FINAL
WEBSTER / HIGHLAND LAKE WATERSHED MANAGEMENT PLAN
Quality Assurance Project Plan
Phosphorus Load Modeling and Reduction Calculations
Using the Reckhow and STEPL Models

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A3 & A4 – Distribution List and Project Organization.

Table 1 presents a list of people who will receive the approved QAPP, the QAPP revisions, and any amendments as well as their role and project responsibilities.

Table 1.0 - QAPP Distribution List and Project Roles and Responsibilities

QAPP Recipient Name	Project Role	Organization	Responsibilities	Telephone number and Email address
Peter Walker	VHB QA/QC Manager	Vanasse Hangen Brustlin, Inc	Project QA/QC	603-644-0888 pwalker@vhb.com
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Vincent Perelli	NHDES Quality Assurance Manager	NHDES Planning Unit	Responsible for NHDES review and approval of QAPP	603-271-8989 vperelli@des.state.nh.us
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A5 – Problem Definition/Background

The overall project purpose is to prevent further water quality degradation and to improve future water quality of Webster Lake, located in the City of Franklin, NH, through the development and implementation of a watershed management plan. A "Partnership Group" has been formed consisting of local officials from the City of Franklin and the Town of Andover, NHDES representatives from the Watershed Management Bureau, representatives from the Webster and Highland Lakes Association and other community members. The partnership group will assist in the development and implementation of watershed management plan and other ongoing activities. The proposed modeling and pollutant loading analysis, described in greater detail in this QAPP, is an integral component of the watershed management plan and will provide the basis for determining what types and at what locations Best Management Practices (BMPs) could be implemented to prevent further degradation and/or improve future water quality in Webster Lake. As noted in Table 1, the consulting firms of Vanasse Hangen Brustlin, Inc (VHB). of Bedford, NH and Hutchins Consulting Services of Salisbury, NH, was retained by the partnership group, to perform the pollutant loading / modeling procedure and identify feasible BMPs that could be implemented to achieve the project goals. Naturesource communications of Boscawen, NH, an independent firm specializing in education and outreach activities, will assist in facilitating the public meetings and the educational components during the development of the watershed management plan.

Webster Lake, in recent years, has experienced more frequent blooms of nuisance algal and particularly cyanobacteria. The NH Department of Environmental Services (DES) has identified Webster Lake as being negatively impacted by pollutants contributed from the watershed. Ongoing water quality sampling conducted by, either NHDES personnel and/or through the Volunteer Lake Monitoring Program (VLAP), has revealed that certain pollutants such as turbidity, phosphorus and the presence of E. coli bacteria are the principal concerns for poor water quality. Phosphorus is perhaps the pollutant of greatest concern because excessive inputs, as in most lakes, stimulates algal productivity and can lead to increased amounts of nuisance algae and especially cyanobacteria. Increased algal productivity is referred to as eutrophication, which results in other adverse water quality effects such as reduced water clarity and dissolved oxygen depletion at depth as the algal biomass dies off and decomposes as it sinks to the bottom causing greater oxygen demand. Since phosphorus readily binds to sediment, preventing soil erosion and controlling sediment transport are often essential components for reducing phosphorus inputs. Soil erosion and sediment transport are generally linked to land disturbing activities such as agricultural practices, timber harvesting, and construction activities and can also include erosion from dirt roads and winter sand applications. Other sources of phosphorus include fertilizer use on lawns, feedlot manure, internal loading from bottom sediments during anoxic conditions, sediment disturbances or shoreline erosion due to boating activity and/or wave action, and faulty shoreline septic systems.

Previous studies and related reports have documented extensive water quality data pertaining to Webster Lake and its tributaries. A 1981 Report, entitled Water Quality Management Investigation: Webster Lake, prepared by Dufresne-Henry, Inc. contains phosphorus concentrations and loading estimates for the principal watershed sources including tributary inputs, shoreline septic systems and atmospheric deposition. Since 1986, various lake water quality data including phosphorus and chlorophyll a concentrations, transparency, and temperature and dissolved oxygen has been measured by VLAP monitors during summer months and the data is documented in the individual VLAP Annual Reports prepared by the NHDES Lakes Management personnel. In 1991, NHDES prepared a Diagnostic/Feasibility Study for Webster Lake, which generated additional phosphorus loading information including stream flow gauging data for the major tributaries and updated land use information.

Current Modeling Goals

The purposes of this current modeling effort are three-fold:

1. To update the previous estimates of relative phosphorus contributions and sediment loading from the various land uses within the watershed and on a sub-watershed basis
2. To estimate the possible load reductions that could be achieved through implementation of various feasible Best Management Practices (BMPs).
3. To determine whether the selected BMP measures and expected load reductions for phosphorus would result in a meaningful reduction in the in-lake phosphorus concentrations and would improve future water quality conditions.

A step-wise process will be followed to achieve these goals, using a combination of available modeling procedures (See Section B2 for a detailed description of the selected models). The modeling will be preformed on a watershed and sub-watershed basis using GIS based information to depict sub-watershed boundaries, land use conditions and other management practices or activities within watershed that may affect phosphorus loading. The sub-watershed boundaries will be compared to previous mapping information and will be verified through field observations. The minimum size of the sub-watershed area will be 5% of the overall watershed area. Land use data will then be incorporated into the map using the GIS based land use data compiled by Lakes Region Planning Commission using 2003 aerial photography and any other supplemental data sources. This land use information will be field checked through limited field reconnaissance and review by local residents that are members of the Partnership Group. The following sections provide additional details on the data quality objectives and modeling approach for this project.

A6 – Project/Milestone Description

The modeling effort will focus on the entire Webster and Highland Lake watersheds, which are located almost entirely in Andover and Franklin, New Hampshire and encompass approximately 11,800 acres of land. See attached watershed map. The modeling will be applied both on a watershed and sub watershed basis, which will help to prioritize the type and best locations for BMP implementation.

The proposed project timeline is outlined in Table 2.0. This study only pertains to the pre-implementation modeling/calculations phase of this project. The results will be used to identify feasible and potentially effective BMPs that could reduce phosphorus loads to Webster Lake. Preliminary locations, sizing, design and cost information will be provided, but the actual implementation of these BMPS will be performed in a subsequent phase to this project with additional funding sources to be determined later.

Table 2.0 - Project Schedule Timeline

Activity	Dates		Product	Due Date
	Anticipated Date(s) of Initiation	Anticipated Date(s) of Completion		
QAPP Preparation	03/25/2006	05/18/2006	QAPP Document	5/18/2006
Pre-implementation modeling/calculations	05/18/2006	06/15/2006	Execute Modeling Procedure	6/15/2006
Interim Progress Report	06/15/2006	06/30/2006	Interim Memo- Existing Data Summary	06/30/2006
Model Procedure Review and QA/QC Assessment	06/30/2006	08/15/2006	Draft Watershed Management Plan	08/15/2006
Final project report preparation	09/012006	10/11/2006	Final Report Preparation	10/24/2006

A7 – Quality Objectives and Criteria

The proposed modeling procedure focuses on estimating relative phosphorus contributions from each of the various land uses and watershed activities and to identify potential BMPs, or combination thereof, that could result in a substantial phosphorus load reduction to Webster Lake. A substantial phosphorus load reduction, for purposes of this project, is one that would reduce the in-lake phosphorus concentration by a minimum of 2.0 parts per billion (ppb) based on the Vollenweider equation. With an existing average in-lake phosphorus concentration of 14.0 to 15.0 ppb, a 2.0 ppb reduction would represent nearly a 15 % reduction. Any BMP, or combination thereof, that would produce less than a 2.0 ppb reduction in the in-lake phosphorus concentration, would be considered not cost-effective given the inherent uncertainties of this procedure. An in-lake phosphorus reduction of 3.0 to 4.0 ppb or roughly 20% or more is a preferred target since it is likely to produce discernable water quality improvement, particularly with respect improved clarity and a reduction in algal biomass. The estimated cost and level of effort required to achieve a substantial reduction in phosphorus will have to be weighed against the expected level of uncertainty inherent to the model results. An assessment of the quality of the data inputs to be used in the model is discussed in Section B.5.

The predicted phosphorus loads using the model procedure, without BMPs, will be checked against the previous phosphorus budget analyses prepared by NHDES (1991) using observed tributary phosphorus concentrations and measured stream flow as a means of limited verification or "reality' check. The previous budget data should provide a reasonable baseline for comparison and verification purposes, since it was generated from measured data collected on a weekly and monthly basis and the predicted in-lake phosphorus concentration using the phosphorus budget data compared favorably (i.e., within 10 %) of the measured in-lake phosphorus concentration of 14 ppb. The modeled predictions generated from this study will be compared to the previously estimated phosphorus budgeted loads on a tributary and overall lake watershed basis. The model results for this study will be considered acceptable if the predicted phosphorus load results in an estimated in-lake phosphorus concentration that is within 20 % of the observed in-lake phosphorus concentration. The primary goal of the model is evaluating the effectiveness of various BMPs in reducing pollutant loads while targeting specific pollutant sources rather than developing a highly accurate phosphorus budget analysis.

A8 – Special Training/Certification

This modeling effort requires proficient knowledge, experience and understanding of the pollutant loading /land use interactions and lake response dynamics to phosphorus inputs. The scientists performing the modeling calculations and the related water quality interpretations of findings are experienced senior level scientists having 20 or more years of experience in surface water impact analysis, pollutant loading and limnological investigations. The appropriate user guides and manuals provided with the models described in Section B2 will be used to guide the modeling process.

A9 – Documents and Records

The modeling methods, assumptions and results will be presented in detail in the Draft and Final versions of the Watershed Management Plan that will be prepared for the Webster / Highland Lake Partnership Group. The Draft Watershed Management Plan is anticipated to be completed and presented to the partnership group by August 15, 2006. The Draft will be available for public review and at a public hearing to receive public comment scheduled for late August. Following partnership and public review, the watershed management plan will be finalized and submitted in both hard copy and electronic format. All project–related memos will be submitted to the partnership group. An interim memo will be prepared

to summarize potential sampling data needs that could be completed in the future by possible student interns, volunteers or city or agency personnel. Another interim memo is planned to summarize the relevant findings of previous studies related to Webster Lake. This interim memo is anticipated to be provided to the partnership group by the June 15th, 2006.

B1 – Project Design (Experimental Design)

As discussed earlier, the primary goal is to identify feasible and cost-effective BMPs that could result in a substantial reduction in phosphorus loading to Webster Lake. The rationale for BMP selection will be based on the magnitude of the anticipated load reduction, projected capital, construction and operational costs, required land area, ease of implementation or likely willingness of affected property owner, if appropriate, and available funding resources. Other considerations may include whether or not the potential BMP may control other pollutants, and maintenance requirements.

The supporting information for each of the BMPs considered, including detailed location maps, preliminary design information and a comparative summary matrix table will be provided in the Draft Watershed Management Plan. The BMP recommendations will be consistent and will support the nine elements of the EPA Section 319 Watershed Restoration Grants.

B2 – Model/Equation Methods

The phosphorus loading predictions will be performed utilizing two separate models including the Reckhow Model (rev 1999) and the Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model (Version 3.1; Sept. 2005) prepared for US EPA by Tetra-Tech, Inc. The Vollenweider equation will be used to convert the estimated phosphorus load and load reductions into in-lake phosphorus concentrations.

Annual phosphorus load contributions from the various land uses will be estimated using the Reckhow Model (Reckhow et al. 1980). The Reckhow Model is a lumped-parameter, spreadsheet model that can be used to estimate a total average annual phosphorus load (i.e., kg/ha or lbs/acre) on a watershed or sub-watershed scale based on empirically-derived phosphorus loading coefficients for different land uses. The Reckhow Model has been widely used and generally accepted for nutrient loading estimates, and is often preferred due to its ease of use. NHDES has worked with the model developer in periodically updating the loading coefficients based on new empirical data generated within the region. The most recent update was conducted in 1999. The Reckhow Model was used by the NYC DEP to perform phosphorus loading analyses in major watersheds contributing to the NYC surface water supply reservoirs in upper state New York. (National Academy Press, 2000). The model does have limitations, however, in that it does not allow the user to assess temporal variability (i.e., daily, monthly, seasonal) in phosphorus loading, nor spatial variability within the watershed nor does it provide estimates of phosphorus removal efficiencies for various Best Management Practices (BMPs).

The Reckhow Model will be supplemented with the use of the Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model (Version 3.1) developed for the US EPA and updated in September 2005 (Tetra Tech, Inc. 2005). The STEPL Model has a major advantage in that it is designed to calculate the average annual loading of both phosphorus and sediment based on runoff volume and pollutant concentrations in runoff as influenced by land use and management practices within a watershed. The added feature of estimating sediment loads can be used to compare to previously measured sediment accumulation rates in the lake. Perhaps, more importantly, the sediment loading component can be used to evaluate how improved erosion control standards for soil-disturbing activities and how sediment filtering or settling

type BMPs could reduce predicted loads. Sediment inputs to the lake can also be predicted. Sediment has been identified as an important contributor to elevated turbidity and in-lake phosphorus concentrations either from internal loading or due to watershed inputs from existing dirt roads and winter sanding practices.

The simulation of runoff and ultimately stream flow within each sub-watershed allows the modeler to evaluate how monthly or seasonal changes in hydrology affect annual loading. This temporal variability has been shown to be a critical factor in previous phosphorus budget analyses preformed by NHDES and could be very important in evaluating the effectiveness of various BMPs that may be influenced by seasonal conditions. The hydrology simulation also allows for additional verification of the model by comparing estimated stream flow with observed stream flow extrapolated from a nearby USGS gauging station. Close comparison of predicted versus observed conditions would substantially raise the level of confidence in the model predictions and would suggest a greater likelihood of success in ultimately reducing pollutant loads through implementation of the selected BMP.

The land uses considered in the model include cropland, pasture land, feedlot, forest and urban land, which compares favorably with the predominant land uses in the Webster lake watershed. The major pollutant sources inherent to the model calculations include cropland, pastureland, farm animals, urban runoff and failing septic systems. The types of farm animals considered include beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys and ducks based on user-defined quantities of each. The other major advantage to the STEPL model is that there are a number of BMPs and their expected pollutant removal efficiencies built into model so that the user can evaluate the effects of various types and combinations of BMPs on pollutant loads. The user can modify the removal efficiency to provide more conservative estimates, if desired. The BMPs are geared toward more rural land uses and include such practices as filter strips, runoff diversions, contour farming, reduced tillage systems, terracing, fencing and stream bank stabilization, mulching and seeding, to name a few, and are more in line with the types of BMPs that could be used in the Webster Lake watershed.

The downside to using the STEPL Model is that it does require additional data inputs and will involve additional person-hours to set up and execute the model compared to other more straight-forward spreadsheet type models, like the Reckhow Model. The added time and effort will presumably result in having greater confidence in the model output and less uncertainty that can help to guide the decision-making process into a successful outcome of reduced pollutant loads. The model does contain default values for critical factors such as weather and soil information based on regional county data within the various states. This data can be used and later modified, if need be, depending on the results of the model runs. The sub-watershed data and land use distribution within each sub-watershed will be based GIS data layers provided by the NH GRANIT system and Lakes Region Planning Commission, respectively. The land use data is based on 2000 Evaluation of Aerial Photos by the Lakes Region Planning Commission.

The final step in the modeling process involves converting the estimated phosphorus load from the watershed into an in-lake phosphorus concentration, which is accomplished by using the Vollenweider equation. The Vollenweider equation mathematically computes an average annual in-lake phosphorus concentration (ppb) from an estimated average annual phosphorus load (Kg/ha) while accounting for the lake's mean depth and hydraulic residence time.

B3 – Quality Control

The model input data sheets will be reviewed for transcription errors following completion of final model runs by the Project QA/QC Manager. Land use data and sub-watershed data will be reviewed against the GIS computations and the previous data published in the NHDES Diagnostic / Feasibility Data. The model output in terms of phosphorus loading will be compared to other previous phosphorus budget

results as a reality check to compare differences with the other model procedures and with the phosphorus budget results for the various tributaries contained in the 1991 D/F Study that was based on observed phosphorus concentration and stream flow data. NHDES as part of the 1991 D/F study showed that the estimated phosphorus concentration predicted by the Vollenweider equation, using the previously estimated total phosphorus load, was closely correlated with the observed in-lake phosphorus concentration. This procedure will be used again to compare the proposed modeling results with more recent observed in-lake phosphorus data, as a verification step. The model will be considered acceptable for the purposes of this study if the predicted in-lake concentration using the model results is within 20 percent of the observed in-lake phosphorus concentration as documented by the most recent VLAP monitoring report. The model development and execution will be performed by an experienced Limnologist and Water Quality Specialist who are members of the project team and identified earlier in this QAPP. The model output and data analysis will be discussed and reviewed by NHDES personnel that are intimately familiar with the Webster Lake watershed.

B4 – Inspection/Acceptance of Equipment and Materials

This section does not apply since there is no new equipment or material purchases planned for this project.

B5 – Non-Direct Measurements

Table 3.0 lists the types of data, the data source and general assessment of the data quality in terms of expected level of accuracy given its source and inherent quality assurance review and procedures.

Table 3.0 –Data Types, Source Information and Quality Assessment for Model Input

Data Type	Source	Assessment of Data Quality *(i.e., poor to excellent)*
Historical Phosphorus Conc. Data	NHDES D/F Study 1991; VLAP Data 1986-present	Very Good*
Land Use data –GIS format	Lakes Region Planning Commission	Good*
Gauged Tributary Flow Data	NHDES D/F Study 1991	Good*
GIS Topography / Soils Watershed Data	NH GRANIT Data	Excellent*
Hourly Precipitation Data	National Climate Data Center	Excellent*

Note: * The data rated as very good to excellent is considered to be generated from highly reliable sources with established QA/QC procedures. The data rated as good is also considered to be generated from reliable sources and/or procedures but less is known about the data collection QA/QC procedures.

B6 – Data Management

All input data, assumptions and model results will be saved in VHB project files both in hardcopy and electronic format, if available. Electronic data will be stored on VHB's network server which is backed up automatically on a daily basis. An electronic project folder system has been set up with dedicated folders labeled for model data/output. Each model run will be numbered sequentially and labeled according to its specific purpose (e.g. exist-conditions., filter strip-50 ft., flow diversion, etc). An evaluation of potential BMPs will not be performed until the model output adequately reflects existing stream flow and in-lake phosphorus concentration in accordance with data quality objectives specified in Section A7.

C1 – Assessments and Response Actions

All modeling runs will be reviewed by the project team's Senior Water Quality Specialist and Senior Limnologist for quality assurance regarding the model input and output and particularly to ensure that the model output reasonably reflects existing conditions or the expected results in evaluating various BMP measures. Final model summary sheets will be reviewed by the project QA/QC Manager. If the model predictions indicate that the various BMPs tested, or combinations thereof, will not result in load reductions sufficient enough to cause the desired reduction in the in-lake phosphorus concentration, then the Grant Managers and NHDES representatives will be notified of the results and a meeting will be scheduled to review the model assumptions, approach and results.

C2 – Reports to Management

The project status and preliminary results will be discussed with NHDES personnel at the Webster/ Highland Lake Partnership Group (PG) meetings that are scheduled for June, August, September and October of 2006 as well as through periodic phone conversations and emails. The preliminary modeling results will presented at the June PG meeting. An interim memo will be provided to NHDES and the PG outlining the general assumptions, methods and findings. Following review and receipt of comments by NHDES, PG and through the public meetings, the modeling procedures will be revised and updated, accordingly, prior to submittal of the DRAFT Watershed Management Plan to be submitted to the partnership group on August 15th. The Final Watershed Management Plan is scheduled to be submitted to the PG, City of Franklin and NHDES in early November.

D1 – Data Evaluation of Load Reduction Estimates

See Sections B1, B2, B3, C1 and C2 above for detailed descriptions of the modeling approach and load reduction evaluations and reporting of findings.

D2 – Evaluation and Project Success

The project's success in achieving load reductions will be assessed through the results of future monitoring conducted through the volunteer lake assessment program (VLAP) in Webster Lake. Following the implementation of the selected BMPs, it is anticipated that future monitoring will show a declining trend in in-lake phosphorus concentrations. The presence, extent and duration of nuisance algal blooms will hopefully diminish as measured through general observations by lake users. It is anticipated that through this VLAP process that the success of this Watershed Management Plan will be documented.

D3- References

Dufresne-Henry. 1981. Water Quality Management Investigation. Webster Lake. Franklin, NH

NH Department of Environmental Services. 1990. Webster Lake Diagnostic Feasibility Study, Principal Investigator. Mr. Jody Conner, DES Limnology Center.

U.S. Environmental Protection Agency. October 2005. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. EPA Office of Water. EPA 841-B-05-005. Washington. D.C.

U.S. Environmental Protection Agency. Sept 2005. User's Guide; Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), Version 3.1. Developed by Tetra-Tech, Inc. Fairfax, Virginia.

Appendix A:

NHDES Watershed Assistance Grant Proposal Application Form Completed by the City of Franklin, NH

Appendix B:

Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) User's Guide