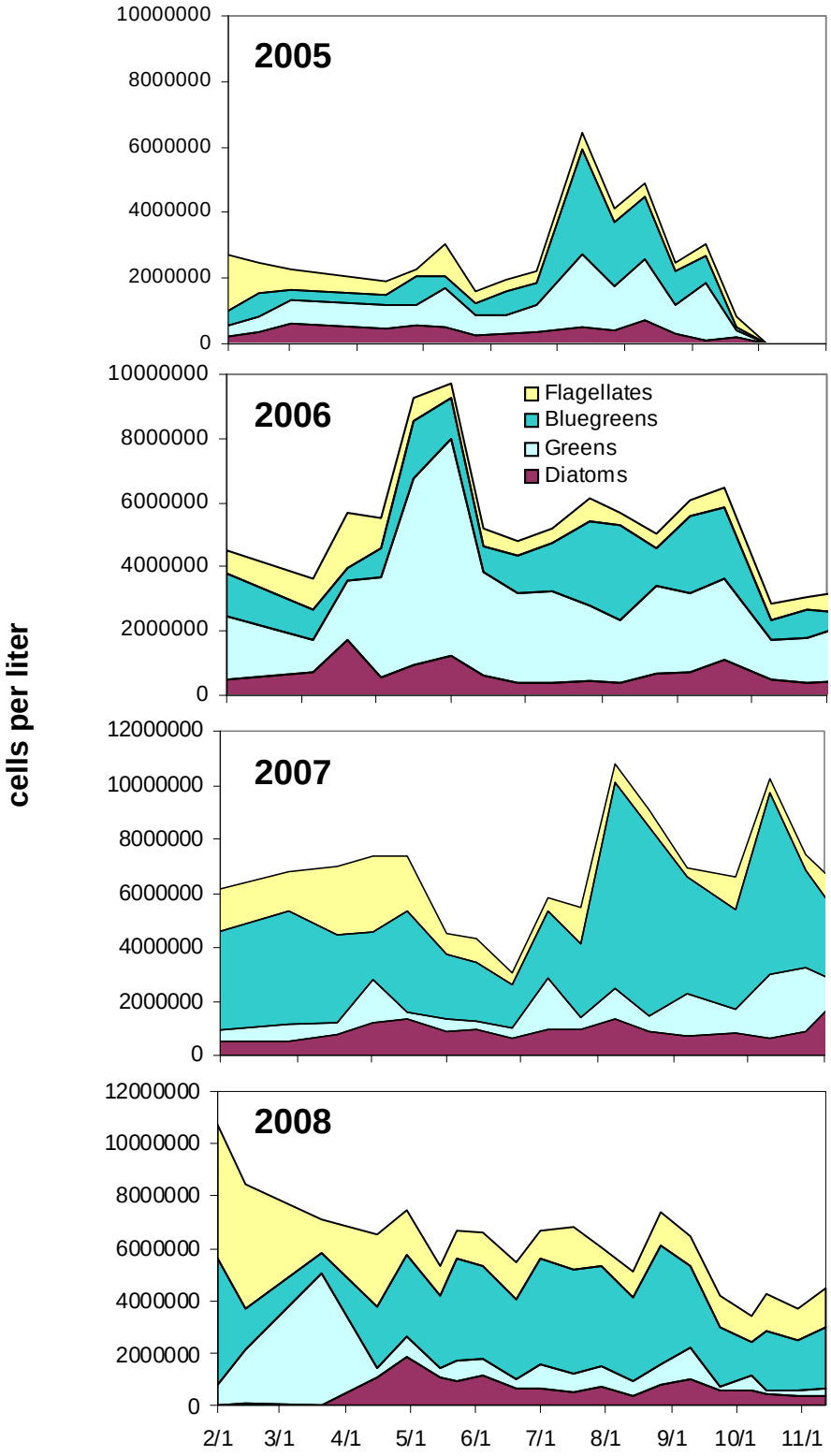


Figure 9: Phytoplankton density Little Platte Lake, MI during 2005-2008. Note change in scale.

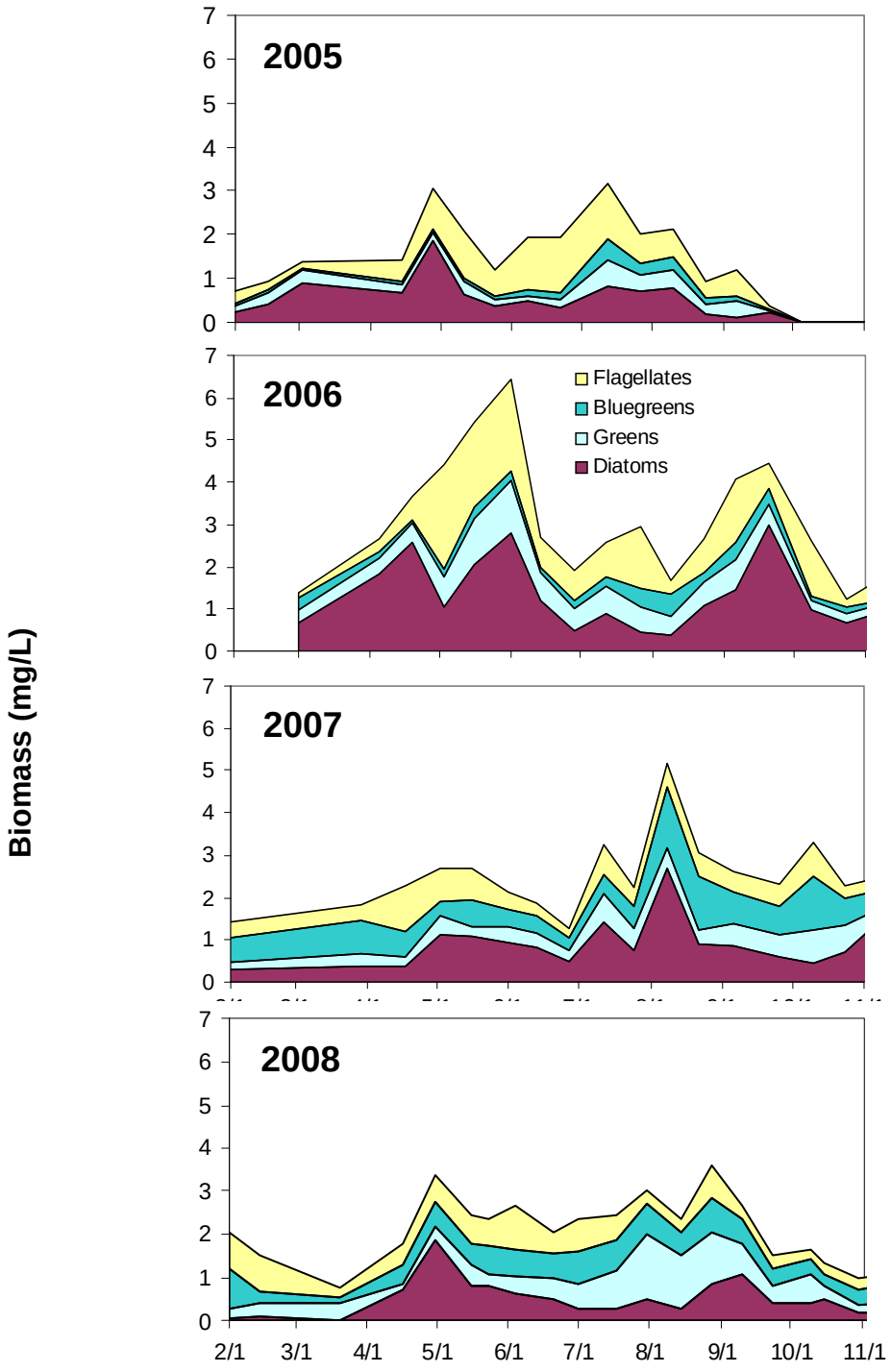


Figure 10: Phytoplankton biomass (wet wt.) in Little Platte Lake, MI during 2005-2008.

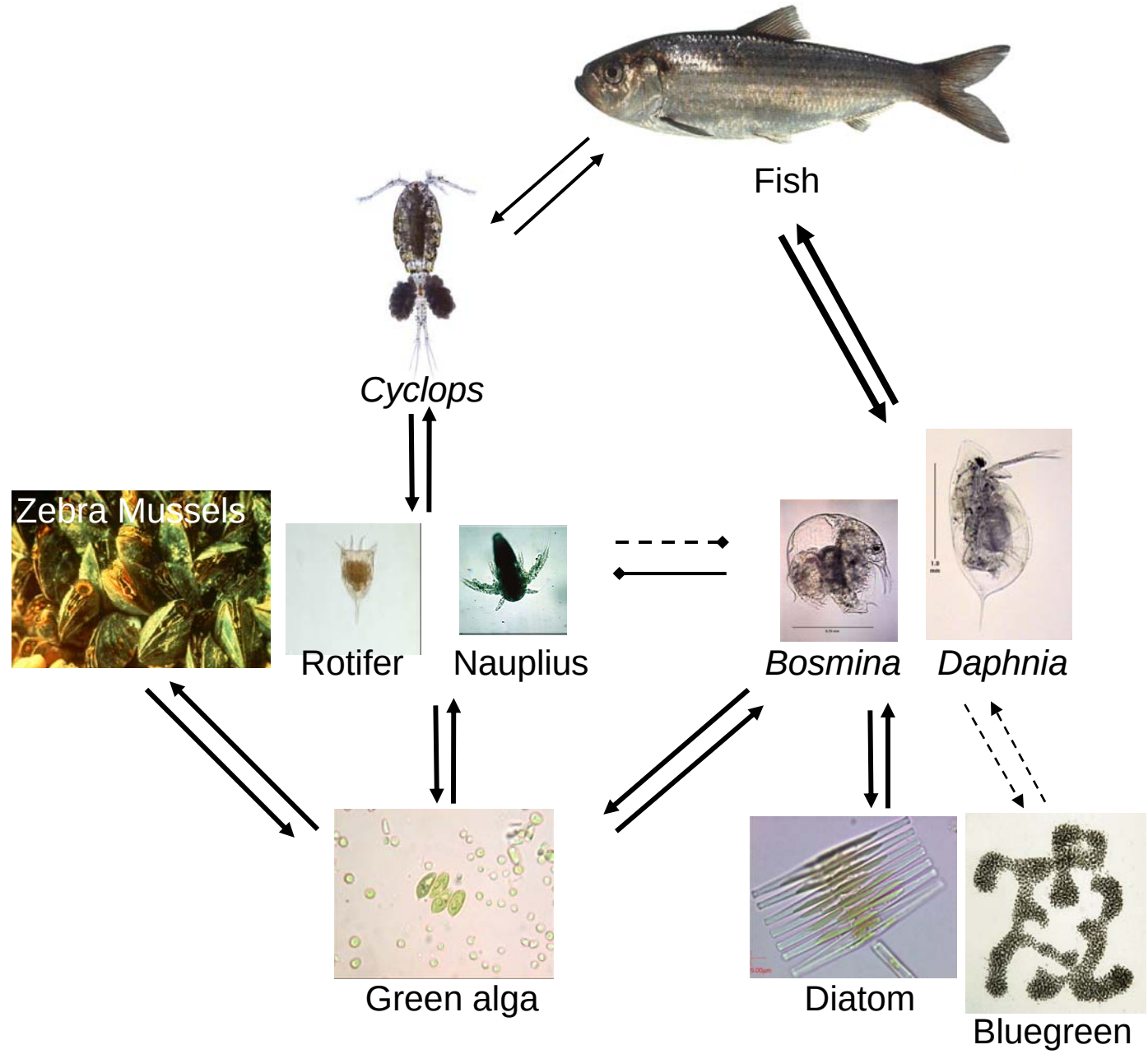


Figure 11: Platte Lake Food Web. Sharp arrow heads indicate direct feeding relationship (positive/negative interaction). Blunt arrow heads indicate indirect competition (negative/negative interaction). Thickness of arrow is proportional to strength of the interaction.

APPENDIX G

SAMPLE TRACKING

Examination of Platte River Watershed Total Phosphorus Data Anomalies

Background

Platte River State Fish Hatchery (PRSFH) monitors total phosphorus (TP) levels in all water sources entering and exiting the facility in accordance with the Consent Agreement between the Michigan Department of Natural Resources (MDNR) and Platte Lake Improvement Association (PLIA). PRSFH regularly monitors TP levels throughout the watershed, including both Platte Lakes. All samples are collected by a Technician employed by PRSFH. The samples are analyzed under contract by Central Michigan University (CMU).

MDNR and PLIA have conference calls twice a month to discuss hatchery operations, sampling procedures, data analysis, etc. These conference calls include Ray Canale- Implementation Coordinator, Wil Swiecki- PLIA President, Gary Whelan- MDNR Fish Production Manager, Ed Eisch- MDNR, PRSFH Manager, and Aaron Switzer- MDNR, PRSFH Technician. In October of 2006 during these meetings it was determined that errors in data may be coming from CMU. A "face to face" meeting with CMU staff was set up to review their laboratory procedures.

Methods

While examining TP data anomalies in the 2006 data it appeared that on occasion the cells on the spreadsheet appeared to be shift up or down. The determination was evident by examining "cut and paste" methods used at CMU during the "face to face" meeting. At this point it was decided that random insertion of a blank sample would capture any shifts in data. The blank is simply a TP sample bottle filled with distilled water. This method was adopted in November 2006.

PRSFH performs quality control/quality assurance (QA/QC) on all data returning from CMU. The QA/QC identifies blanks and any other data anomalies. PRSFH will notify CMU immediately of any blanks that return with a high TP concentration. The purpose is to help CMU identify the reasons samples were switched and to allow them to repeat the sample.

In November of 2007 a new format for reporting results was adopted. The Implementation Coordinator worked with CMU staff to implement a protected spreadsheet that would minimize "cut and paste" errors.

Results and Discussion

At the end of 2008 there were 127 blank TP samples sent to CMU for analysis. In that time, 16 blanks have returned with TP levels greater than 4.00 ug/L. This indicates 13% of the samples have returned with TP levels that are considered unacceptable for distilled water blanks.

Eleven of the 16 samples returned high and were repeated because they fell out of the statistical parameters. All repeats returned with TP levels that were acceptable for distilled water blanks. CMU has explained this as carry over contamination from the prior sample. Therefore, 69% of the high blank returns have been affected by this circumstance.

Five of the 16 samples returned with high TP levels that were not acceptable for a blank. Two of these blank samples had a sample in the same data set, near the blank, return with a low TP level. These samples would indicate a shift in data and possible "cut and paste" errors. The other three have no clear explanation to high TP levels.

Repeats are done in duplicate and those samples are very consistent with each other. However, they can vary dramatically from the original reading. This is evident in the samples that are affected by carry over from a prior sample.

Conclusions

Thus, five of the 127 (or 4%) of the distilled water test samples were mishandled by CMU. One of these five samples has occurred since the implementation of the protected spreadsheet; it appeared to be a shift in data. This conclusion is not concrete because a new employee at CMU accidentally discarded that sample and there is no repeat data.

At this point, we have eliminated the possibility of "cut and paste" errors. Prior to the implementation of the protected spreadsheet, there was an 8% chance of error, not acceptable. Since the implementation of the protected spreadsheet, there is a 1% chance of error. This is an acceptable number; there has been a dramatic increase in the reliability of the data returning from CMU. There is a high probability that the data anomalies occurring at the beginning of this project were directly related to "cut and paste" errors.

We have accomplished that there is a 4% error rate for mishandled samples since 2006, 1% since the implementation of the protected spreadsheet. The project has successfully eliminated the "cut and paste" errors. The project is an excellent means for monitoring the reliability of results returning from CMU. Barring consent of all parties, it is recommended we continue this project as a tool for QA/QC.

APPENDIX H

SOP DOCUMENTATION

STANDARD OPERATING PROCEDURES FOR WATER QUALITY SAMPLE COLLECTION AT PLATTE RIVER STATE FISH HATCHERY

Edited and Revised
Aaron Switzer
2-20-2009

SCOPE

The Platte River State Fish Hatchery collects water quality data from Big Platte Lake and its tributaries in an effort to quantify phosphorus concentrations in the watershed. This data will also be used to detect changes in water quality over time. The ultimate goal of this effort is to restore and preserve water quality in the Platte River watershed.

PURPOSE

The purpose of this document is to provide a detailed outline of the procedures used in sample collection. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

INDEX

STANDARD OPERATING PROCEDURES
COLLECTING SAMPLES FOR CHLOROPHYLL *A* ANALYSIS

1. SCOPE/ PURPOSE

1.1 This Standard Operating Procedure (SOP) describes the procedure for using the chlorophyll *a* sampler to collect samples for Chlorophyll *a* analysis. This sample allows a composite water sample to be collected from the entire column of the photic zone. It is assumed that the photic zone of the lake being studied is two times the Secchi depth.

2. REFERENCES

2.1 Handbook of Common Methods in Limnology, Lind, Owen T., 1995.

3. DEFINITIONS

3.1 Chlorophyll *a* is a photosynthetic pigment found in plants, including phytoplankton. It constitutes about 1 to 2% of the dry weight of planktonic algae; therefore the total phytoplankton biomass may be estimated based on the chlorophyll *a* concentration.

3.2 Photic zone is the column of water reaching from the surface to the photic depth. The Photic depth is the depth that receives 1% of surface illumination.

4. MATERIALS

4.1 Tube sampler.

4.2 Brown bottles.

5. SAMPLE COLLECTION

5.1 The tube sampler is lowered 30 feet into the water column and then emptied into a 5L Nalgene brown bottle labeled “Platte Lake” or “Little Platte Lake”. This procedure is repeated three times to provide enough water for complete sample collection. At Little Platte Lake the sample is collected by the Kemmerer.

5.2 Once the sample water is collected and transported back to the lab, the 5L Nalgene brown bottle is shaken vigorously before pouring. This procedure is repeated following each chlorophyll *A* sample bottle fill.

5.3 The sample will then be poured into a 1000ml brown chlorophyll *A* bottle.

5.4 Place a 45µ filter on the filtering apparatus on the vacuum pump.

5.5 Pour 200ml of each sample into the filtering apparatus and begin filtering.

5.6 Place the filter into a mini Petri dish and label with the date, bottle number and the amount sampled.

5.7 Wrap Petri dish in aluminum foil and place in freezer until shipping.

STANDARD OPERATING PROCEDURES
CLEANING SAMPLE BOTTLES

1. SCOPE

1.1 These Standard Operating procedures (SOP's) describe the methods to be used for cleaning sample containers.

2. PURPOSE

2.1 It is critical that these procedures are followed to ensure that all sample bottles are contaminant free and that they are prepared in away that is suitable for the activities for which they are designed.

3. PROCEDURES

3.1 10 liter Nalgene plastic bottles

3.1.1 After samples are collected the bottles and tops should be rinsed with tap water and scrubbed with a brush to remove any dirt. The bottles are turned upside down in the sink and allowed to drain. Bottles should never be washed with detergents.

3.1.2 Rinse sample bottles with a 5% mixture of hydrochloric acid after each use.

3.1.3 Rinse sample bottles with distilled water and allow them to drain and dry.

3.1.4 The 30-gauge needle on the sampler should be removed and purged with a spare syringe before every sample bottle placement. The needle should be replaced if air doesn't move easily through it.

3.2 Erlenmeyer flask

3.2.1 Rinse flask with tap water and scrub with a brush to remove any dirt.

3.2.2 Rinse flask with a 5% mixture of hydrochloric acid.

3.2.3 Rinse flask with distilled water and allow it to drain and dry.

4 QUALITY CONTROL

4.1 It is critical that these procedures are followed to ensure that all equipment is contaminant free. All other sample bottles will be cleaned by CMU until further notice.

4.2 Any cleaned sample bottles with loose caps or caps missing should be return to CMU for additional cleaning.

STANDARD OPERATING PROCEDURES
USING A KEMMERER TYPE SAMPLER

1. SCOPE/PURPOSE

1.1 This standard operating procedure (SOP) describes the procedure for using the Kemmerer type sampler at discrete depths. The design of the sampler allows transfer of water into storage bottles without agitation.

2. REFERENCES

2.1 Handbook of Common Limnology Methods, Lind, Owen T., 1985

3. DEFINITIONS

3.1 The messenger is a lead device that is dropped down the line to which the sampler is attached. When it reaches the sampler it trips the device causing the plungers to close.

3.2 Water samples are collected for a variety of analysis including total dissolved solids, phytoplankton, zooplankton, phosphorous, calcium, and alkalinity.

4. PROCEDURE

4.1 The Kemmerer is opened and lowered to the depth of interest. This is determined by measured markings on the rope to which the sampler is attached.

4.2 When the desired depth is reached the messenger is dropped to close the sampler and it is raised to the surface and lifted into the boat.

4.3 The sample is then deposited into the appropriate bottles for each analysis required.

5. SAMPLER STORAGE

5.1 The sampler is stored in the open position to keep moisture from being trapped inside and to avoid plunger wear.

STANDARD OPERATING PROCEDURES
FOR COLLECTING SAMPLES FOR PHYTOPLANKTON ANALYSIS

1. SCOPE/ PURPOSE

1.1 This Standard Operating Procedure (SOP) describes the procedure for using the tube sampler to collect samples for phytoplankton analysis. This sample allows a composite water sample to be collected from the entire column of the photic zone. It is assumed that the photic zone of the lake being studied is two times the Secchi depth.

2. REFERENCES

2.1 Handbook of Common Methods in Limnology, Lind, Owen T., 1995.

2.2 Fish Hatchery Management, Piper, et al., 1982.

3. DEFINITIONS

3.1 Phytoplankton are minute pants suspended in water with little e or no capability for controlling their position.

3.2 Photic zone is the column of water reaching from the surface to the photic depth. The Photic depth is the depth that receives 1% of surface illumination.

4. MATERIALS

4.1 Tube sampler.

4.2 One 5L brown Nalgene bottle.

4.3 One 10L Nalgene bottle.

4.4 Three 250ml bottles.

5. SAMPLE COLLECTION

5.8 The tube sampler is lowered 30 feet into the water column and then emptied into a 5L brown Nalgene bottle labeled “Tube”.

5.9 The bottle is then shaken vigorously and one 250ml bottle is filled.

5.10 Add 10 drops of Lugol iodine to the 250ml sample bottle and mixed.

5.11 Pour the remaining sample into the 10L nalgene bottle. The contents will be processed at the hatchery lab.

5.12 This procedure is repeated three times to provide enough water for complete sample collection.

STANDARD OPERATING PROCEDURES
USING LI-COR RADIATION SENSORS

1. SCOPE/PURPOSE

1.1 This standard operating procedure (SOP) describes the procedure for using the Li-Cor Radiation Sensor in the atmosphere and at three foot depth intervals in Platte Lake.

2. REFERENCES

2.1 Li-Cor Radiation Sensors Instruction Manual, Li-Cor Inc., 1990

3. DEFINITIONS

3.1 The spherical quantum sensor is the light bulb like device on a lowering frame to which coaxial cable is attached. The Li-Cor model LI-250 Light Meter is attached at the other end of the coaxial cable.

3.2 The Li-Cor model LI-250 Light Meter measures photosynthetic active radiation.

4. PROCEDURE

4.1 The spherical quantum sensor and the lower frame are held in the atmosphere on the sunny side of the boat.

4.2 Attach the other end of the coaxial cable to the light meter.

4.3 Turn on the light meter by holding the ON/CAL button for at least two seconds. Pressing the ON/CAL button once more places the meter in calibration constant mode. The calibration constant for the atmosphere is -133.7. The constant can be changed by pressing the HOLD/MULTISELECT button.

4.4 Once the proper calibration constant is selected press the ON/CAL button again to put the meter in the read mode. The proper units for the read mode are umol.

4.5 A reading is taken by pressing the AVG button, which takes a 15 second average of the current readings. Take the reading for the atmosphere at this point and recorded on the data sheet. Pressing the HOLD/MULTISELECT button puts the meter back into read mode.

4.6 The meter must now be calibrated for reading in the water. Refer to 4.2 and 4.3 for this procedure. The calibration constant for the water is -216.6.

4.7 Refer to 4.4 for the procedure of taking readings. The first reading in the water is taken with the spherical quantum sensor just under the surface of the water on the sunny side of the boat.

4.8 Readings are then taken at three foot intervals until a reading of 1% of the surface reading is achieved.

4.9 The meter is then turned off by pressing and holding the OFF button. Unplug the coaxial cable from the light meter and prepare for storage. See Section 5.

5. SAMPLER STORAGE

5.1 The light meter is stored in a plastic zip lock type bag which is placed in the tool box.

5.2 The coaxial cord is reeled up on the cord reel and a sock is placed over the spherical quantum sensor. The entire apparatus is then placed in one of the Rubbermaid totes.

STANDARD OPERATING PROCEDURES FOR FISH FOOD SAMPLING

1. SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time. Part of this program includes modeling of a phosphorus budget for the Platte River State Fish Hatchery. The phosphorus contained in the food that is fed to the fish at the hatchery is a major component of the whole-hatchery phosphorus budget.

2. PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample collection when fish food is fed at the hatchery. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3. RESPONSIBLITIES

3.1 The Technician performing the preparation work shall be trained in standard procedures described within.

4. PROCEDURE

4.1 Day fish food shipment arrives –

4.1.1 Record food size and lot numbers on Fish Tissue and Food Sample Tracking spreadsheet.

4.1.2 Advise cultural staff to notify when feeding new food.

4.1.3 Make calendar with the projected start date.

4.1.4 Watch for sample from manufacturer to arrive on or near shipment date.

4.2 Manufacturer's food sample -

4.2.1 This sample is split between Central Michigan University and Lake Superior State University.

4.2.2 The sample is emptied into two Whirl-pak style bags that are labeled numerically. Please reference the Fish Tissue and Food Sample Tracking spreadsheet for the numbering system for each university.

4.2.3 Record all pertinent information into the Fish Tissue and Food Sample Tracking spreadsheet.

4.2.4 Ship or refrigerate samples depending on the day of the month and shipping schedule. Fish food samples are shipped once at the beginning of the month.

4.2.5 Enter data collected into Access database "Sample FP".

4.2.6 Create Export files, edit and print, put copies into binder in lab.

4.3 Fish Food received at the Hatchery -

4.3.1 Begin sampling fish food at the hatchery once the cultural staff has indicated they are feeding in to the fish.

4.3.2 Fish food at the hatchery is sampled in triplicate from three bags per lot code. If there are three or more pallets, sample one bag from each pallet. If there are less than three pallets, sample three bags form separate areas of the pallet. All of these samples are prepared for Central Michigan University.

4.3.3 One of the above triplicate samples is split with Lake Superior State University.

4.3.4 The samples are collected with Whirl-pak style bags that are labeled numerically. Please reference the Fish Tissue and Food Sample Tracking spreadsheet for the numbering system for each university.

4.3.5 Record all pertinent information into the Fish Tissue and Food Sample Tracking spreadsheet.

4.3.6 Ship or refrigerate samples depending on the day of the month and shipping schedule. Fish food samples are shipped once at the beginning of the month.

4.3.7 Enter data collected into Access database “Sample FP”.

4.3.8 Create Export files, edit and print, put copies into binder in lab.

4.3.9 Send Export files to PLIA Contacts.

STANDARD OPERATING PROCEDURES
SAMPLING PREPARATION

1 SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time.

2 PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample collection. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3 RESPONSIBLITIES

3.1 The Technician performing the preparation work shall be trained in standard procedures described within.

4 PROCEDURE

4.1 Day before event –

4.1.1 Conduct an inspection of YSI equipment and charge batteries if needed.

4.1.2 Inspect boat and trailer and make sure there is plenty of gas in can.

4.1.3 Gather together equipment.

4.1.4 Gather together bottles and coolers.

4.1.5 Clean any equipment or bottles that have not been cleaned.

4.2 Day of event -

4.2.1 Calibrate YSI following (SOP's) before departure.

4.2.2 Fill coolers with ice or ice packs if weather dictates.

4.2.3 Conduct sampling in accordance with (SOP's)

4.2.4 After sampling is completed. Return all equipment to designated storage location and conduct post calibration check on YSI.

4.2.5 Ship or refrigerate samples depending on the day of the week. The current schedule dictates that samples collect Friday are refrigerated and used to cool samples shipped on Tuesdays. Samples are shipped UPS at Platte River Printing.

4.2.6 Clean bottles and related equipment.

4.2.7 Enter data collected into Access database “Sample FP”.

4.2.8 Create Export files, edit and print, put copies into binder in lab.

4.3 Day after event -

4.3.1 If not done already, conduct any items not complete from the day before.

4.3.2 Conduct maintenance as needed on any equipment.

4.3.3 Send Bottle Export file to CMU.

4.3.4 Send all Export files to Ray Canale and Jim Berridge.

STANDARD OPERATING PROCEDURES
PLATTE HATCHERY, BIG PLATTE LAKE AND TRIBUTARY SAMPLING

1. SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time.

2. PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample collection. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3. RESPONSIBILITIES

3.1 The individual technician responsible for sampling shall be trained in the standard operating procedures described within.

4. PROCEDURES

4.1 Platte Hatchery sampling - per location (NOTE: Sample only the water sources being used at the present time.)

4.1.1 Effluent Pond Intake

Equipment and bottles

- (3) 250ml acid washed plastic bottles
- (1) Glass pocket thermometer
- (1) Hatchery Data Sheet

Step 1: Remove 10 liter Nalgene bottle from inlet to settling basin.
Step 2: Take temperature of sample water from 10 liter Nalgene bottle and record it with bottle numbers on data sheet.
Step 3: Shake sample container vigorously.
Step 4: Pour a small amount of water into 250ml plastic bottle. Recap shake and empty.
Step 5: Shake Nalgene bottle one more time.
Step 6: Refill to neck of bottle.
Step 7: Repeat for two remaining bottles. Swirl Nalgene bottle to keep sample well mixed before filling each bottle.

4.1.2 Upper Discharge

Equipment and bottles

- (3) 250ml acid washed plastic bottles
- (1) Glass pocket thermometer
- (1) Hatchery Data Sheet

Step 1: Remove 10 liter Nalgene bottle from the collection box for the upper discharge.
Step 2: Take temperature of sample water from 10 liter Nalgene bottle and record it with bottle numbers on data sheet.
Step 3: Shake sample container vigorously.

Step 4: Pour a small amount of water into 250ml plastic bottle. Recap shake and empty.
Step 5: Shake Nalgene bottle one more time.
Step 6: Refill to neck of bottle.
Step 7: Repeat for two remaining bottles. Swirl Nalgene bottle to keep sample well mixed before filling each bottle.

4.1.3 Brundage Creek

Equipment and bottles

(3)	250ml acid washed plastic bottles
(1)	Glass pocket thermometer
(1)	Hatchery Data Sheet

Step 1: Remove 10 liter Nalgene bottle from intake structure below bridge of county road 669.
Step 2: Take temperature of sample water from 10 liter Nalgene bottle and record it with bottle numbers on data sheet.
Step 3: Shake sample container vigorously.
Step 4: Pour a small amount of water into 250ml plastic bottle. Recap shake and empty.
Step 5: Shake Nalgene bottle one more time.
Step 6: Refill to neck of bottle.
Step 7: Repeat for two remaining bottles. Swirl Nalgene bottle to keep sample well mixed before filling each bottle.

4.1.4 Brundage Spring

Equipment and bottles

(3)	250ml acid washed plastic bottles
(1)	Glass pocket thermometer
(1)	Hatchery Data Sheet

* Brundage Spring samples are collected at the 55 gallon reservoir in the boiler room during periods in which water is being used in the Hatchery Building or at the spring pond intake structure when water is not being used in the Hatchery Building.

Step 1: Remove 10 liter Nalgene bottle from its location witch will depend on were is water is being used.
Step 2: Take temperature of sample water from 10 liter Nalgene bottle and record it with bottle numbers on data sheet.
Step 3: Shake sample container vigorously.
Step 4: Pour a small amount of water into 250ml plastic bottle. Recap shake and empty.
Step 5: Shake Nalgene bottle one more time.
Step 6: Refill to neck of bottle.
Step 7: Repeat for two remaining bottles. Swirl Nalgene bottle to keep sample well mixed before filling each bottle.

4.1.5 Platte River

Equipment and bottles

(3) 250ml acid washed plastic bottles
(1) Glass pocket thermometer
(1) Hatchery Data Sheet

Step 1: Remove 10 liter Nalgene bottle from river just below pump house.
Step 2: Take temperature of sample water from 10 liter Nalgene bottle and record it with bottle numbers on data sheet.
Step 3: Shake sample container vigorously.
Step 4: Pour a small amount of water into 250ml plastic bottle. Recap shake and empty.
Step 5: Shake Nalgene bottle one more time.
Step 6: Refill to neck of bottle.
Step 7: Repeat for two remaining bottles. Swirl Nalgene bottle to keep sample well mixed before filling each bottle.

4.2 Big Platte Lake

Equipment Requirements

Boat and motor
Life jackets
YSI 600R/Sonde/cord
Kemmerer/messenger
Secchi disk/line
Zooplankton net/rope
Tube sampler/10L bottle
GPS
Extra batteries C/AA/ 9V
Pencil x2
Formalin
Tap water wash bottle
Lugols Iodine solution
Lake Data Sheet

Bottles

(1) 10L acid washed plastic bottle
(2) 5L acid washed brown bottles
(8) 125ml acid washed plastic bottles
(9) 200ml rinsed plastic bottles
(33) 250ml acid washed plastic bottles
(7) 250ml acid washed plastic bottles
(1) 500ml acid washed plastic bottles

4.2.1

Step 1: Record the lake gauge height (by outhouse) on data sheet.
Step 2: Locate sampling waypoint on GPS unit and anchor boat at that position.
Step 3: Calibrate YSI 650 MDS and 600R sonde for depth (see YSI calibration SOP).
Step 4: Lower sonde on cable to each required depth. Allow values to stabilize approximately two minutes and record values for temperature, conductivity, D.O, pH and ORP on data sheet.

Step 5: Use Kemmerer to collect water at Surface, 7.5ft, 15ft, 30ft, 45ft, 60ft, 75ft, and 90ft, and fill bottles. The remaining water left in the sampler form depths of 45-90 shall be collected and mixed into the 5L brown bottle labeled 45+. (See Kemmerer SOP)
Step 6: Record bottle numbers on sheet.
Step 7: Determine Secchi Disk Depth (see Secchi Disk SOP)
Step 8: Record Secchi Depth on data sheet.
Step 9: Use tube sampler (x3) to collect a composite sample in the 5L brown bottle labeled tube. (see Phytoplankton SOP)
Step 10: Record bottle number on data sheet.
Step 11: Use tube sampler (x4) to collect a composite sample in the 10L bottle. Agitate sample and collect in respective bottles.
Step 12: Record bottle number on data sheet.
Step 13: Add 10 drops of Lugols Iodine solution to all phytoplankton bottles.
Step 14: Lower zooplankton net and collect a sample from three individual hauls. (See Zooplankton SOP)
Step 15: Record bottle number on data sheet.

4.3 Tributaries – per location

4.3.1 Platte River at M-22 Bridge

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet

Step 1: Lower Dip Sampler off center of bridge.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet.
Step 6: Fill 200ml bottle for turbidity readings and NOX.
Step 7: Read gauge height and record value on data sheet.

4.3.2 North Branch Platte River at Dead Stream Rd.

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet
(1)	PVC Staff Gage

Step 1: Lower Dip Sampler off center of catwalk.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet.
Step 6: Fill 200ml bottle for turbidity readings and NOX.
Step 7: Read staff gauge height at the upper section of the fish ladder and record value on data sheet.

Step 8: Lower PVC staff gage along the north keyway on the dam read staff gage at the top of the keyway and record value on data sheet.

4.3.3 Platte River at US Hwy31 Bridge below Honor

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet

Step 1: Lower Dip Sampler off center of bridge.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet.
Step 6: Fill 200ml bottle for turbidity readings and NOX.
Step 7: Read gauge height and record value on data sheet.

4.3.4 Featherstone Creek

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet

Step 1: Lower Dip Sampler off center of culvert.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet and NOX.
Step 6: Fill 200ml bottle for turbidity readings.

4.3.5 Platte River at Stone Bridge

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet

Step 1: Lower Dip Sampler off center of bridge.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet and NOX.
Step 6: Fill 200ml bottle for turbidity readings.

4.3.6 North Branch Platte River at Hooker Rd.

Equipment and bottles

(1)	Dip Sampler
(3)	250ml acid washed plastic bottles
(1)	200ml rinsed bottle
(1)	Tributary Data Sheet

Step 1: Lower Dip Sampler off center of culvert.
Step 2: Fill bottle, agitate and empty.
Step 3: Refill to neck of bottle.
Step 4: Repeat for two remaining bottles.
Step 5: Record bottle numbers on data sheet and NOX.
Step 6: Fill 200ml bottle for turbidity readings.

4.4 Little Platte Lake

Equipment Requirements

Boat and motor
Life jackets
YSI 600R/Sonde/cord
Secchi disk/line
Kemmerer
Tube sampler
GPS
Extra batteries C/AA/ 9V
Pencil x2
Lugols Iodine solution
Lake Data Sheet

Bottles

(1)	5L acid washed brown bottle
(5)	125ml acid washed plastic bottles
(1)	200ml rinsed plastic bottle
(3)	250ml acid washed plastic bottles
(6)	250ml acid washed plastic bottles
(1)	500ml acid washed plastic bottles

4.4.1

Step 1: Locate sampling waypoint on GPS unit and anchor boat at that position.
Step 2: Calibrate YSI 650 MDS and 600R sonde for depth (see YSI calibration SOP).
Step 3: Lower sonde on cable to required depth. Allow values to stabilize approximately two minutes and record values for temperature, conductivity, D.O, pH and ORP on data sheet.
Step 4: Use Kemmerer to collect water at Surface and fill all sample bottles. (See Kemmerer SOP)
Step 5: Record bottle numbers on sheet.
Step 6: Determine Secchi Disk Depth (see Secchi Disk SOP)
Step 7: Record Secchi Depth on data sheet.
Step 8: Add 10 drops of Lugols Iodine solution to all phytoplankton bottles.

STANDARD OPERATING PROCEDURES
SLUDGE HAULING

1 SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time. Part of this program includes modeling of a phosphorus budget for the Platte River State Fish Hatchery. The phosphorus contained in the sludge that leaves the hatchery is a major component of the whole-hatchery phosphorus budget.

2 PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample collection while the sludge tank is being emptied. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3 RESPONSIBLITIES

3.1 The Technician performing the preparation work shall be trained in standard procedures described within.

4 PROCEDURE

4.1 Day before event –

4.1.1 Notify PLIA contacts via email.

4.1.2 Gather together 250 ml sample bottles labeled in red lettering - sludge.

4.1.3 Print waste collection data sheets.

4.1.4 Gather together digital camera and GPS.

4.2 Day of event -

4.2.1 Meet with truck drivers to discuss sampling protocol.

4.2.2 Collect three samples from each load leaving the hatchery grounds. Collect samples at the beginning, middle and end of each load.

4.2.3 Record date, time, gallons loaded and sample bottle numbers.

4.2.4 It is essential that the Technician ride along or follow truck drivers to the injection site. Digital photographs should be taken at the site and GPS coordinates recorded. Photos should include the injection unit during the actual injection process. Send this information, including photos, to the PLIA contacts.

4.2.5 Ship or refrigerate samples depending on the day of the week and shipping schedule.

4.2.6 Enter data collected into Access database “Sample FP”.

4.2.7 Create Export files, edit and print, put copies into binder in lab.

4.3 Day after event -

4.3.1 Send Export files to PLIA Contacts.

4.3.2 Monitor level of sludge tank and fill rate.

STANDARD OPERATING PROCEDURES
SLUDGE TANK AND CLARIFIER OVERFLOW SAMPLING

1. SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time. Part of this program includes modeling of a phosphorus budget for the Platte River State Fish Hatchery. This data is used to detect changes in water quality over time.

2. PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample collection. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3. RESPONSIBLITIES

3.1 The Technician performing the preparation work shall be trained in standard procedures described within.

4. PROCEDURE

4.1 Clarifier Overflow Sampling (Site 28)

Equipment and bottles

- (3) 250ml acid washed plastic bottles - RED labels
- (1) 200ml rinsed bottle – RED labels
- (1) Production Waste Data Sheet

Step 1: Check clarifier to assure it is full and overflowing.
Step 2: Collect samples at the pipe that enters the effluent pond on the east side bank.
Step 3: Fill bottle, agitate and empty.
Step 4: Refill to neck of bottle.
Step 5: Repeat for two remaining bottles.
Step 6: Record bottle numbers on data sheet.
Step 7: Fill 200ml bottle for turbidity readings.
Step 8: Place 250ml bottles in Ziploc bag and store in refrigerator.
Step 9: Run turbidities and record on data sheet.

4.2 Sludge Tank Overflow Sampling (Site 27)

Equipment and bottles

- (3) 250ml acid washed plastic bottles - RED labels
- (1) 200ml rinsed bottle – RED labels
- (1) Production Waste Data Sheet

Step 1: Check sludge tank to assure it is full and overflowing.

Step 2: Collect samples at the pipe that enters the effluent pond on the east side bank.
Step 3: Fill bottle, agitate and empty.
Step 4: Refill to neck of bottle.
Step 5: Repeat for two remaining bottles.
Step 6: Record bottle numbers on data sheet.
Step 7: Fill 200ml bottle for turbidity readings.
Step 8: Place 250ml bottles in Ziploc bag and store in refrigerator.
Step 9: Run turbidities and record on data sheet.

STANDARD OPERATING PROCEDURES
SECCHI DEPTH TRANSPARENCY

1. SCOPE/ PURPOSE

1.1 Secchi disk transparency is used to estimate photic depth.

2. REFERENCES

2.1 Handbook of Common Methods in Limnology, Lind, Owen T., 1985.

3. DEFINITIONS

3.1 The Secchi dick is a 20-cm disk on which opposite quarters are gloss black and gloss white.

3.2 Photic zone is the column of water reaching from the surface to the photic depth.

3.3 The photic depth is the depth that receives 1% of surface illumination.

4. MATERIALS

4.1 Secchi disk.

4.2 Calibrated line.

5. PROCEDURES

5.1 Lower the Secchi disk on the calibrated line until it disappears from view. Record this depth.

5.2 Raise disk until it reappears and record depth.

5.3 The average of these depths is “Secchi Disk Transparency.”

5.4 Make the determination of Secchi disk transparency in the shade of the boat.

5.5 Do not wear sunglasses when making the determination.

STANDARD OPERATING PROCEDURES FOR WATER SAMPLE SHIPPING

1. SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time. Part of this program includes modeling of a phosphorus budget for the Platte River State Fish Hatchery. This data is used to detect changes in water quality over time.

2. PURPOSE

2.1 The purpose of this document is to provide a detailed outline of the procedures used in sample preparation collection. Adherence to a consistent sampling protocol is vital to ensure data is of a known quality and integrity.

3. RESPONSIBLITIES

3.1 The employee performing the preparation work shall be trained in standard procedures described within.

4. PROCEDURE

4.1 Gather together cooler.

4.2 Recruit biologist or another technician to load cooler.

4.3 That individual must check each bottle cap and bottle to ensure that they are securely fastened, not damaged and not leaking.

4.4 Once loaded: inspect, photograph and sign off with the individual on the export sheet that is in the Water Sample Copies binder in the lab.

4.5 Add the bottle export hard copy and any additional packing material.

4.6 Place an ice pack in the cooler and close the lid tight.

4.7 Use the clear packing tape in the lab to secure the cooler lid, twice in each direction.

4.8 Use the colored tape in the lab to wrap around the cooler once covering the tag end of the packing tape.

4.9 Photograph and load into truck for shipping via UPS at Platte River Printing.

STANDARD OPERATING PROCEDURES
SIGMA MODEL 900 PORTABLE SAMPLER

1. SCOPE/PURPOSE

1.1 This standard operating procedure (SOP) describes the procedure for using the Sigma 900 portable samplers. There are five of these samplers located on the hatchery grounds. The design of the sampler allows it to sample a calibrated volume of water at programmed time intervals over a 24 hour period.

2. REFERENCES

2.1 Model 900 Standard Portable Sampler – Instrument Manual, American Sigma, 2002

3. DEFINITIONS

3.1 Platte River State Fish Hatchery uses this type of automated sampler to monitor the amount total phosphorus entering and exiting the hatchery.

4. PROCEDURE

4.1 The Sigma sampler is opened by removing the cover that contains the keypad.

4.2 The properly labeled acid washed 10L wide mouth poly carboy is placed inside the unit.

4.3 The cap on the carboy is removed and placed into the Ziploc bag inside the unit.

4.4 Replace cover.

4.5 Press the START button located in the center of the keypad at the top.

4.6 The display will read “START OR RESUME PROGRAM?” - press the START button.

4.7 Within 30 seconds the display will read “PROGRAM RUNNING”.

4.8 Return in approximately 24 hours.

4.9 Press the CHANGE/HALT key, #2 on the keypad. The display will read “PROGRAM HALTED”. Collect the sample and replace cover.

5. SAMPLER MANTENANCE

5.1 The sampler tubing should be replaced at least once every six months or as needed.

5.2 The sampler should be calibrated at the time of tube replacement or as needed. Refer to the Sigma binder in the lab for these methods.

5.3 Any maintenance and/or modifications to the program is recorded and entered into the Sigma Log - Access database and the Sigma binder.

STANDARD OPERATING PROCEDURES
STREAM FLOW METER

1. SCOPE/PURPOSE

1.1 This standard operating procedure (SOP) describes the procedure for ensuring accurate meter performance (Pygmy and Price AA) in the field.

2. REFERENCES

2.1 USGS, Office of Surface Water Technical Memorandum No. 89.07

3. DEFINITIONS

3.1 The current meters are used to determine flow and velocity of the flowing waters in the Platte Lake Watershed.

4. PROCEDURE

4.1 The meters are visually inspected before field measurements are made. Bent cups and other signs of wear will give inaccurate flow results.

4.2 Before taking field measurements, a full timed spin test should be performed. A spin test simply means spinning the cups and recording the time it takes for the cups to stop moving.

Minimum acceptable spin test times are:
Pygmy meter: 0:45 seconds
Price AA meter: 2:00 minutes

4.3 A record of spin tests is kept in the current meter log.

4.4 Between measurements in the field, the cups are spun (not timed) to check for smooth operation.

5. SAMPLER STORAGE

5.1 The meters are dried and stored in their protective cases provided by the manufacturer.

STANDARD OPERATING PROCEDURES
HACH TURBIDIMETER OPERATION

1. SCOPE/PURPOSE

1.1 This standard operating procedure (SOP) describes the procedure for using the Hach Turbidimeter in the Platte River State Fish Hatchery water quality lab. Turbidity in water is the presence of suspended solids, which reduce the transmission of light either through scattering or absorption.

2. REFERENCES

2.1 Laboratory Turbidimeter Instruction Manual, Hach Company, 1999

3. DEFINITIONS

3.1 The turbidimeter is used to measure the presence of suspended solids.

4. PROCEDURE

4.1 Warm samples to room temperature to avoid condensation on the sides of the sample tube.

4.2 Turn ON turbidimeter and allow warm up time of 30 minutes.

4.3 Fill sample tube to the white line at the top. Apply a thin bead of silicone oil to the surface of the sample cell. Spread the oil uniformly across the surface using the black oiling cloth. The surface should appear dry, not wet.

4.4 The sample cell is then placed into the turbidimeter. Open the cover and line up the white down arrow on the sample cell with the arrow on the turbidimeter. Close cover and press ENTER.

4.5 The first number to appear on the display is used for the first reading, readings are NTU. Readings are done in triplicate, repeat procedure with two more samples.

4.6 The meter must be checked monthly to verify the instruments calibration using Gelex Secondary Standards.

4.7 Refer to the laminated Quick Reference Guide for clarification on the above procedure and calibration of the meter.

4.8 When finished using the turbidimeter turn OFF and replace transparent dust cover.

STANDARD OPERATING PROCEDURES
HOBO WATER LEVEL LOGGER

1 SCOPE/ PURPOSE

1.1 The HOBO water level logger is used to determine flow rates entering and exiting the clarifier. The unit is also used when performing flow rate calibrations to inflowing hatchery water.

2 DEFINITIONS

2.1 The water level logger is a 6" x 1" solid stainless steel cylinder.

2.2 The Optic USB Base Station is device used for communication between the water level logger and the computer. It is located in the laboratory at the hatchery.

2.3 The stilling well is a 4" PVC pipe attached to the catwalk of the clarifier. It is used to stabilize the water surrounding the level sensor.

3 MATERIALS

3.1 HOBO water level logger.

3.2 Optic USB Base Station.

4 PROCEDURES

4.1 Launching Logger

4.1.1 Insert water level logger into optic USB base station and open HOBOware program on computer desktop.

4.1.2 Follow onscreen prompts to launch logger.

4.1.3 Once logger is successfully launched remove from base station and transfer to clarifier stilling well.

4.1.4 Insert water level logger into screw cap and lower into the stilling well.

4.2 Retrieving Logger

4.2.1 Remove water level logger from the stilling well.

4.2.2 Insert water level logger into optic USB base station and open HOBOware program on computer desktop.

4.2.3 Follow onscreen prompts to retrieve data from logger.

4.2.4 Transfer data into an Excel spreadsheet and email to implementation coordinator.

STANDARD OPERATING PROCEDURES FOR CALIBRATION OF YSI 650 MDS AND 600R SONDE

1 SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time.

2 PURPOSE

2.1 This (SOP) describes the proper procedure for calibration of YSI 650 MDS and 600R sonde units. These instruments are used for the collection of water quality data on Big Platte Lake and its tributaries. Adherence to a consistent calibration protocol is necessary to ensure effective and consistent water quality data collection.

3 REFERENCES

3.1 YSI Environmental Operation Manual

4 CALIBRATION

4.1 The YSI 650 MDS and 600R sonde are calibrated in the lab at Platte River State Fish Hatchery. All calibration solutions are stored in the lab. The YSI 650 MDS and 600R are always calibrated prior to use on the day that it is used in the field.

4.2 Conductivity Calibration

4.2.1 Rinse the calibration cup twice with distilled water, then once with 0.02N KCL solution. Fill the calibration cup with the 0.02N KCL solution such that the conductivity block is fully submerged. Tap the sonde unit to dislodge any possible air bubbles.

4.2.2 Select “Sonde Menu”, then “calibrate”, “conductivity”. Then “spcond”.

4.2.3 Enter the value 2.76 ms/cm for calibration of (0.02N KCL). The display will then return to the data display screen, with the option “calibrate” highlighted. Record the displayed spcond value as the initial reading. Then select enter; the calibration will stabilize and be completed. Record the displayed value in the YSI calibration logbook as the calibrated value. Select the highlighted option “continue” by pressing enter. The display will then continue with options. Advance to “sonde run”.

4.2.4 Rinse the calibration cup twice with distilled water then once with 0.01N KCL solution. Fill the calibration cup with the

0.01N KCL solution such that the entire conductivity block is fully submerged. Tap the unit to dislodge any air bubbles.

4.2.5 Record the displayed conductivity value in the logbook as the "initial reading".

4.2.6 After use in the field, conduct the post-calibration procedure by repeating 4.2.1 and 4.2.3. The displayed value for each solution should be recorded as the "after use" value. The difference between the "after use" value and the "calibrated value" (for 0.02N KCL) and "initial value" (for 0.01N KCL) should be recorded as drift.

4.3 Oxidation Reduction Potential (ORP)

4.3.1 To determine if the sensor is functioning correctly place the probe in 3682 Zobell solution and monitor the millivolt reading. The probe should read in the range of 221-241 at normal ambient temperature (17-32 degrees Celsius). If the reading is out side this range, the probe can be calibrated to the correct value outlined in section 2.6.1 of the operations manual.

4.4 Temperature

4.4.1 The temperature sensor is factory calibrated.

4.5 Depth Calibration

4.5.1 Calibration of depth should occur in the field immediately prior to use.

4.5.2 Suspend sonde unit so that the probe is just above water surface. Select "sonde menu", then "calibrate", then "pressure –ABS" on display unit. Enter calibration value (0.0 feet). The display will then return to the data display screen, with the option "calibrate" highlighted. Select enter, and the calibration will stabilize and be complete.

4.6 pH Calibration

4.6.1 Remove the weighted probe guard from sonde. Rinse calibration cup and probes with distilled water. Thoroughly mix container of pH 7 buffer, making sure the solution is dated and fresh. Rinse the probes in the calibration cup with pH 7 buffer, and then fill the cup with buffer until all probes are submerged. Allow readings to stabilize for approximately 90 seconds.

4.6.2 Select "Sonde Menu", then "Calibrate", then "pH" then "3 point cal " on the display unit. Enter the first pH buffer for calibration (pH 7). The display will then return to the data display screen, with the option "calibrate" highlighted. Record the displayed pH value as the initial reading in the YSI calibration logbook. Then select enter, the calibration will stabilize and be completed. Record the new displayed value in

the YSI calibration logbook as the calibrated value. Select the highlighted option “continue” by pressing enter.

4.6.3 Repeat for both pH 10 and pH 4.

4.6.4 After use in the field conduct the post-calibration procedure by repeating 4.6.1 for all three-pH solution. The displayed values should be recorded as the after use value in the YSI calibration logbook. The difference between the “after use” value and the “calibrated” value is the drift.

4.7 **Dissolved Oxygen (DO) calibration**

4.7.1 Start the vacuum pump attached to air stones. The air stones are in two 10L glass bottles, one refrigerated and one at room temperature. Let the vacuum pump run at least one half hour to completely saturate the water.

4.7.2 Place sonde (with attached weighted probe guard) into five-gallon DI water bucket in lab. Allow the unit to stabilize in bucket for 10 minutes.

4.7.3 Obtain the current barometric pressure from weather station, read in inches (in.) of Hg. Convert this value to millimeters (mm) of Hg through a multiplication factor of (25.4). Record the mm of Hg value in YSI calibration logbook.

4.7.4 Select “Sonde Menu”, then “Calibrate”, then “DO%” on the display unit. Enter the calculated barometric pressure “mm/Hg”. The display will return to the data display screen, with the option “calibrate” highlighted. Press enter and the calibration will stabilize and be completed.

4.7.5 Place the sonde into the refrigerated 10L glass bottles from 4.7.1 which are now saturated with oxygen. Let the 650 stabilize approximately 90 seconds. Record the value for DO% and DO mg/L. Repeat this procedure for the 10L glass bottle at room temperature. Compare these readings to the Oxygen Saturation at Temperature spreadsheet posted on the side of the refrigerator. The 650 DO mg/L readings should be within the hundredth. If not consult the YSI Operations Manual for proper recalibration procedures.

4.7.6 After use in the field, conduct the post-calibration procedure repeating 4.7.1 through 4.7.5 as listed above. The difference between the displayed DO value recorded in the logbook and the post-calibration reading is the drift, which should be recorded in the logbook.

STANDARD OPERATING PROCEDURES
AND MAINTENANCE OF YSI 650 MDS AND 600R SONDE

1 SCOPE

1.1 The Platte River Fish Hatchery collects water quality data from Platte Lake and its tributaries as part of an ongoing water quality program. This data is used to detect changes in water quality over time.

2 PURPOSE

2.1 This (SOP) describes the proper procedure for care maintenance and storage of the sonde and probes that will maximize their lifetime and minimize the time required getting ready for a new application.

3 REFERENCES

3.1 YSI Environmental Operation Manual

4 PROCEDURE

4.1 After use the YSI 650 MDS and 600R sonde should be cleaned and stored in the lab.

4.2 The cable is cleaned and recoiled, clean and lubricate the rubber connectors. Store the sonde unit with ~ ½ inch of tap water in storage cup.

4.3 Replace Dissolved Oxygen (DO) membrane every 30 days. Avoid over stretching the membrane, invert sonde unit several times; check for trapped air bubbles under the membrane.

4.4 Rinse pH bulb with tap water to remove any film or debris. If good readings are not established, soak the probe in a dishwashing liquid 10-15 minutes. A cotton swab can be used gently to clean the bulb if needed.

4.5 Clean the conductivity block and electrodes with dishwashing liquid solution every four months.

4.6 The temperature sensor is factory set and requires no maintenance.

4.7 The function of the Redox (ORP) sensor should be checked quarterly against a standard Zobell's solution.

STANDARD OPERATING PROCEDURES
COLLECTION AND PRESERVATION OF ZOOPLANKTON SAMPLES

1 SCOPE/ PURPOSE

1.1 A zooplankton tow net is used to collect zooplankton in Platte Lake. The samples are preserved and sent to the lab for analysis.

2 DEFINITIONS

2.1 The zooplankton net is conical in shape and has a metal frame at the large opening and a male plastic connection at the small opening.

2.2 The plankton bucket attaches to the male plastic connection at the smaller opening on the zooplankton net.

3 MATERIALS

3.1 Zooplankton net and plankton bucket.

3.2 Calibrated line.

4 PROCEDURES

4.1 Connect the calibrated line to the frame at the large end of the zooplankton net.

4.2 Lower the zooplankton net slowly into the water. Make sure there are no air bubbles trapped in the net. Continue to lower the net until the 85' mark is reached. The 85' mark is bright red edged with black.

4.3 Once the 85' mark is reached allow the line to become taut and begin retrieving the net. The average rate of retrieval is 60 seconds.

4.4 When the net reaches the surface hold vertically above the water surface and splash surface water onto the sides of the net to wash down any zooplankton stuck to the inside of the net.

4.5 Remove the plankton bucket form the net and pour its contents into a 250ml sample bottle, be sure to record the bottle number on the Laboratory Data Form.

4.6 Spray down the inside of the plankton bucket with a squeeze bottle filled with tap water from the hatchery. Repeat.

4.7 Add formalin to the sample bottle to preserve the zooplankton. The amount of formalin is approximately 20% of the total sample volume.

5 STORAGE

5.1 Following sampling the net is rinsed and hung in the lab to dry. The plankton bucket is removed, rinsed and inverted for drying.

5.2 Once dry the plankton bucket is placed back on the net. A sock is used to cover the bucket to prevent damage to the net. The net is carefully folded up in a towel and put into storage.

APPENDIX I

CERTIFICATION LETTERS

STATE OF MICHIGAN
JENNIFER M. GRANHOLM
GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
LANSING

REBECCA A. HUMPHRIES
DIRECTOR

February 18, 2009

Dr. Raymond P. Canale
710 SW Manitou Trail
Lake Leelanau, MI 49653

Dear Dr. Canale,

The purpose of this letter is to certify that I have reviewed all data analysis results received from Central Michigan University's Water Research Laboratory for the year 2008.

I have compared all bottle tracking numbers that have left the laboratory at Platte River State Fish Hatchery with all bottle tracking numbers and results received from Central Michigan University's Water Research Laboratory. I certify that these results are accurate and correct. Any discrepancies have been clearly noted in writing to you and all involved with the Consent Agreement.

Sincerely,

Aaron Switzer, Fisheries Technician
Platte River State Fish Hatchery
15210 US Hwy 31
Beulah, MI 49617

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www.michigan.gov/dnr ● (517) 373-2329

STATE OF MICHIGAN
JENNIFER M. GRANHOLM
GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
LANSING
REBECCA A. HUMPHRIES
DIRECTOR

February 13, 2009

Dr. Raymond P. Canale
710 SW Manitou Trail
Lake Leelanau, MI 49653

Dear Dr. Canale,

The purpose of this letter is to certify that I have reviewed and updated the Water Sampling Preventive Maintenance and Calibration Schedule for the year 2008.

All equipment calibration and preventive maintenance has been completed. All equipment is in good working order. The LiCor meter is currently on loan to Central Michigan University. Please review and contact me with any questions.

Sincerely,

Aaron Switzer, Fisheries Technician
Platte River State Fish Hatchery
15210 US Hwy 31
Beulah, MI 49617

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STATE OF MICHIGAN
JENNIFER M. GRANHOLM
GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
LANSING
REBECCA A. HUMPHRIES
DIRECTOR

February 19, 2009

Dr. Raymond P. Canale
710 SW Manitou Trail
Lake Leelanau, MI 49653

Dear Dr. Canale,

The purpose of this letter is to certify that I have reviewed and updated all Standard Operating Procedures related to water quality sample collection for the year 2008.

There has been one Standard Operating Procedure for sampling fish food added this year. There was also one Standard Operating Procedure added for shipping. Please review and contact me with any questions.

Sincerely,

Aaron Switzer, Fisheries Technician
Platte River State Fish Hatchery
15210 US Hwy 31
Beulah, MI 49617

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