A Concept Proposal
IJC-LCBP Partnership
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Missisquoi Watershed (US sector) Non-point Phosphorus Critical Source Analysis

Introduction

The Lake Champlain Basin management plan, *Opportunities for Action–An Evolving Plan for the Future of the Lake Champlain Basin* (2003) was endorsed by the governors of New York, and Vermont, the Directors of USEPA Regions 1 and 2, and contains a letter of commitment from the Premier of Quebec. The management plan identifies four highest priority management goals for Lake Champlain, one of which is the reduction of phosphorus in Lake Champlain. Widely considered the most critical water pollution issue in the Lake, phosphorus levels in Missisquoi Bay remain very high, averaging approximately 0.045 mg/l through the past several years. These levels reflect excessive phosphorus entering the bay from the adjacent rural watershed.

The Province of Quebec and the State of Vermont are working both individually and jointly, through their transboundary partnership in the Lake Champlain Basin Program (LCBP), to reduce phosphorus concentrations in Missisquoi Bay. Special challenges of phosphorus reduction in the Missisquoi River Basin are described in the 2002 *Memorandum of Agreement* between the Province of Quebec and the State of Vermont that apportions responsibility for phosphorus load reduction as 40% and 60% respectively. Recent monitoring data indicates that load reductions have been very difficult to achieve. There has been a reduction in phosphorus in the Quebec sector (Pike River) but the comparatively larger Vermont sector of the Missisquoi River drainage basin is particularly problematic.

Three cross-boundary tributary rivers, the Missisquoi, Rock and Pike Rivers, contribute the main phosphorus load to Missisquoi Bay. Stream discharge and phosphorus concentration data collected at points along these rivers indicates that phosphorus loading arises primarily as nonpoint source load from the agricultural landscape and from gradational fluvial geomorphic processes.

Recent and Ongoing Stewardship

From 2004 to 2007, acting in the area of its jurisdiction, the Province of Quebec has invested more than $1million in research, monitoring and modeling of agricultural non-point loading to identify sensitive areas and critical sources of nutrient loads and the effectiveness of best management practices. Management planning in critical source areas of the Quebec sector of the watershed is supported by hydrologic modeling techniques, detailed soil information, micro-topographic terrain analysis based on high resolution laser (LiDAR) elevation data, multispectral remote sensing imagery and

program and regulation enforcement. Plan implementation efforts benefit greatly from the research, monitoring and modeling on which Quebec's management planning is particularly based.

In the Vermont sector of the Missisquoi Bay watershed, amounting to 720 square miles, the non-point source nutrient loading challenge is greater, in part due to its greater areal extent. In order for nutrient management planning to be effective in the Vermont sector of the Missisquoi Bay watershed similar research, monitoring and modeling of non-point loading, particularly from agricultural and developed areas, to identify critical sources of nutrient loads is required.

A key partner in the LCPB, the State of Vermont's Agency of Natural Resources, released a draft workplan for the *Center for Clean and Clear* (August, 2007) identifying Vermont's strategies for implementing the bi-state Lake Champlain Phosphorus TMDL. While no International Joint Commission funds will be directed to any compliance or implementation task, it is noteworthy that Vermont's draft workplan highlights the need for more effective targeting of scarce management resources to critical source areas of non-point source pollution.

US Environmental Protections Agency phosphorus reduction efforts managed by the Lake Champlain Basin Program have supported a program of long term monitoring of water quality in Missisquoi Bay and at the mouth of the Missisquoi River since 1992. Resulting water chemistry and biological data for Missisquoi Bay and for the Missisquoi River provide a basis for nutrient load estimates, long-term trend analyses and measures of success or failure of stewardship efforts.

International Joint Commission support for farm nutrient management planning in the Missisquoi watershed, through the Lake Champlain Basin Program, is now in its second year. This task is developing 30 nutrient management plans on small farms in the watershed through a voluntary program of consultation with nutrient management specialists. Nutrient management plans will conform to the USDA NRCS 590 standard, and are subject to review by NRCS partners at the conclusion of the project.

In January, 2008, The US Department of Agriculture–Natural Resource Conservation Service, working with other LCBP partners, prepared *The Missisquoi Areawide Plan: A Watershed Approach to Improving Water Quality in Lake Champlain.* This management plan is focused on reducing agriculturally-related phosphorus pollution in Missisquoi Bay. *The Missisquoi Areawide Plan* has assembled and made available a wide array of existing geographic and physical data pertaining to non-point phosphorus contamination, identified several significant data and information gaps, and provided a framework for water quality efforts to be supported by the Conservation Title of the US Farm Bill.

Immediate Needs

Three collaborative resource management initiatives reflect the immediate needs of the Lake Champlain Basin Program partners, and are expressed in *Opportunities for Action (LCBP),* the *Center for Clean and Clear* workplan (Vermont), and *The Missisquoi Areawide Plan (NRCS).* These three plans present phosphorus reduction priorities and needs at increasing levels of specificity and geographical detail.

The Missisquoi Areawide Plan has identified several severe limitations in available data, including:

- "…our gaps in knowledge and the risk associated with implementing programs and practices in such uncertainty";
- The need for an "… understanding of how sediment and phosphorus enter the Bay and the relative magnitude of those sources";
- "Sufficient data needs to be collected in order to evaluate the results of our decisions and then make needed adjustments";
- "High resolution digital aerial photography … would greatly aid in the targeting of specific problem areas, especially if on-site access is difficult to obtain";
- LiDAR (Light Detection and Ranging laser remote sensing) "…data could be used to more accurately determine the slope of crop fields. It could … be used to identify steep areas of concentrated runoff within field areas…identify classic gullies. … LiDAR would be an effective means of identifying scour erosion in floodplains."
- Monitoring water quality on tributaries within the watershed would be a valuable targeting tool in the Missisquoi watershed.

Most urgently needed is an analysis of critical sources of phosphorus loading of tributary drainage in the US sector of the Missisquoi, Rock and Pike Rivers. Such an analysis will enable managers to allocate scarce management resources more effectively to reduce the phosphorus load carried by tributaries, and eventually to reduce the phosphorus concentration in Missisquoi Bay. Combined with an assessment of best management practices and improved tributary monitoring data an adaptive management program will become possible. The critical analysis of sources in the US sector of the Basin should be developed in terms that reflect the experience of LCBP partners in the Province of Quebec in order to permit more effective collaboration across the boundary, and a more unified approach to stewardship throughout the international watershed.

Proposed Tasks

The four tasks proposed below support a thorough assessment of critical sources of phosphorus in the Vermont sector of the Missisquoi River watershed. The approach proposed for each task is directly responsive to the highest priority phosphorus reduction goals of *Opportunities for Action* (2003), and also reflects specific needs identified in the *The Missisquoi Areawide Plan: A Watershed Approach to Improving Water Quality in*

Lake Champlain 2008. While these tasks are not directed toward any compliance requirements under either State or Federal law, they are developed in collaboration with the State of Vermont's Clean and Clear Center, which seeks to implement the bi-state Lake Champlain Phosphorus TMDL and would benefit greatly from the information resulting from this effort.

Under the proposed task plan, the LCBP will be authorized to enter into sub-contractual agreements to obtain the data and analyses associated with several tasks. Other tasks will be managed directly by LCBP staff. Sub-contracts in excess of $20,000 awarded for the implementation of tasks under this agreement will be the result of the established LCBP Request-For-Proposals process. The LCBP RFP process for sub-contracts includes a professional and confidential peer review of both task proposals and key deliverables, ranking of reviewed proposals by the LCBP Technical Advisory Committee and a Record of Decision by the Lake Champlain Steering Committee or its Executive Committee.

Task 1: Critical Source Area Methodological Workshop

To benefit directly from the considerable Quebec experience with hydrologic modeling and agricultural non-point source load source analyses in the Canadian sector of the Missisquoi watershed, LCBP will convene a workshop and follow-up meetings for the sharing of information about recent applications of the USDA Soil and Water Assessment Tool (SWAT), LiDAR digital elevation data and related geographical analyses in Quebec. The workshop will explore the optimal parameters for identification and definition of critical source areas, and the specific algorithmic options available for the use of SWAT and related geographical analysis techniques in the US sector of the Missisquoi watershed. The workshop will also address methodology for projecting the spatial extent and nutrient loading significance of spring flooding and tributary monitoring needs through the year.

Workshop participants will include colleagues from the Quebec Ministry of Développement Durable, Environnement et Parcs, researchers from the Institut de Recherche et de Developpement en Agroenvironnement (IRDA), and from McGill University's Macdonald Campus, as well as other LCBP partners, researchers from academic institutions in Vermont and New York, Vermont Agency of Natural Resources, Vermont Agency of Agriculture, Food and Markets, the USDA NRCS VT office, US Geological Survey, other US Federal agency partners and other professionals as appropriate.

Task deliverables will include:

- A Final Report will include the workshop agenda, preparation materials, a list of participants, a summary of discussions and concluding recommendations..

Task Implementation: *LCBP Staff will implement this task*
Task Duration: *October - November, 2008*
Task Budget: *$30,000*

Task 2: ***LiDAR and Aerial Photographic Data Acquisition***

Since the summer of 2006, LCBP partners have been assembling existing GIS data layers, integrating databases, and identifying priorities for information and analysis. The overarching goal was to identify management options to reduce the delivery of Phosphorus to waters of Lake Champlain, especially to Missisquoi Bay. This project has resulted in *The Missisquoi Areawide Plan: A Watershed Approach to Improving Water Quality in Lake Champlain*, including an assemblage of databases and a summary analysis of data needs. As partners in Quebec have already demonstrated the suitability of the USDA Soil and Water Assessment Tool (SWAT) with local modifications for critical source analyses, the application of a similar modeling framework is of heightened interest for use in the US sector of the Missisquoi watershed.

Among the most challenging gaps in available information required for an effective application of SWAT is high resolution geo-referenced digital elevation data needed for analysis of slope angle and aspect of fields and areas of concentrated runoff, and the connectivity of micro-topographic features such as ditches. Existing elevation data are of coarse resolution and poorly suited to this application. The Quebec experience as well as the broader literature demonstrates that LiDAR digital elevation data are well suited to this application.

A second input requirement for the effective application of the SWAT model and other essential geographical analyses is large-scale digital aerial photography. Simultaneous conventional color and or color infrared aerial photography will be included in the LiDAR aerial mission, permitting a detailed manual assessment of land use, land cover, farm practices, farmyard drainage, impervious surface conditions, and the connectivity of numerous ditches that empty into streams.

LCBP will sub-contract the task of acquiring LiDAR and digital photographic imagery over the watersheds draining into Missisquoi Bay. RFP preparation and review of deliverables will include close collaboration with the Natural Resource Conservation Service, US Geological Survey and the Vermont Agency of Natural Resources Center for Clean and Clear. The subcontractor will be selected from respondents to the LCBP's RFP.

Task specifications, subject to adjustments resulting from the outcome of the workshop (Task 1), to be reflected in the RFP include:

- Low level, high density LiDAR and large-scale aerial photography acquisition over Missisquoi Bay watersheds will be acquired.
- LiDAR data specifications will meet minimum FEMA standards, to maximize usefulness for digital floodplain mapping not presently available in the study area.
- Ground truth references at the time of data acquisition will be provided.
- An LCBP-approved Quality Assurance Project Plan (QAPP) will be required.

- A mid-fall 2008 mission schedule (after leaf drop and before snow) is desired. Alternatively, a spring 2009 mission schedule (after snow melt and before leaf-out) will be accommodated.
- Deliverables from contractor will include
    - Raw LiDAR point-cloud data and geo-referenced bare-earth raster elevation data with artifact removal.
    - Contractor's metadata and preprocessing error reports
    - Digital color and or color infrared aerial photographic image data.
    - Appropriate mission specifications, metadata, flight report, flight line data and instrument package documentation.

Task Implementation: *LCBP will subcontract through an RFP process*
Task Duration: *October - November, 2008: data acquisition*
November, 2008 – March, 2009: data pre-processing
March - May, 2009: Contract Final Deliverables
Task Budget: $295,000

Task 3: Short-term Synoptic Tributary Monitoring

To address the need for more detailed spatial data of tributary nutrient concentration and load within the watershed and to support improved calibration and validation of modeling of nutrient loading, a short-term tributary monitoring program will be developed. A two-year water quality monitoring program will be established at 10 or more bridges or other appropriate locations within the public rights-of-way, on tributaries of the Missisquoi, Rock and Pike Rivers in the US Sector of the watersheds, where conditions permit.

This task includes preparing a topographic profile of the channel cross-section at monitoring sites, and periodic sampling of nutrient concentrations and stream velocity. Workplan elements of sampling location, frequency, measurement parameters, and analytic techniques will be approved by the Lake Champlain Basin program, in consultation with its Technical Advisory Committee and subject to approval of the International Joint Commission Project Officer. An LCBP-approved Quality Assurance Project Plan (QAPP) will be required.

Task deliverables will include:

- 10 or more new water quality monitoring stations will be established at selected tributary sites within the Vermont sector of the Missisquoi Bay watershed and maintained for a period of two sampling years (April-September).
- A survey of stream cross-sectional profile adequate for discharge calculations will be established at each monitoring site.
- Water quality parameters sampled are yet to be finalized, but will include total phosphorus, dissolved phosphorus, nitrogen and suspended

sediments, sampled at approximately weekly intervals and also following precipitation events.
- Stage and velocity measurements will be made at sampling intervals to permit calculation of tributary discharge, flow adjustment and tributary nutrient load, and to contribute to a stage-discharge record.
- An LCBP-approved Quality Assurance Project Plan (QAPP) will be required.
- Raw digital data of nutrient concentration, stage, discharge, cross-sectional profile and related metadata will be provided.

Task Implementation: *LCBP will subcontract through an RFP process*
Task Duration: *December, 2008 - October, 2010*
Task Budget: *$72,000*

Task 4: SWAT Analysis with other Geographical Analyses

This task is an analysis of critical sources of phosphorus loading of tributary drainage in the Vermont sector. In order to identify critical sources of non-point phosphorus loading of tributaries of Missisquoi Bay, a watershed model based on the USDA Soil and Water Assessment Tool (SWAT) will be developed for the US sector of the of the Missisquoi, Rock and Pike Rivers. Other locally important GIS-based geographical analyses also may be required in association with this task. Where possible, this analysis of sources in the US sector of the Basin should benefit from the shared experience of LCBP partners in the Province of Quebec, in order to permit more effective collaboration across the boundary, and a more unified approach to stewardship throughout the international watershed.

This task will have at its disposal the report of (Task 1) the *Critical Source Area Methodological Workshop* subject to the timeline provisions indicated. Also to be made available for this task will be the data produced by (Task 2) *LiDAR and Aerial Photographic Data Acquisition*, and by (Task 3) *Short-term Synoptic Tributary Monitoring,* subject to the timeline provisions indicated. The USDA Natural Resource Conservation Service's 2008 draft *Missisquoi Areawide Management Plan* has assembled and interpreted a significant array of geographical and farmstead data providing a preliminary and general assessment of agricultural source areas. The report also identifies numerous informational sources and links to economic and agricultural data and physical environmental resource data required for this task. The SWAT modeling task and related geographical analyses should, where possible, build upon and extend the results of the NRCS report.

This task is intended to enable resource managers to better allocate scarce management resources to reduce the phosphorus load carried by tributaries, and eventually to reduce the phosphorus concentration in Missisquoi Bay. The watershed modeling and critical source analysis will consider and characterize all major phosphorus sources including:

- agricultural operations,
- other developed lands of all sorts,
- roads and other impervious surfaces, and
- fluvial processes acting within river corridors.

The pollutant of primary focus in this task is total phosphorus, but there is significant interest in dissolved phosphorus, nitrogen and suspended sediments. An LCBP-approved Quality Assurance Project Plan (QAPP) will be required.

Deliverables will include:

- A Final Report with supporting digital files describing a functional watershed model based on the NRCS Soil and Water Assessment Tool and including relevant modeling algorithms that are clearly defined and well documented.
- Attendant data used to drive the model should be clearly presented, well documented and accompanied by metadata as appropriate.
- A report on significant phosphorus source areas, including:
  - a quantitative characterization of critical area load,
  - spatial data of critical area location and extent,
  - a narrative descriptive analysis of associated land use, physical site conditions, other environmental factors and management practices driving the designation of critical areas,
- A characterization of Best Management Practices, with regard to reductions in phosphorus load, that are best suited to critical source areas,
- A sensitivity analysis to characterize the degree to which input parameters have impacted the results of the modeling effort,
- A characterization of model calibration and parametric uncertainty,
- Documentation of specific adaptations of the SWAT model found appropriate in this task.

Task Implementation: *LCBP will subcontract through an RFP process*
Task Duration: *December, 2008 - December, 2010*
Task Budget: *$240,000*

Summary Task Budget

Task 1: Methodological Workshop	$ 30,000
Task 2: LiDAR, Aerial Photographic Data	$ 295,000
Task 3:Tributary Monitoring	$ 72,000
Task 4: SWAT and Geographic Analyses	$ 240,000
LCBP Task Coordination, Administration	$ 52,000
LCBP Project Indirect Costs	$ 111,000
TOTAL	**$ 800,000**