GUIDANCE MANUAL
TO EXPLORE NONPOINT SOURCE NUTRIENT TRADING
IN LONG ISLAND SOUND WATERSHEDS

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PUBLIC SUMMARY

The purpose of this document is to provide guidance for the exploration of nutrient trading involving urban and non-urban nonpoint sources (NPS) of pollution primarily in the in-basin drainage areas tributary to Long Island Sound (LIS). Although nutrient trading (as a watershed-based program) has long been in the toolbox for nutrient control strategies in this region, it has been so far used only for the point sources of pollution (i.e., publicly owned wastewater treatment works, POTWs) in the State of Connecticut.

Both the New York State Department of Environmental Conservation (NYSDEC) and the State of Connecticut Department of Environmental Protection (CTDEP) will need to review regulations and allow a voluntary generation and trading of nutrient reduction credits to meet water quality goals under applicable laws and regulations. Credits can also include actions associated with sediment control, as a surrogate water quality improvement measure, related to nutrient reduction. The guidance is aimed at stimulating further discussions and initiatives at the LIS Scientific and Technical Advisory Committee (STAC) to facilitate total nitrogen (TN) trading involving NPS loads.

Phase III of LIS Total Maximum Daily Load (TMDL) requires a ten (10%) percent reduction from various NPS loads from baseline conditions. This reduction appears to be modest and can possibly be achieved through implementation of best management and low impact development (BMP/LIDs) within each source category, e.g., urban, forestry and agriculture. After the achievement of 58.5% TMDL target reductions from point sources by 2014 or soon after, it may be determined from ongoing monitoring that further reductions in NPS loads may be necessary to eliminate or reduce hypoxia.

Control of NPS loads is still largely voluntary. Underestimation of NPS control costs and overestimation of point source control costs have triggered alarming concerns about the cost-effectiveness of point to NPS trades. Similarly, the excessive monitoring needs associated with NPS performance evaluation add significant costs to the administrative and technical elements of trading. These factors often lead to NPS trading being less cost-effective and more demanding in terms of administrative, regulatory and policy elements, in comparison to point source trading.

Long-term achievement of water quality goals may inevitably involve NPS reductions beyond
the initial 10% target. In addition, the NPS controls can be designed to achieve several auxiliary objectives including sustainability, streambank protection, water reuse, and flood mitigation that enhance the ecosystem valuation aspects of NPS control projects. Point source controls essentially achieve load reductions with minimal to no achievement of auxiliary objectives. Therefore, a major paradigm change needs to occur from the current viewpoint of NPS control projects or trading initiatives as revenue generating or cost-saving mechanisms, and consider them as part of the toolbox for contributing to long-term sustainability and ecosystem restoration aspects of watershed management.

This guidance document is aimed at instigating pilot trading implementation projects with full support and active participation from both NYSDEC and CTDEP, so that trading truly becomes a part of a long-term adaptive management toolbox for NPS nutrient control. Based on the stakeholder meetings held, some key technical, administrative and regulatory barriers had been identified that would need to be addressed by undertaking pilot trading implementation projects. Two candidate watersheds were used here to quantify pollutant loads from various sources to provide perspectives on the potential for trading. These include the Saugatuck River watershed in Connecticut and Oyster Bay Harbor and Mill Neck Creek watershed in Nassau County, New York. Additional modeling work performed to support this quantification is provided in separate appendices for the New York and Connecticut watersheds, respectively.

It is recommended that trading strategies be explored in two stages based on the complexity of regulatory review and approval. First stage can involve urban and non-urban NPS as well as point discharges that are aimed at cost-effective achievement of reductions at watershed scales (i.e., within a watershed). Many of the reported impediments to establishing a structured, viable trading program can be overcome with additional planning and implementation at a watershed-scale. Specific suggestions and considerations for stakeholders (including regulatory agencies) in the LIS drainage areas for Stage 1 trading exploration are provided below.

1. Nonpoint to nonpoint source exchange programs (direct trades or offsets) can look promising when goals such as “no-net-increase in loads” are aimed at and imposed on new and redevelopment projects;

2. Septic systems and large nutrient loads from these systems must be included in the trading program. Conversion of septic systems into sewered areas or serviced by small
package plants can reduce loads into groundwater and into surface water from failing septic systems;

3. CTDEP’s point source trading has already established many challenging elements of a trading program including the trading ratios, stakeholder communications, and a market-based framework. Extension of these to include NPS loads is viable, but due to lack of cost competitiveness of NPS controls to the point sources, a market-like or incentive-based framework will be more appropriate for NPS trading;

4. States can steer the trading program with development of guidance documents or manuals such as West Virginia, Pennsylvania, Michigan and Minnesota. Alternatively, they can support third-parties to administer and manage trades, thereby, reduce the liability on trade participants and the administrative burden on regulatory agencies;

5. Integration of permit requirements for wet weather discharges and treatment plants can offer incentives for trading. This “group-permit” approach for POTWs and urban/suburban NPS sources in NY and CT drainage areas can allow a sustained and effective way of tracking and permitting of TN loads, if managed at sub-watershed or municipal scales using applicable trading ratios; and

6. Valuation methods must go beyond the traditional cost-effectiveness calculations. Long-term sustainability outlook involving ecosystem valuation or multi-objective decision models must be used to support the trading evaluations.

The second stage can involve cross-media and other more complex strategies including: (a) reduction of loads from atmospheric sources (through air permitting) and linking to other water quality pollutant sources included in Stage 1; and (b) nutrient uptake or dissolved oxygen improvement in the waterways (e.g., coastal wetlands, in-stream aeration, and oyster farming) and relating those to NPS loads coming from upstream drainage areas. Potential strategies proposed in Stage 2 will require longer timeframe to overcome barriers in the air and water quality permitting programs or to establish equivalency of in-stream or open-water treatment technologies and the associated reductions in upstream NPS. Fundamental and applied research efforts are necessary to enhance our understanding of Stage 2 projects and these may require 2-5 years of timeframe to initiate, evaluate and disseminate findings. Therefore, it is recommended that pilot implementation projects be undertaken in the near-
term (less than 2 years) focusing on Stage 1 with urban and non-urban NPS and research efforts be undertaken over 2-5 years to support the Stage 2 initiatives.

It must be emphasized that this guidance document or examples provided are not adjudication or a regulation that individuals or watershed agencies can undertake on their own. Pilot projects and discussions at the STAC level must be pursued to gain approval from regulatory agencies (NYSDEC and CTDEP) so that permits or credit-tracking mechanisms can be well established for a watershed-wide application and prepared for regulatory acceptance.

Finally, this guidance document is aimed at promoting discussions within in-basin drainage areas involving CTDEP and NYSDEC. Upstream drainage areas located in other states and the Province of Quebec in Canada can use this guidance but the exploration of trading strategies will need to be performed in collaboration with the respective regulatory agencies.
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DEFINITIONS/ ACRONYMS

**Aggregator/Broker** - An entity that can buy and track credits from individual sources such as farmers or POTWs. It can then sell credits in a marketplace or directly to buyers such as point source or MS4 permit holders.

**AVGWLF** – ArcView Based Generalized Watershed Loading Functions Model

**Best Management Practices (BMPs)** - Structural, vegetative, or management practices that are process-based treatment systems designed to reduce nutrient loads carried by runoff from drainage areas upstream of these systems, and thereby reduce loads to the receiving water downstream.

**CAA** – Clean Air Act

**CCMP** – Comprehensive Conservation and Management Plan

**Certification** – Review and approval of credits generated by a farmer or other NPS, by a regulatory agency

**CNPCP** – Coastal Nonpoint Pollution Source Program

**Conservation Plan** - A farm specific plan with detailed information on the type of management practice and location and its installation and operation and maintenance specifications to be developed by NRCS or designated third party.

**Credit** – A unit for measuring nutrient load reduction per unit time (e.g., a calendar year) to be used in a trading program

**Credit Marketplace** - An on-line or third-party maintained system that facilitates exchange of nutrient credits among buyers and sellers, or agents such as brokers (e.g., NutrientNet)

**CTDEP** – State of Connecticut Department of Environmental Protection

**CWA** – Clean Water Act

**Discharge Monitoring Report (DMR)** – Online database maintained by the USEPA on municipal and industrial NPDES permittees

**DO** – Dissolved Oxygen

**EMC** – Event Mean Concentrations

**EPA** – United States Environmental Protection Agency

**EQIP** – Environmental Quality Incentives Program

**GWLF** – Generalized Watershed Loading Functions Model

**HSPF** – Hydrologic Simulation Program in Fortran

**LA** – Load Allocation, that specifies target pollution reduction for nonpoint sources in a TMDL

**LIS** – Long Island Sound
LISO – Long Island Sound Office of the United States Environmental Protection Agency, a program supported by both Regions 1 and 2 of the EPA to focus on LIS issues

LISS – Long Island Sound Study

**Low Impact Development Practices (LIDs)** – Management measures integrated with landscapes of existing land uses without extensive structural elements. Most of these measures are considered green infrastructure elements aimed at nutrient reductions but also provide auxiliary benefits such as flood reduction, energy conservation and aesthetics improvement

MEP – Maximum Extent Practicable

MNC – Mill Neck Creek

MS4 – Municipal Separate Storm Sewer Systems

NGO – Non Governmental Organization

Nonpoint Source (NPS) – A source of water pollution that reaches receiving water in diffuse form, with multiple piped or natural outlets from a drainage area. Examples include, but are not limited to: urban stormwater from various landuses, agriculture, atmospheric deposition, failing septic systems, waterfowl/wildlife, and forestry

NPDES – National Pollutant Discharge Elimination System, the permit program required under the federal Water Pollution Control Act (also known as the “Clean Water Act”), administered by the states (in New York State, it is designated as State Pollutant Discharge Elimination System, SPDES)

NRCS - Natural Resources Conservation Service, part of the United States Department of Agriculture

NutrientNet – An online software program created by the World Resources Institute (WRI), to provide an interface for administering the trading program (e.g., nutrient reduction calculations, credit registry and tracking interface)

**Nutrient Trading** – Transactions that involve the exchange of quantifiable nutrient reduction credits

NYSDEC – New York State Department of Environmental Conservation

O&M – Operation and Maintenance

OBH – Oyster Bay Harbor

**Point Source (PS)** – Any NPDES-permitted discharge from a municipal or industrial treatment plant and per the definition of EPA (2002, 2010) the stormwater discharges governed by MS4 permits

POTWs – Publicly Owned Treatment Works

RUNQUAL – Urban Modeling Component of AVGWLF Model
**Stream or River Segment** – Specific reaches or portions of the stream/river where the water quality issue is being evaluated

**SWMM** – Storm Water Management Model, developed by the EPA

**Third Party** - Any entity that does not discharge nutrients or create nutrient credits and that participates in a trading program to approve credit generation proposals. It can involve environmental interest groups, developers, watershed associations, aggregators/brokers, businesses, and nonprofit organizations

**TMDL - Total Maximum Daily Loads** – A regulatory mechanism established by the EPA to prescribe reductions in loads from various sources. It accounts for a margin of safety to include factors such as uncertainty in load estimation and is expressed in terms of mass per time. Waste load allocation (WLA) portion of TMDL specifies allowable loads from point sources and load allocation (LA) covers the nonpoint sources

**Trading Ratio** - Equivalency factor applied to nutrient reductions, to account for in-stream attenuation from source area to the western end of LIS

**UAL** – Unit Area Loads

**Uncertainty Ratio** – Discount factor that accounts for factors such as the uncertainty in the estimation of NPS loads or performance assessment of BMP/LIDs

**USDA** – United States Department of Agriculture

**Verification** - Process by which a third party or regulatory agency determines that a credit represents a real reduction in nutrient loading that is eligible for trading

**WERF** – Water Environment Research Foundation

**WQT - Water Quality Trading** – Market-based or market-like mechanism aimed at trading pollution load reductions among contributing sources, to achieve an overall efficiency in costs or ecosystem valuation

**WLA** – Waste load allocation, that specifies target pollutant load reduction for point sources in a TMDL
1. INTRODUCTION

1.1. Water Quality Concerns

Long Island Sound (LIS) covers approximately 1,300 square miles of open waters, extending about 100 miles from east to west and about 21 miles wide at its widest point (LISS, 2011). Also referred to as the Sound hereafter, it is an estuary providing habitat for feeding, breeding, nesting, and nursery areas for diverse animal, aquatic and plant life. Fresh water comes from several rivers into the estuary, including the Connecticut, Housatonic, Thames, Saugatuck, Norwalk, Bronx, Hutchinson and Mamaroneck/Sheldrake Rivers. Contributing drainage area is approximately 16,000 square miles and includes most of the land area of Connecticut, and portions of New York (including New York City), Massachusetts, Rhode Island, Vermont, New Hampshire, and the Canadian province of Quebec.

Drainage area surrounding the Sound is among the most densely populated region in the U.S. It provides significant recreational and commercial value, with more than eight million people living within the watershed and millions flocking to its shores for recreation. An estimated five billion dollars is generated annually from boating, commercial and sport fishing, swimming, and beach-going. Among the serious water quality problems in LIS is the low dissolved oxygen (DO) level, a condition called hypoxia, determined to be caused by nitrogen. As a result, a 58.5% reduction in nitrogen loads was assigned by NYSDEC and CTDEP (2000) to publicly owned treatment works (POTWs) that discharge into LIS. Similarly, in-basin (areas adjacent to the Sound) nonpoint sources (NPS) of pollution were assigned a 10% nitrogen load reduction from the contributing urban and non-urban land uses.

Since the federal Clean Water Act (CWA) became law in 1972, investments in regional water pollution control programs have led to measurable improvements in the LIS water quality. Municipal and industrial discharges are being controlled through the National Pollutant Discharge Elimination System (NPDES) permit programs administered by the States of New York (NY) and Connecticut (CT).

As shown in Figure 1-1 below, the progress in reducing the duration and extent of hypoxia has been slow for more than 20 years. In spite of the appreciable progress seen with the point source controls, the slow progress can be attributed to continued and significant contributions from NPS loads. Such sources can include runoff from various land uses within the drainage areas and associated pollutant loads from those areas transported into the waterways as diffuse
(e.g., forestry and agriculture) or end-of-pipe (e.g., urban and sub-urban storm water) discharges.

In-basin pollution contributions come from developed areas adjacent to the LIS shoreline (with more than 20 million people living in urban/suburban areas within 50 miles of the shoreline). Other contributors include non-urban sources, including runoff and groundwater (baseflow) and associated pollutants from agricultural, forest, and riparian areas that drain to the Sound through major rivers and their tributaries. The DO-related water quality impairment significantly affects commercial and recreational uses. Most residents in areas surrounding the Sound are aware of water quality impairment; however, a survey pursued by Stony Brook University (2006) revealed that homeowners and agricultural communities still pursued practices that degraded water quality. While the NPDES program can be attributed to progress in point source controls, implementation of NPS controls is voluntary and also quite challenging from technical, regulatory and policy perspectives. Some challenges include:

Figure 1-1. Areal Extent of Hypoxia in the 1987-2009 Period (CTDEP, 2010)
Administrative: While nutrient control targets are established by the LIS TMDL (NYSDEC and CTDEP, 2000), the associated pollution control activities are to be developed and implemented by local watershed agencies and municipal/county agencies. For example, achievement of 10% reduction in NPS loads in the Saugatuck River watershed will require collective control of urban sources (stormwater discharges from 11 municipalities) and the agricultural/other non-urban sources (e.g., golf courses, horse farms, septic sewered areas, waterfowl and wildlife). An inter or intra-basin trading can pose significant administrative burden on local watershed agencies in tracking load reductions through collaborative partnerships among stakeholders (i.e., farmers, septic system owners, and municipalities) and getting approval by the regulatory agencies.

Technical: Tasks pertinent to planning and implementation of BMP/LIDs such as conceptualization and selection of specific technologies, funding for construction/operation and maintenance (O&M), and follow-up monitoring to assess performance, are often carried out by municipal/regional governments in an isolated manner. Such tasks demand significant financial and technical resources to perform and document for review and approval by the states. For most municipal/regional governments and farming communities, these tasks can be daunting due to limited in-house staff resources or financial constraints to get external help.

Regulatory: While the EPA has been promoting the use of watershed-based trading (EPA, 1996; 2003; 2004) involving point and nonpoint sources, only some states have adopted them due to lack of administrative and policy structure or the necessary manpower to put this structure in place and administer. For example, the CTDEP has implemented a point-source trading program and received the Blue Ribbon Award from EPA Region 1, whereas the NYSDEC has not embraced point source trading in the in-basin drainage areas. Impediments can range from simple establishment of trading credits to a complex trade administration and enforcement.

Most technical, administrative and policy barriers can be overcome with upfront planning by a lead agency and collaboration/communication among various stakeholders. Lessons learned from other nationwide programs can potentially help the program startup in this region also.

1.2. Why Nutrient Trading

The LIS TMDL has a phased implementation plan with Phase III requiring 10% reduction in
in-basin urban and agricultural land use NPS loads from baseline conditions, reported in Table 6 of NYSDEC and CTDEP (2000). This in-basin area includes 11 management zones adjacent to the Sound (see Figure 1-2). Phase IV targets 10% reduction in urban and agricultural loads throughout the LIS basin north of Connecticut and an 18% reduction in atmospheric nitrogen loads. The basis for reduction in atmospheric nitrogen enrichment is that the implementation of Clean Air Act (CAA) will reduce basin-wide loads by 18%. Phase V identifies non-treatment alternatives necessary to achieve the DO standards, such as artificial wetlands and seaweed farms.

The non-urban (e.g., agriculture and forestry) NPS controls are currently implemented on a voluntary basis. To control urban pollutant loads, individual municipalities need to comply with MS4 stormwater regulations (e.g., characterization of drainage areas, inventory of stormwater drains, conceptualization and implementation of BMPs/LIDs, and monitoring as appropriate to ensure BMP/LID performance) in the midst of their shrinking financial and staff resources. For example, CTDEP (2005) quotes MS4 mechanism as the major component of implementation plan to reduce bacteria loads and achieve TMDL targets in three CT watersheds. Innovation and commitment are needed from various stakeholders including the state regulators, local municipalities and watershed organizations that strive to establish nutrient controls locally in their individual watersheds, while benefiting the global goal of eliminating hypoxia in the Sound.

If all point sources were required to perform upgrades to achieve the same levels of reduction in TN loads without trading, the CTDEP estimated the cost to meet the necessary reductions to be over $1 Billion (Breetz et al., 2004). This may have slowed down the progress in terms of meeting the 15-year target reduction. The CTDEP’s *out-of-the-box* approach to point source controls involving creation of credits by POTWs that can achieve controls beyond their permit limits, which can then be bought by the municipalities that cannot meet their permit limits. The technical basis was to create a market-based credit program that the municipalities can use, and the CTDEP steered this process analogous to a *bank* administering...
credit transactions. This leadership and administrative structure led to achieving the TN load reductions sooner than 2014 and at a potential saving of over $200 million in public funds (Breetz et al., 2004).

Although trading involving NPS loads can be complex, the administrative and regulatory aspects were researched as early as 1990s (Bartfeld, 1993; Ribaudo et al., 1999), and further case studies were developed by the Water Environment Research Foundation (WERF) in the late 1990s to early 2000s (WERF 2002a; 2002b). Point/NPS trading was recognized as most feasible when both point and nonpoint sources contribute significantly to total pollutant loads (Bartfeld, 1993; Ribaudo et al., 1999). When point sources are very large in comparison to NPS, savings from trading might not justify the administrative expense of a trading program. Similarly, Bartfeld (1993) concluded that trading would be most suitable for water bodies with long pollutant residence times (e.g., lakes and estuaries) and a potential trading between NPS would work only if there would be enforceable cap on runoff or pollutant load (e.g., TMDL). The LIS region meets both of these criteria in terms of long residence time and significant baseflow (groundwater), atmospheric deposition and septic system NPS loads in most of the watersheds draining to the Sound.

The CTDEP point-source-trading framework can be extended with appropriate modifications to modeling and trade calculation methods to explore nutrient trading opportunities between point and nonpoint sources or among NPS. Understanding and overcoming the technical, administrative and regulatory barriers can help trigger NPS trades in the LIS watersheds. Implementation of urban NPS to rural NPS or point source to NPS trades requires an innovative basis, partnership between pollution sources, administrative support, and also a post-compliance monitoring program to ensure that the desired benefits are fully realized.

In this project, two case studies were used to hypothetically explore the potential for nutrient trading involving NPS loads. Discussions at the STAC and among stakeholders, the lessons learned from nationwide case studies and establishment of regulatory and administrative structures are the next key steps to take this exploration to a successful implementation of the trading program. Past knowledge includes what worked well in the CT point-source trading program, relative contributions of point and NPS loads in individual watersheds for assessing the technical and economical feasibility, and establishment of stakeholder collaboration in watersheds such as Saugatuck (based on ongoing efforts by The Nature Conservancy) and Oyster Bay Harbor and Mill Creek (Friends of the Bay and the Town of Oyster Bay).
Besides introducing cost savings, the NPS trading brings other tangible benefits, such as: (1) provision of much needed funding for NPS controls (shifting from voluntary to a mandated control); (2) resolution of conflicts between economic development and environmental protection, through balancing of priorities using a multiobjective process such as triple bottom line or return-on-investment analysis, and; (3) involvement of farmers, environmental groups and local watershed officials interested in healthy watersheds, thereby, raising the overall public awareness. Trading program design and implementation challenges will need to be addressed programmatically. An environmentally and economically successful program must consider issues such as transaction costs, environmental equivalence, ecological valuation benefits, hot spots, NPS reduction quantification, field-scale and ambient water quality monitoring and program enforcement.

Finally, it must be emphasized that trading can be used to maintain higher water quality in segments of tributaries/rivers that already meet or exceed the state water quality standards, as long as the standards are met and beneficial uses are protected. For example, trading can be used for expansion of capacity or establishment of a new POTW to avoid degradation of water quality. This may be relevant for upper portions of the tributaries/rivers with pristine background conditions for source water supply or trout population. Water purveyors such as Aquarion will be among key stakeholders when trading is explored in stream segments or reservoirs with water supply intakes.

1.3. Organization of the Manual

This manual draws mainly from the Water Quality Trading guidance published by the EPA (EPA, 2003) and is substantiated with methods adopted in developing frameworks for several other Nutrient Trading Programs across the country. It is aimed at providing an objective overview of the process and elucidating some of the common barriers faced by previous NPS trading programs along with approaches/discussions to potentially overcome such barriers in the LIS region.

Consistent with guidelines from EPA (2003), this document covers all the necessary elements that can make a trading program credible and successful: (a) Legal authorities and mechanisms for trading to occur; (b) Clearly defined units of trade; (c) Creation and duration of credits; (d) Quantifying credits and addressing uncertainty; (e) Compliance and enforcement provisions;
(f) Public participation and access to information; and (g) Periodic program evaluations. Some of these elements are covered in more detail than others based on the current status of LIS TMDL program and relevance to this region.

Some basic definitions and stipulations are introduced in Section 2, that are vital to the establishment and sustenance of a nutrient trading program involving NPS. Based on the input provided by watershed stakeholders in the two pilot watersheds and also on the review of literature (e.g., Stephenson et al., 2010; Siems, 2006), key barriers to exploration and implementation of NPS trading are summarized in Section 3. Also included in Section 3 are specific suggestions for enhancing the viability of NPS trading in the LIS region.

Section 4 covers the trade elements that the state and local governments or watershed organizations can pursue to initiate trades involving NPS loads in individual watersheds. These are some of the key elements including trade components, structure and financial aspects covered in the EPA guidance documents (EPA, 2003; 2004). Hypothetical examples of trading in the two pilot watersheds are also provided in Section 4 to review the tools and calculations necessary for trade evaluations.

Appendix A summarizes nationwide case studies that have involved NPS trades, along with access links to their websites. This information has been compiled as literature review and guidance for the benefit of LIS community to explore trading potential in their watersheds. Appendix B provides an overview of BMP/LID operation and maintenance costs, along with their planning-level performance information. Appendices C and D, respectively, review the mathematical modeling work performed to calibrate the watershed models and quantify baseline (existing conditions) pollutant loads from various contributing sources in the two pilot watersheds: Saugatuck River and tributaries in CT and Oyster Bay Harbor (OBH) and Mill Neck Creek (MNC) in NY. Finally, the pertinent references from other trading programs and academic/trade publications are provided in Appendix E.
2. TRADING BASICS

The definitions of terms used throughout this guidance document are provided in the beginning of this manual. In this section, some additional basic definitions pertinent to point to NPS or nonpoint to NPS trading in the LIS region are summarized.

2.1. Water Quality Parameters Eligible for Trading

Excessive nitrogen is the primary cause for hypoxia in the western end of LIS, although phosphorous and silica are also attributable to this water quality impairment. Total nitrogen (TN) is the only nutrient discussed in this manual, pertinent to meeting the LIS TMDL requirements. Excessive algal growth in local ponds or water supply reservoirs within individual watersheds can require phosphorus reductions. In addition, sediments are often used as surrogate parameters for nutrient controls from NPS and sediment control can enhance the geomorphological health of creeks and rivers. Trading guidelines provided here for TN can be extended for total phosphorus and sediment throughout the LIS region.

It must be emphasized that the water quality improvement needs associated with other regulations (e.g., source water protection and indicator bacteria TMDLs) can also reduce TN loads. Current baseline conditions for LIS TMDL includes contributions from sources such as illicit discharges into storm sewers, failing septic systems and non-migratory waterfowl. These are significant sources of indicator bacteria and when management measures (e.g., illicit discharge elimination or repairing of failing septic systems) are undertaken to eliminate or reduce these sources, corresponding reductions in nutrients will also be realized. Credits for nutrient trading can be generated by the municipal or watershed agencies after addressing the minimum requirements of an MS4 program such as elimination of illicit discharges and failing septic systems.

2.2. Types of Trades Envisioned

Any trade that involves NPS loads is covered in this manual. Non-urban NPS are not regulated and urban NPS are governed by the MS4 program. A watershed-based trading program must target to generate enough credits from NPS based on reduction of loads below required values, to make it economically or ecologically viable. Some recent examples of trading (e.g., Lower Boise River) pursued NPS reductions in lieu of implementing facility upgrades to further decrease pollutant loads from existing point source discharges.
As shown in Figure 2-1, two general types of exchanges are viable for NPS trades – one with direct trade negotiations between point and NPS loads without the involvement of a third party and another with a centralized pool of credits established by a third party (e.g., government and non-governmental organizations-NGOs) which buys credits from NPS and sells them to point sources. Successful examples of both types of exchanges can be seen from nationwide trading programs involving nutrients and mercury.

Figure 2-1. PS-NPS Trade and NPS Credit Exchange Comparison (EPA, 2004)

In the LIS context, the following trading possibilities can be explored for implementation:

- POTW nutrient loads can be traded with any urban or non-urban NPS load within the same watershed;
- Traditional (land use based) stormwater pollutant loads from urban areas can be traded with non-traditional MS4 permittees; and
• Urban/suburban stormwater loads can be traded with non-urban stormwater loads (e.g., agriculture and forestry).

2.3. Some Guiding Principles for Trading

A key consideration is that the low DO levels persist in the Sound during the summer months of July and August. Pollutant reductions are tracked on an annual basis by the LIS EPA and states (or averaged over the entire year to convert to daily loads), but the BMP/LIDs that achieve higher nutrient reductions during summer periods can provide a better basis for achieving the reductions and consequent water quality improvement.

Trading can be very effectively managed and administered if occurs within the same watershed in a single state (NY or CT). There are several watersheds that are covered by the two states such as Mianus, Byram and Silvermine Rivers. Interstate trading of nutrient credits can be promoted within the same watershed as long as the overall outcome is compliant with applicable state policies, rules or laws.

Trading can occur among the various sources within a watershed for TN on the stipulation that the discharges covered by a specific trade do not exceed water quality standards nor any nutrient cap load (e.g., 10% reduction in TN load) established for this watershed. Based on a review of selected trading programs from across the country, the following principles can be adopted for exploration and implementation of NPS trades in LIS watersheds:

1. Trades must involve only comparable water quality parameters (e.g., TN). There are concerns cited in the literature such as the equivalency between dissolved nutrients discharged from POTWs that are more bio-available (biologically reactive) than the particulate nutrients from farms and forests. In the LIS context, only TN must be used as tradable nutrient. An additional factor of safety can be used in conjunction with previously established trading ratios to alleviate this concern;

2. Trades must be expressed as mass per unit time (e.g. pounds per year). Since the hypoxia is experienced in July and August, BMP/LIDs that perform better in terms of TN reductions over summer can be tracked on a seasonal basis (e.g., during a 4-month period from June to September) instead of the entire year. The premise here is that the overall water quality on an annual basis will be much better if it, in this 4-month
period, can be demonstrated to reduce loads by the desired cap (e.g., 10%) from baseline levels;

3. Trades can occur only between eligible parties (defined in the next section). Based on whether the trading program is led by a third party or not, the entities that can either generate or buy TN credits become eligible parties once they agree to abide by the trading regulations and associated performance tracking; and

4. Credits generated by trading cannot be used to comply with existing technology-based effluent limits set forth for POTWs, except when authorized by federal and approved by local regulations. For NPS, the performance of BMP/LIDs has been improving based on research efforts on process-based nutrient uptake mechanisms. Although technology-based effluent limits cannot be established for BMP/LIDs, the focus can be on getting maximum practicable reductions at minimal cost.

Additional guidelines are provided in Section 4 to promote trading in the LIS region.

2.4. Eligible Parties

Trading can be established between combinations of eligible point sources, traditional and non-traditional MS4 systems, non-urban NPS and approved third parties such as credit aggregators/brokers. Public and private entities are eligible to participate, but each potential seller has to meet the applicable minimum requirements to generate approvable and tradable credits. Also, the trading parties can agree on specific terms and stipulations of a trade by entering into private contracts or through third party contracts.

For point sources to be eligible to generate credits, the minimum requirement can be the minimum of technology-based or water quality-based effluent limitation or cap load allocation expressed in an NPDES permit. CTDEP’s point source trading program allows trades among point sources that collectively meet or exceed their NPDES obligation of 64% from baseline levels. Although a trading framework has not been formally adopted, the NYSDEC issued a group or bubble permit for Westchester County POTWs to collectively reduce the total load by 58.5% from baseline conditions.

Defining minimum requirements for NPS can be challenging, however, the development of strict policies upfront is essential to the long-term success of NPS trading (Ghosh et al., 2011). For NPS to become eligible to sell credits, minimum requirements can be imposed such that
the credits become available only after the BMP/LIDs are implemented, installations are inspected by the point source (trading partner) or a third party, and the reductions have been verified through monitoring and performance evaluation. In addition, O&M procedures are established and that the point sources have retained (or contracted out) the full responsibility for the quantity and delivery of credits it purchases from NPS to meet its NPDES limit.

Traditional and non-traditional MS4 systems (urban and suburban stormwater contributions that are considered as point sources) must, at a minimum, achieve “maximum extent practicable (MEP)” compliance with the NYSDEC/CTDEP MS4 NPDES permit requirements to be eligible to generate credits from additional reductions. Where a numeric effluent limitation is not applied, the permittee is similarly obligated to meet the applicable management requirements to the maximum extent practicable. As such, the minimum technical or management requirements must be met in order to generate tradable TN reduction credits.

Both CTDEP and NYSDEC have broad authorities to manage NPS nitrogen loads and have committed to implementing the Comprehensive Conservation and Management Plan (CCMP) in order to reduce loads through state and federal programs. The NPS program addresses existing impairments and prevents threats to water quality through a network of statutory and regulatory authorities, policies, and voluntary compliance assistance, implemented through both formal and informal programs administered by federal, state, and municipal government agencies (CCMP, 2010). Such programs include state NPS (CWA §319) and Coastal Nonpoint Pollution Source Program (CNPCP), and Stormwater MS4 program.

For non-urban NPS, the minimum requirements can include a set of regulatory obligations applicable to the specific NPS load. For example, both NY and CT do not have sector-specific regulatory requirements for agricultural NPS. A nutrient management plan can be imposed as minimum requirement before credits can be generated by a non-urban NPS. Additional watershed-specific regulations can be imposed where agricultural operations lead to impairment of surface or groundwater sources.

Generation and tracking of credits become even more complex for trades between urban and non-urban NPS. The MS4 permitting program governs urban NPS, whereas the non-urban NPS are voluntary. Both of these are diffuse sources of pollution although the MS4 systems are designated as point sources (EPA, 2002; 2010) since the discharges occur through outfalls
that are included in a NPDES permit. Extensive inspection and monitoring, along with the establishment of O&M responsibilities, have to be essential elements of such trades.
3. BARRIERS AND POTENTIAL SOLUTIONS TO NUTRIENT TRADING

Though the point source trading has become well-established and implementable through state NPDES programs (e.g., CTDEP, 2010), trading involving NPS has yet to overcome concerns or impediments over its successful implementation. The traditional belief is that when NPS pollution is large enough and comparable with point source loads, cost of its control is lower than that necessary to reduce point sources loads through additional treatment processes. The eventual objective is to achieve water quality goals at a much lower cost (Letson et al., 1993). This kind of reduction is obtained because the point source compensates the NPS for reducing its pollution levels. However, the progress on a national level is slow, although the large-scale watershed studies in Chesapeake Bay and the Gulf of Mexico embrace nutrient trading as the immediate opportunity to progress towards the achievement of water quality goals (Faeth, 2000; Greenhalgh and Sauer, 2003; Nelson, 2007).

As reported in Greenhalgh and Sauer (2003) and Faeth (2000), the cost of nutrient controls in agricultural and other NPS can be competitive. In reality, obstacles may arise in the form of political, administrative, regulatory and technical challenges that can be watershed or region-specific. Addressing such challenges add administrative and programmatic costs that can gradually decimate the cost-effectiveness aspects primarily estimated from technical considerations (Fang et al., 2005; Stephenson et al., 2009; 2010). Such challenges pertinent to LIS watersheds in the in-basin drainage area are discussed here, along with potential solutions/suggestions to overcome those in favor of exploring point to nonpoint source or NPS to NPS trading. These challenges have been compiled based on the stakeholder input in January 2010 conducted for the Saugatuck and Oyster Bay Harbor watersheds and also based on literature (Siems, 2006; Stephenson et al., 2009).

3.1. Demand for Credits

Demand for credits is the primary driver for initiation of trading programs nationwide. Many literature documents cite the lack of caps for nutrient loads as the primary reason for lack of market demand for credits. The caps were not determined in such instances due to a TMDL not being established to set the target reductions or not acceptable since TMDLs were established with inadequate scientific and regulatory rigor. Where the TMDLs have been established with rigor, the trading framework draws from caps set for nutrient load in
discharges. If these caps were exceeded, the point sources were required to finance NPS offsets (e.g., Lower Boise River TMDL).

For the in-basin LIS drainage area, CT and NY have established point source pollution caps of 64% and 58.5%, respectively. Connecticut has established an award winning point source trading program to achieve this target reduction by 2014. For NPS, a 10% reduction has been established from baseline pollutant loads shown in Table 6 of LIS TMDL (NYSDEC and CTDEP, 2000). In comparison to the out-of-basin drainage areas, the in-basin areas have very minor agricultural operations. So, a direct Lower Boise River (Idaho) or Greater Miami River (Ohio) solution may not be applicable. On the other hand, the forestry operations, open space areas or septic systems can be explored with additional BMP/LIDs or even connection of septic areas into public sewers to generate TN credits. With a TMDL-prescribed cap of 10% reduction in NPS loads, a regulatory driver for trades involving NPS does exist in the in-basin (Phase III) and out-of-basin (Phase IV) drainage areas.

3.2. Trading Ratios

In comparison to POTW outfalls with known geographical locations, the diffuse NPS discharges reach waterways through multiple outfalls and the transported nutrient load can vary significantly based on several factors including seasonal fertilizer applications, soil erosion, uptake in farm fields or vegetated forest areas, and precipitation intensity and volumes. Spatio-temporal variations in pollutant loads from NPS, in-stream transformation and decay, distribution of dissolved (bio-available) and particulate forms of nutrients (EPRI, 2007), and the uncertainty in the estimation of effectiveness of individual BMP/LIDs were accounted for using several safety factors in other trading programs (e.g., WVDEP, 2009). Collaborations among stakeholders and environmental agencies that do the research and monitoring to enhance confidence on these numbers would be essential for the effective startup and sustenance of these trading programs.

Simple ratios such as 1:2 or 1:3 have been used in some studies and detailed water quality modeling has been performed in others to scientifically characterize the transformation and decay effects (e.g., MCD, 2005; Shortle and Horan, 2006). In the LIS region, the CTDEP has developed trading ratios for various watersheds within Connecticut based on the component influences of nutrient loads from those watersheds on hypoxia in the western end of LIS. These ratios are shown in Figure 3-1.
Trading ratios in LIS were derived using a comprehensive assessment of TN loads from various watersheds performed with comprehensive mathematical modeling frameworks. On the CT side, this framework included Hydrological Simulation Program in Fortran (HSPF) for watershed modeling and subsequent evaluation of the component effects on DO depletion using a System-wide Eutrophication Model, SWEM (AQUA TERRA and HydroQual, 2001). Similarly in the NY side, a rainfall-runoff modeling program was used to develop pollutant loads and SWEM for water quality analysis. Unit loads of TN were assumed for individual landuses in the calibration process. However, large uncertainties can exist in the generation of nutrient loads from specific agricultural operations or forested areas or the quantification of effectiveness of BMP/LIDs to reduce loads from those areas. Field-scale modeling and monitoring may be required to reduce this uncertainty and develop performance information.

Figure 3-1. Trading Ratios for Connecticut Municipalities
(Source: CTDEP, 2010)

In the interim, an uncertainty ratio (UR) in the range of 1.5 to 2 is suggested besides the
trading ratio to enable the creation of credits and startup an NPS trading initiative. For example, a trading ratio in the lower Connecticut River of 0.22 can be reduced by a factor of two to derive a new trading ratio of 0.11. A nine-pound reduction in TN in this region is necessary to trade with one-pound of load near the western end of LIS. Similarly, a ratio of \((0.22/0.19 \times 2, \text{ or } 2.32)\) can be used for creation of credits in the upper Connecticut River drainage area to trade with one-pound in the lower Connecticut River drainage area in CT. The basis is to use trading ratios established as part of the point source trading program and apply them in a pragmatic way to extend to the NPS trading initiatives.

Although the trading ratios have not been used explicitly in New York drainage areas at a subwatershed scale, the above applications discussed for CT are equally applicable for NY. Attenuation factors for individual tributary watersheds draining to LIS from New York can developed using mathematical models and then be used to develop appropriate trading ratios. For Westchester County, the effort can focus on reducing the uncertainty ratio since the trading ratio will be equal to 1 (one) similar to the southwestern edge of Connecticut.

3.3. Transaction Costs

Determination of reasonable prices for trading plays a vital role in the stakeholder acceptance of trading program outcomes. The more the number of stakeholders, this process took longer and led to some inefficiency in other trading programs. There is also a general lack of financial incentives. Based on a review of literature, POTW upgrades are usually overestimated (e.g., Tar-Pamlico program), and NPS control costs and administrative efforts associated with the transactions are underestimated (Stephenson et al., 2010, Fang et al., 2005). Advancements in POTW treatment processes are leading to reduced unit costs of nutrient removals. Therefore, the frameworks drawn on these erroneous estimations tend to look promising in the early stages but turn out to be less attractive in terms of actual costs in the latter stages of nutrient trading.

Cost curves associated with phosphorus control are much steeper than those for nitrogen control, on a per-pound basis (Greenhalgh and Sauer, 2003; EPA, 2007). Cost numbers from EPA (2007) are summarized in Table 3-1. University of Georgia researchers (Rowles, 2005; 2006) determined that the financial viability of trading programs became attractive when the phosphorus control limits reached a threshold of 1.0 milligrams per liter (mg/l) in the State of Georgia. Marginal costs of treating wastewater effluent to levels above this threshold were
comparable with the NPS control costs and, therefore, there is very limited financial advantage to pursue a trade.

Table 3-1. Nutrient Reduction Costs for Chesapeake Bay (EPA, 2007)

<table>
<thead>
<tr>
<th>Conservation Activity</th>
<th>Phosphorus ($/pound)</th>
<th>Nitrogen ($/pound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal waste treatment</td>
<td>$4.78 to 105.54</td>
<td>$5.73 to 10.77</td>
</tr>
<tr>
<td>Conservation tillage</td>
<td>$7.38</td>
<td>$1.59</td>
</tr>
<tr>
<td>Agricultural grass buffer</td>
<td>$20.67</td>
<td>$1.03</td>
</tr>
<tr>
<td>Animal waste management/runoff control</td>
<td>$30.51</td>
<td>$3.93</td>
</tr>
</tbody>
</table>

Stacey (2006) explored the potential for trading between point and NPS sources. The approved pricing for TN in 2009 was $4.54 per pound for point source control (CTDEP, 2009). Stacey (2006) compared the cost per pound of nitrogen removal and similar costs for control from NPS sources. Major concerns for point to NPS trading were identified to be uncertainty in performance and transaction costs to meet the 10% reduction in TN loads.

The current 10% reductions in NPS loads from baseline levels may be achievable through traditional controls at the respective sources (POTWs and NPS). This is particularly valid when considering the high administrative costs involved in establishing the first NPS trading program and transactions, involving a high degree of uncertainty in effectiveness of control practices. All point source controls are targeted for completion in 2014. The LIS TMDL is an adaptive framework and the 10% reduction in NPS loads may not achieve the desired water quality outcomes, which will be assessed through ongoing water quality monitoring efforts. As such, additional NPS load reductions may be desired to accelerate water quality improvements. Similarly, the local TMDL efforts in individual watersheds aimed at reducing algal growth in impoundments or eliminating high DO swings in streams may require reductions in phosphorus loads. Imposition of additional nutrient controls may become the tipping point for LIS watersheds to consider NPS trading more favorably.

3.4. Voluntary Participation of Farmers

Eliciting voluntary participation of farmers in trading programs can prove to be quite difficult if the farmers do not trust the regulatory agencies and become concerned about being targeted as polluters. In spite of the common perspective that NPS sources are voluntary and have not
pursued any controls, the USDA’s EQIP and states’ 319 grants have largely addressed NPS sources. Ensuring flexibility in regulations will be a major driver for farmers to participate in trading programs. This impediment is more apparent for out-of-basin drainage areas with large number of farmers and agricultural operations, in comparison to in-basin areas that tend to have small-scale commercial or family-owned farms.

Cost aspects will drive NPS controls towards establishing or installing large-scale projects in priority areas. Such projects can place small-scale farmers at a distinct disadvantage. Stewardship criteria tying credits to long-term or permanent contract puts a barrier to their families’ future access to the land. Ensuring participation in a robust manner instead of emphasizing on large scale projects in priority areas would be an effective way to address this concern (Hosterman, 2008).

Also, it is important to engage organizations or trade groups with strong working relationships or trust with the farmers. The Soil and Water Conservation Districts, operated by the USDA, can be effective partners to enhance this relationship, which can form a strong foundation for the technical, regulatory and administrative aspects to receive favorable consideration.

As reviewed in Appendix A, numerous successful trading programs have been established, involving point and nonpoint sources. Out-of-basin drainage areas have extensive agricultural operations that can significantly benefit from NPS trading by creating nutrient exchange or direct sale of credits in a competitive marketplace. For the in-basin areas, trading between point and NPS sources or among various NPS are potential opportunities for exploration.

Specific institutional mechanisms need to be in place to address uncertainty. It is important to have transparency over creation and verification of credits with contractual agreements outside of NPDES permits that farmers would be more comfortable with (similar to EQIP, for example). This type of arrangement reduces risk by knowing where impairments exist before entering a trading program and the agreement establishes dual NPDES liability, identifies an insurance pool and backs up credits.

3.5. Stakeholders Participation

It is also very important that all stakeholders interested in watershed management be involved
in early discussions to guide the establishment of a trading framework. Benefits achieved and
timelines associated with program implementation on a watershed-scale be discussed through
an open process. Individuals or organizations representing potential buyers and sellers (e.g.,
home builders, farmers, and municipalities) must be involved in these discussions; as a means
of bringing groups into the process and gather opinions on what are considered barriers and
solutions in individual watersheds.

Existing stakeholder involvement and review including STAC in the LIS region can be
leveraged to provide perspectives on trading involving NPS loads. For the specific pilot
implementation watersheds, a broader level of stakeholder participation from existing
watershed management programs (e.g., The Nature Conservancy for the Saugatuck River
watershed in Connecticut and Friends of the Bay for Oyster Bay Harbor watershed in New
York) can be leveraged.

3.6. Establishment of Baseline Conditions

Identification of acceptable baselines conditions for calculation of trades has been a
controversial issue in many national trading programs involving NPS. For example, the
trading involving urban stormwater runoff must meet or exceed state/federal requirements to
be eligible to generate credits (Stephenson et al., 2009). Thus, any new development will have
to implement additional strategies on top of the municipal stormwater control practices in
order to generate offsets. The federal program does not specify any numeric limits for specific
practices and the language itself becomes an impediment for defining baselines. Point sources
in some states (including the Commonwealth of Virginia) raised concerns about baseline
conditions for NPS, considering their voluntary nature and lack of controls in the same
timeframe when NPDES program was governing point source controls. At the same time, it
is important to recognize that POTWs had received significant federal and state financial
grants and loans towards progress achieved so far, whereas the NPS had only availed limited
funding avenues such as EQIP and 319 grants.

For LIS TMDL, the baseline scenario established through watershed modeling for 1988-89
hydrologic and water quality conditions can be used as basis for NPS loads (Table 6 of LIS
TMDL, NYSDEC and CTDEP (2000)). In addition, AQUA TERRA and HydroQual (2001)
developed detailed estimates of TN loads for all CT watersheds. Farley and Rangarajan (2006)
developed TN estimates for all in-basin drainage areas in CT and NY using AVGWLF (Haith
et al., 1992; Evans et al., 2003) and similar work has been performed for out-of-basin drainage areas by Penn State (2007). Finer resolution and localized calibration of these models can help in reducing uncertainties associated with these estimates, similar to the two case studies’ calculations shown in Appendices C and D. However, the trading framework and addressing the administrative and regulatory barriers can be pursued with extant information on baseline pollutant loads.

3.7. Trade Insecurity

There is a general sense of insecurity expressed by the point sources in many trades involving NPS. The point sources have stringent regulation controls, failing to meet which, they are held legally liable and are subject to large fines or permit suspensions. However, the NPS are relatively less liable to strict regulations since they do not fall under a permit system and cannot be held legally responsible for exceeding discharge limits.

Also, the point sources have concerns about the success ratio of farm-scale BMP implementation considering that they put in the capital costs upfront and are not assured of negotiations on the permit discharge levels should the installed BMP/LIDs fail. Hence, a stronger trade agreement that would facilitate economic benefits by assuring success of the installed BMPs even if the lands were sold between different farmers would be an ideal point to start correcting this issue.

Development of trust or confidence is an important component of trading process. Two suggestions to consider for addressing this are to establish liability language with water quality as a public asset (not a property right or home rule to have variations in the process), and build a safety factor for some level of anticipated failures in BMP/LIDs to be installed.

3.8. Administrative Responsibilities

Similar to the New York State’s position expressed during the OBH stakeholder meeting, many state authorities are unwilling to take on the administrative power in their trading programs since it imposes legal liability and resource requirements to review and approve trades to include in NPDES permits. The associated administrative costs can be excessive and cannot be managed without support from a secondary framework such as a local governmental authority or third-party verification.
Quantifying the impact of runoff is a complex task and flexible regulations, yet rigid trading program implementation requirements, are necessary to ensure a smooth trading process with respect to the costs and durations of credits purchased. The involvement of local municipal authorities or watershed agencies taking over the administrative roles is the most ideal way to address this concern. It is imperative that the identification of BMP/LIDs be done with the goal of producing the required offsets with ease of verification and contracting, such as the Rahr Malting Permit (see Appendix A for additional details). This will reduce the trade insecurity concerns of the point sources participating in the trade.

With respect to using agricultural NPS offsets, it has to be noted that farms in many regions tend to be small. Average farm size in New Jersey, for instance, is around 71 acres, and 194-228 acres in New York (National Agricultural Statistics Service, 2009). When it comes to small farms like these, there are high transaction costs associated with multiple small contracts. In addition, they carry risks associated with noncompliance on one hand, especially since there is not quantitative measurement index for the reductions and increased fear by the farming community about being subject to even more regulations, on the other.

The Lower Boise River Effluent Trading Demonstration Project addressed this issue by breaking down the watershed on the basis of irrigation districts and by using them as aggregators or potential brokers, hence resulting in the local governments, authorities and non-profit organizations gaining the trust of the agricultural community. For in-basin drainage areas, the municipal boundaries within each watershed can be considered similar to the districts and can be allowed to aggregate within those geographical areas.

Another promising concept is the establishment of market-based approach to regulatory agency review and approval. The NYSDEC, for example, hired a consulting firm through penalty monies associated with New York City’s consent order programs for the review of projects being implemented and the overall progress being made by the City. This type of third-party (hired or voluntary) arrangement can help in alleviating the common concern on limited resources of state programs to facilitate or administer an NPS trading program. Some trading programs in Ohio and Minnesota have involved third-party contractors in setting up the data management, reporting procedures, online tracking and bidding interfaces, and preparation of standard legal documents for review by various parties. NutrientNet is a utility
being used or recommended to be used in watersheds tributary to the Chesapeake Bay. It must be emphasized that the final approval authority remains with the state agencies.

### 3.9. Technological Feasibility

Apart from high control costs, usage of stormwater BMPs as control practices has some technical challenges. In the Chesapeake Bay program, assuming a 2:1 trading ratio, retrofitting residential areas to achieve required amounts of offsets would require an average of around 50 square miles for a 9,000 lb offset (Stephenson et al., 2009). Alternatively, if BMPs such as bioretention, sand filters, constructed wetlands or wet ponds were to be used, the nutrient reduction per unit of these may not be so significant and a large number of units may be required.

Large-scale pilot programs involving aggregated BMP/LID installations and performance evaluations can reduce the technical and administrative burden on various stakeholders, particularly, the liable parties in the trading program. This is particularly valuable considering the LIS large-scale TMDL effort with over 16,000 square miles of total drainage area and over 1,300 square miles of open waters constituting the Sound. State-of-the science information on the performance of urban and agricultural BMP/LIDs (effectiveness) can be developed, that would be acceptable to the regulatory agencies for approval. The uncertainty and field-scale evaluation considerations pertinent to such practices must be considered explicitly in adopting the performance information in trade calculations.

### 3.10. State or Interstate Trading Policy Adaptation

As far as state-wide policies and frameworks regarding NPS trading are concerned, legislation to fund upgrades to point sources reduces the potential credits for trading and subsequently, the economic driver for trades to occur. When large watersheds like the LIS are involved, there are many difficulties pertaining to settling on a common agreement by the various states that are part of the overall drainage area. Chesapeake Bay is a unique situation where the EPA (2001) conducted a multi-year stakeholder-driven process to establish the fundamental principles and guidelines for nutrient trading.

A common issue seen in inefficient NPS trading programs seems to be the seemingly complex legal and regulatory framework that these programs are based on. Ensuring simplicity and
straightforwardness with clearly defined and accessible trading rules would definitely ensure a higher success rate. Setting high standards for quality assurance before ensuring participation is not the way to initiate a trading program. Emphasis should be on participation first. Apart from this, efforts to educate agricultural and other NPS communities and holding workshops with regard to trading programs and merits for their participation would have benefits in the long run.

Integration of regulatory framework (i.e., TMDL, MS4 requirements for stormwater, and safe drinking water requirements) is a key step to ensuring participation and alignment of overall programs towards the ultimate water quality goal. During the OBH stakeholder meeting, there was an expressed interest to explore cross-media trading, which could require integration with air permitting requirements. A common trait in many successful programs is to start out slowly with stakeholder participation, allow for improvements to be made to the process and use of pilot or mock trades to get tools, skills, and frameworks in place. Simplifying the process to shorten the timeframes for buying credits, completing paperwork, and drafting/issuing NPDES permits were also necessary elements. Also, a clear definition or clarification on the responsibility for failure to secure/generate credits would facilitate the trading process, in order to share the risks or consequences when a specific trade fails due to negligence or actual performance of BMPs being not as good as anticipated.

3.11. Suggested Drivers for Promoting NPS Trading in the LIS Region

A number of nationwide trading programs involving NPS are reviewed in Appendix A. Based on the impediments identified above and the lessons learnt from other programs, trading between point and nonpoint or nonpoint to nonpoint does not emerge as promising option from a cost-effectiveness standpoint. This has been emphasized in review articles such as Stephenson et al. (2010) and Fang et al. (2005).

Besides the common impediments such as uncertainty in BMP/LID performances and administrative challenges, the high costs of implementing BMP/LIDs in urban/suburban landscapes (land costs, labor, etc.) in the in-basin drainage areas can escalate the overall cost of reducing nitrogen from NPS. For example, Stacey (2006) explored the feasibility of PS to NPS trading in Connecticut and generated the following summary shown in Table 3-2.
Table 3-2. Comparison Summary Between Point and NPS Trading (Stacey, 2006)

<table>
<thead>
<tr>
<th>Trading Fundamentals</th>
<th>Point to Point Source Trading</th>
<th>Point to NPS Trading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common WQ problem</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Technically feasible to meet pollutant reduction target</td>
<td>Yes</td>
<td>Uncertain</td>
</tr>
<tr>
<td>Compelling member benefits, especially economic</td>
<td>Yes</td>
<td>Point to NPS/Stormwater</td>
</tr>
<tr>
<td>Ability to quantify and track pollutant loads</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Credit costs based upon agreed protocols</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Diverse market, viable supply and demand</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Reduce overall cost</td>
<td>Yes</td>
<td>Point to NPS/Stormwater</td>
</tr>
<tr>
<td>Transaction cost low relative to price</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Many of the reported impediments to establishing a structured, viable trading program can be overcome with additional planning and implementation. Specific suggestions and considerations for stakeholders (including regulatory agencies) in the LIS drainage areas are provided below, that can facilitate the startup and implementation of trades involving NPS:

1. Utilization of urban stormwater from MS4 systems in a trading program, as the in-basin areas do not have large-scale agricultural operations to consider those as a major player in trading. Although point to NPS trading has become a frequently attempted framework (as seen in the literature review in Appendix A), nonpoint to nonpoint source exchange programs (direct trades or offsets) can look promising when goals such as “no-net-increase in loads” are aimed at. An example is New York City’s phosphorus trading program in which the development aspects were designed to drive NPS reductions more than cost-effectiveness considerations;

2. Consideration of septic systems and large nutrient loads from these systems in the trading program. Conversion of septic systems into sewered areas or serviced by small package plants can reduce loads into groundwater and into surface water from failing septic systems. As documented by Mullaney et al. (2002), Mullaney (2006), and Scorca and Monti (2001), groundwater is a major source of nitrogen pollution from both CT and NY portions of the in-basin areas and the extent to which inputs to groundwater sources is reduced, there will be improvements realized over the long run;
3. CTDEP’s point source trading has already established many challenging elements of a trading program including trading ratios, stakeholder communications, and a market-based framework. Extension of these to include NPS loads can be performed with moderate additional effort, however, as indicated in many literature including CTDEP (2010), Randall and Taylor (2000), Shabman and Stephenson (2007), and Stephenson et al. (2010), a market-like or incentive-based framework is more appropriate for NPS trading in the LIS drainage areas;

4. Research and feasibility studies on large-scale TMDLs including Tar-Pamlico, Gulf of Mexico and Chesapeake Bay conclude that NPS trading will be a valuable long-term approach in the toolbox for achieving water quality standards. In spite of the in-basin drainage areas being urban/suburban, when the out-of-basins are considered, the NPS trading can also become increasingly appealing for the LIS region and can be applied at inter-state, inter-basin and intra-basin scales similar to pilot projects being done in other areas (Chesapeake Bay/Gulf of Mexico) with large-scale TMDLs;

5. Long-term water quality improvements resulting primarily from point source controls can further shed light on the importance of NPS controls. Potential additional reductions in point sources can significantly increase the marginal costs, making NPS trading more appealing. An example is Rowles (2005; 2006) that concluded that phosphorus controls to 1 mg/l would tip the scale towards NPS controls due to excessive point source control costs to achieve a level at or below 1 mg/l. Similarly, additional target reductions in NPS loads (that can emerge as part of the adaptive implementation plan) can also lean towards NPS trading as necessary tool to ultimately reduce or eliminate hypoxia in the western end of LIS;

6. States can steer the trading program with development of guidance or manuals such as West Virginia, Pennsylvania, Michigan and Minnesota. Alternatively, they can support third-parties (non-governmental organizations, consulting firms or dedicated steering committees with representation from various stakeholder groups) to administer and manage trades. This process can reduce the liability on trade participants and the administrative burden on regulatory agencies;
7. Integration of permit requirements can offer incentives for trading. For example, the NYSDEC has established an integrated permit for New York City to collectively assess TN loads from POTWs and wet weather sources and compare with the LIS TMDL requirements for Zones 8 and 9 (representing the upper and lower East River management zones, respectively). Similar “group-permit” approach for POTWs and urban/suburban NPS sources in NY and CT drainage areas can allow a sustained and effective way of tracking and permitting of TN loads, if managed at sub-watershed or municipal scales using applicable trading ratios; and

8. Valuation methods can go beyond the traditional cost-effectiveness calculations. Long-term sustainability outlook involving ecosystem valuation (Ribaudo et al., 2010; Stephenson and Shabman, 2011a; Higgins et al., 2011) or multi-objective decision models can be used to support the trading evaluations. A traditional method will compare the costs of BNR-upgrade in a POTW with implementation of BMP/LIDs in agricultural or forested areas to achieve similar levels of reduction and monitoring to ensure their performance. An ecosystem valuation model can include other factors such as:

(a) Does the BMP/LID remove additional pollutants such as sediments and metals from runoff besides removing nitrogen;

(b) Are there additional BMP/LID implementation benefits in in-stream water quality aspects such as bank/ channel erosion, erosive velocity reduction, tree canopy to reduce urban heat island mitigation effects and increase in assimilative capacity? For example, Table 3-3 shows a comparative assessment developed in MCD (2005) to show the additional benefits of NPS control projects in comparison to the equivalent point source control; and

(c) Do the BMP/LIDs complement other watershed management goals such as flood mitigation and habitat restoration that enhance aesthetics or public safety and other sustainability elements? Maryland trading program (MDE, 2010) considers innovative practices such as algal turf scrubber, oyster aquaculture and carbon sequestration in their toolbox. Similar initiatives are being pilot-tested in LIS and Jamaica Bay to characterize their potential for improving DO levels in these waterbodies.
Table 3-3. Potential Environmental Benefits of NPS Trading (MCD, 2005)

<table>
<thead>
<tr>
<th>Benefits</th>
<th>POTW Upgrade</th>
<th>Traded NPS Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollutant of concern (TN) reduced</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other pollutants reduced (e.g., TP, TSS, and metals)</td>
<td>TP (yes), Others (?)</td>
<td>Yes</td>
</tr>
<tr>
<td>Habitat Improvement</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Canopy enhanced</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Streambanks stabilized</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Flow velocity decreased to reduce erosion potential</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Wetlands created</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Floodplains preserved/enhanced</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Assimilative capacity increased in waterways</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In conclusion, NPS trading would be an attractive approach in the toolbox for reducing nitrogen loads to LIS since they can offer cost-effective or ecologically better solutions to address local or Western-LIS focused nutrient reductions. Ongoing monitoring programs over the next few years will give further insights on improvements happening in the Sound. Even though the potential administrative and technical requirements lend themselves to NPS trades not being cost-competitive, the start-up and pilot implementation projects do take longer timeframes and the timing for a startup process cannot be more favorable than now to explore NPS trades in the LIS region.
4. GUIDANCE FOR NPS CREDIT GENERATION AND TRACKING

The LIS TMDL is a mature program to address hypoxia concerns in the western end of LIS and currently the Phase III and IV are aimed at reducing NPS loads by 10% from in-basin and out-of-basin drainage areas, respectively. Phase V will explore non-treatment alternatives based on adaptive implementation strategy that will use ongoing monitoring results in the Sound as guide to pursuing additional control measures.

In this section, specific guidance is given on elements that are necessary to setup trading programs involving NPS in the LIS drainage area. Some of these are pre-planning elements that will need further guidance and effort from regulatory agencies and other stakeholders and also need to be pursued in the short-term (< 2 years). These will form the foundation for triggering actual implementation projects, and the remaining implementation-oriented elements can then be pursued to facilitate NPS trades.

4.1. Farmland and Open Space Preservation

A major concern expressed by environmental organizations in other programs is that trading should not be considered or used by any entity as a driver for conversion of productive farmlands or open spaces into commercial, industrial or residential developments, even if the conversion and associated stormwater controls can result in reduced TN loads to the waterways. Development pressures are generally high in the Northeast and New England regions, so it is inevitable that some farms and open areas will be converted to urban/suburban land uses. In such circumstances, long-term sustainability vision must be exercised to reduce TN loads beyond what the traditional development-related regulations (e.g., pre vs. post peak runoff reduction) can achieve. It is imperative that additional LID practices and smart growth principles be implemented to a level beyond federal, state, county or local legal development requirements call for.

For example, NYSDEC (2010) and CTDEP (2004) prescribe pre versus post-construction peak runoff as primary requirement, with some additional water quality provisions. Consideration of the capacities of local and neighborhood-scale infrastructure (storm sewers, urban creeks or rivers) often will provide additional criteria that the local municipal governments (cities and counties) can enforce as part of permit approvals for new or re-development projects. For example, some recent development projects in New York City have had to meet both pre vs.
post peak runoff along with “no-net increase in combined sewer overflows” at a neighborhood to watershed-scale. California requires consideration of stream velocity to support the geomorphological health of rivers in development projects. Such criteria will result in additional storage or treatment requirements at site that the developers will need to meet.

In specific instances where a conversion of farmland or open space occurs, credits can only be generated based on the potential benefits (in terms of reductions in TN loads) between the advanced design and traditional development regulations-driven design for the same land use type. A multiobjective design approach is also recommended here, with the nitrogen load reduction and other smart growth elements accounted for explicitly in the design and the resulting TN reductions used towards credit generation.

### 4.2. Potential Changes to TMDL Language

The following language has been extracted from NYSDEC and CTDEP (2000):

> Any reallocations of LAs among management zones, or reallocations between WLA and LAs within and among management zones will be reflected in a revised TMDL to ensure that there is a reasonable assurance that the modified LAs could be achieved. This approach could be modified pending development of a trading program that lays out the framework and requirements necessary to provide reasonable assurance on achievement of LAs.

Regulatory flexibility in a TMDL setting is key to exploring trading strategies, so as to achieve overall watershed-wide pollution controls in a cost-effective manner. This is particularly true with trades involving NPS with variable loads and performance effectiveness of BMP/LIDs. In anticipation of a potential trading program, the above language calls for a framework and requirements necessary to provide reasonable assurance on achievement of the LAs. However, such reallocations of LAs or reallocations between WLA and LAs must be reflected in a revised TMDL.

Modification to the TMDL language must be enacted by NYSDEC and CTDEP to facilitate trading within each management zone and tier. LIS TMDL revision was initially anticipated in 2010, but due to the involvement of three additional states (Massachusetts, New Hampshire and Vermont), the TMDL revision would require additional time and effort. This time-delay
can be used by NYSDEC and CTDEP as a window of opportunity to incorporate revisions that will promote NPS trading within in-basin drainage areas. For start-up purposes, trading between management zones in the in-basin areas need not be considered.

Potential trading partners and trades, through this language modification, can include the following:

- Smaller POTWs in CT (those that were not included in the early Nitrogen Credit Exchange program) and NY to explore point to NPS trading; and
- NPS to NPS trading within any in-basin management zone or tier

Upon incorporation in a revised TMDL, the appropriate General Permit section of NPDES permits (for trades involving point sources) or NPS control sections governing LAs can be modified by CT and NY. The EPA documents (EPA, 2007; 2008) provide additional guidance and recommendations on trading that can assist NYSDEC and CTDEP in reviewing and approving applications for trading. Similarly, the manuals developed by some states or national organizations for programs involving NPS (EPRI, 2002; OEPA, 2007; WERF, 2007; VADEQ, 2008; WVDEP, 2009; and EQB, 2010) can be useful to modify the appropriate regulatory languages.

### 4.3. Quantification of Load and Credit Generation

The NYSDEC and CTDEP are ultimately responsible for approval of trading credits and acceptance in the respective NPDES permits. In order to facilitate this regulatory outcome, a methodology for quantification of load and credit generation is proposed here based on lessons learned from nation-wide case studies involving NPS.

This involves two steps: (a) quantification of point source loading, which is straightforward based on the procedure used by CT Nitrogen Credit Exchange (CTDEP, 2010). Pollutant concentrations in the effluent (measured weekly, based on the 10 million gallons per day threshold) is multiplied with design flow of a POTW to calculate its TN-mass limit; and (b) determination of NPS load from urban and non-urban landuses, that involves some uncertainty related to estimation of loads or credit generation.
Unit area loads (UAL) or event mean concentrations (EMCs) can be used as potential approaches to estimate the NPS loads. Models previously applied for CT watersheds (AQUA TERRA and HydroQual, 2001) or for in-basin areas (Farley and Rangarajan, 2006) used UAL for load estimation. Similarly, the models for suburban or urban landuses such as EPA SWMM use EMC values. A Generalized Watershed Loading Functions (GWLF) model is generally applied for mixed landuse watersheds (Haith et al., 1992), but a recent modification to create RUNQUAL algorithms for urban landuses by Penn State researchers makes it even more useful for the in-basin and out-of-basin drainage areas.

Baseline NPS loads were computed for the 1988-89 period during the LIS TMDL development, and were summarized for in-basin management zones or tiers (Table 6 of NYSDEC and CTDEP, 2000). Recent modeling applications have been developed for in-basin and out-of-basin areas since LIS TMDL development. Therefore, the first step is to resurrect a recently developed watershed model and review the background data used to construct it. Where applicable, recent physiographic data on landcover/landuse, stream cross-sections, etc. need to be used to update it. Following approaches can then be used to estimate baseline loads from various landuses within a watershed: (a) apply the 1988-89 rainfall record; or (b) use a representative or long-term average precipitation record in the region. Sometimes it may be effective to use the limited data available for calibration/validation to also support the calculation of baseline loads.

Example resurrection and calibration of previously established modeling tools and their usage to estimate baseline loads are shown in Appendices C and D for the Saugatuck River and Oyster Bay Harbor/Mill Neck Creek watersheds, respectively. Review of recent available information on flow and water quality and data analysis to derive calibration parameters (or supplement with literature values), and procedures for calibration and validation can be seen in these appendices. Availability of information can vary with specific watersheds, so the procedures shown as examples can be tailored for a specific watershed under consideration.

For estimating credits based on BMP/LIDs being considered, it is prudent to start with the best available performance information from literature. There are concerns about using constant percent removals to represent BMP/LID performances, primarily due to the associated variability caused by storm conditions, seasonality, and other factors (Jones et al., 2008). Alternate performance evaluation metrics such as effectiveness ratio or variable percent removals have been recommended in the literature (Jones et al., 2008). Irrespective of such
concerns, a constant percent removal metric is appropriate for trading evaluations and implementation due to its simplicity in representation in a trading framework and for effective communication with various stakeholders. Percent removals and planning-level costs compiled from a recent literature search for both urban and non-urban BMP/LIDs are summarized in Appendix B for the benefit of the LIS community.

For a trading program start-up in the LIS region, the percent removal concept is suggested. However, the long-term success for a program lies in understanding the uncertainties associated with BMP/LID performances and addressing them through solid protocols and monitoring. Common uncertainties considered by the scientific community for NPS include:

- **Measurement Uncertainty:** Pertinent to the duration and frequency of field testing through influent and effluent monitoring to characterize the performance of BMP/LIDs, under varying hydrologic and water quality loading conditions;
- **Implementation Uncertainty:** Guidelines used by professional community can vary significantly in the design, construction, and O&M of BMP/LIDs; and
- **Performance Uncertainty:** This pertains to the risk of BMP/LID failures due to human-induced or extreme events.

The State of West Virginia (WVDEP, 2009), for example, incorporated these uncertainties using an uncertainty ratio in its guidance manual, in addition to a trading ratio that accounts for the fate and transport of nutrients from source area to the locations in waterways where the impacts are realized. Trading ratios have already been established for individual management zones/tiers and the CTDEP extended these to individual municipality levels within the CT drainage areas. An uncertainty ratio similar to the West Virginia approach is suggested for the LIS drainage areas, until the establishment of streamlined procedures for design, O&M and monitoring, and enforcement strategies for performance failures assessment and correction. Application of this uncertainty ratio ensures that the actual loads resulting from a trade do not violate the water quality standards despite the inability to accurately measure those loads (Jones et al., 2005).

Use of this uncertainty ratio can be avoided or minimized where steps are undertaken to ensure high levels of caution and rigor in the use of practices pertaining to monitoring, modeling or estimating the effectiveness of specific or combinations of BMP/LIDs being implemented. Monitoring can be performed using either edge-of-field techniques or ambient
water quality characterization. Placement of flow and water quality monitoring instrumentation at strategic locations will help assess the water quality benefits from installed BMP/LIDs. USEPA (1997) provides ample guidance for the design of water quality monitoring programs in order to assess impacts from NPS and evaluate the effectiveness of control practices.

A common barrier to trading (as discussed in Section 3) is the cost involved in performance monitoring and evaluation. Field or edge-of-field techniques can be very expensive and can be adopted on as-needed basis for enforcement actions or to address legal challenges. In all other instances, monitoring of ambient water quality to demonstrate the overall loading from areas tributary to those sampling locations and consequent improvements from BMP/LID installations will be a better use of limited available personnel and financial resources.

Spatial resolution of the watershed models must be designed to capture the performance of potential groups of BMP/LID locations. For each subwatershed or neighborhood areas being considered, the TN load can be calculated as:

\[ \text{TN}_i = \sum_{j=1}^{n} Q_{i,j} C_j \]

where, \( \text{TN}_i \) is the total nitrogen mass in drainage area \( i \), \( Q_{i,j} \) is the flow volume from landuse type \( j \) within area \( i \), and \( C_j \) is the EMC or UAL for the landuse type \( j \). The above equation derives the TN mass for all landuse types (from 1 to \( n \) types) during one time-step. Total load from this NPS can be estimated by cumulating the mass for all time-steps within the annual period being used for trading evaluation.

Similarly, for the BMP/LID applications in each landuse type, there can be reductions in flows generated due to infiltration-based controls and reductions in EMC/UAL being represented by constant percent removals for the specific BMP/LIDs adopted. Many such controls can be placed in each landuse type, therefore, a weighted average value of percent removal (represented as additional variable \( k \) in the equation below) will need to be derived and used here based on the fraction of areas controlled by specific BMP/LIDs.
Credit generated from this BMP/LID application can be computed as:

\[ Cred_i^k = (TN_i - TN_i^k) \times TR_i \times UR_i \]

where, \( Cred_i^k \) is the generated credit, \( TR_i \) is the trading ratio for drainage area \( i \) computed based on its geographical location with respect to the other area being considered for trading, and \( UR_i \) is the uncertainty ratio applied for this drainage area \( i \). With the application of trading ratios, the credits computed will be trade equalized credits (a term that the LIS community is familiar with, based on the CT Nitrogen Credit Exchange program) available for transaction in the marketplace.

The \( UR \) accounts for uncertainties associated with estimating the effect of temporal, spatial, and water quality factors specific to reductions; variations in annual/seasonal weather, in the fields and crops, in human practices, in receiving streams, in the estimation of past loadings, and in the equivalency of various forms of pollutants (e.g. bound vs. biologically available nitrogen). Suggested \( UR \) value is 0.5, which basically means that a ratio of 1:2 is conservatively applied to account for the various types of uncertainties. The above calculation methodology is provided as suggestion and other scientifically defensible calculation methods can be used, if desired, in individual watershed trading programs (evaluations) to generate credits.

Credits must be expressed in terms of the unit of compliance (e.g., pounds per day), and the accounting of trading and uncertainty ratios will yield an equivalent nitrogen credit that can be traded with another point or nonpoint source. In the LIS point source load calculations, the annual mass over an entire year is computed and by dividing by the number of days in that year, the loads (in pounds per day) can be calculated.

Such credits generated will be valid for one calendar year or other time period determined by NYSDEC or CTDEP to be appropriate for the trading evaluation. Credits need to be measured, verified and accounted for within this approvable time period. For example, if a BMP/LID has a longer lifespan than a year and supported with a legally binding O&M plan
for consistency in performance, credits can be generated for up to five years to coincide with
the permit renewal frequency for point sources.

It is recommended that individual or groups of BMP/LIDs be subjected to this guidance to
generate groups of credits on a management zone/tier level, with a valid timeframe of up to 5
years. Credits generated in one year must be applied within the same year during trade
transactions.

A formal application must be developed and approved by the regulatory agencies to facilitate
credit generation. In CTDEP's nitrogen credit exchange program (CTDEP, 2010), the process
for point source trades was straightforward. For trades that involve NPS, the following
minimum data or information (listed in Table 4-1) is recommended for review and
consideration by the regulatory agencies and trading partners.

Table 4-1. Minimum Data/Information for Review of Credit Generation Process

| Credit generator: Type, Contact person(s), Contact information (Phone/Fax/E-mail/
| Physical Address, County, State, Zip Code, Latitude and Longitude) |
| Watershed information: Tributary/river segment, management zone/tier/municipality to
| identify trading ratio (for LIS TMDL), Designated use of receiving water (e.g., water supply
| intake, coldwater fishery) and any impaired segments and related local TMDL efforts that
| may require nutrient reductions beyond the 10% that LIS TMDL calls for |
| Responsible Party: In charge of verification - Third-party, NGO or steering committee |
| Current BMP/LIDs in the drainage area (may or may not have been constructed when
| baseline was established): Types, Dates of installation, Descriptions of units (treated area,
| storage in acre-feet, etc.), Any design modifications to be done to enhance nutrient removal
| (e.g., conversion of dry ponds to wet ponds), Percent removals for these BMP/LIDs, and
| Project lifespan |
| New BMP/LIDs to be implemented in the drainage area: Types, Descriptions of units
| (treated area, storage in acre-feet, etc.), Preliminary or final design documents, Expected
| percent removals for these BMP/LIDs, O&M protocol and frequency, and Project lifespan |
| Step-by-step procedure for credit calculation: Geographical setting of existing and new
| BMP/ LIDs and use of trading and uncertainty ratios to determine the credit to be generated,
| for review by the regulatory agency and a third-party |
| Restrictions or Disclosure: Any funding source that may have been used to pay for existing
| BMP/LID that may restrict or limit in any way the sale or income from credit generation |

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Verification: Procedure for verification (e.g., maintenance of records of BMP implementation, manure management or reduction in fertilizer application to be maintained by the seller) and public or open access to this information for all stakeholders; and a course of action for managing potential risks of BMP/LID failure

Additional benefits: Any known or anticipated local benefits that may transpire from implementation of BMP/LIDs (e.g., source water protection, habitat restoration, flood mitigation, aesthetics, standards of living, greenhouse gas reductions, and increased property value)

Submittal information: Name, address and contact information for the submitting agency, if a proposal is being submitted on behalf of a credit generator

Two example pollutant load trading calculations are shown here for the Saugatuck and OBH/MNC watersheds here.

Example 1: Saugatuck River Watershed:
From Appendix C, the annual load for say, the Upper Saugatuck River subwatershed, is 1,003 lb/year for Hay/Pasture and 766 lb/year for Forest. A 10% reduction in TN loads from these two landuses is 177 lb/year. Hypothetically, we want to show the percent reductions in pollutant loads needed to consider trading between these two non-urban NPS with urban stormwater.

Low density (376 lb/year) and high density (1,988 lb/year) landuses make up a total of 2,364 lb/year. A 10% reduction translates to 237 lb/year to meet the LIS TMDL requirement. With an uncertainty ratio of 0.5 and assuming that the entire urban load is being targeted for trading, the total reduction in loads expected from non-urban NPS will be:

Total load reduction = 10% Non-urban + (10% Urban)/Uncertainty Ratio, yields a total of 751 lb/year reduction from non-urban NPS. This translates to about 37% reduction in non-urban NPS, instead of the original 10% when NPS trading was not considered. A 37% reduction can be challenging from these two landuses, so a more balanced distribution of say 5% of urban TN loads are being considered for trading. Even this yields a total of 414 lb/year reduction from the two non-urban uses (about 24% reduction from baseline). Cost of this can be evaluated using BMPs that are beneficial for the Forest and Hay/Pasture landuses and determining the areal extent of these BMP installations needed to achieve the 24% reduction.
It can then be compared with what it would take to reduce 5% of TN loads from dense urban or suburban areas.

Example 2: Oyster Bay Harbor/Mill Neck Creek Watershed

Let us consider the Mill Neck Creek subwatershed in this example. Urban landuses contribute 2,322 lb/year and a 10% reduction yields 232 lb/year. The septic system load is 31,429 lb/year (with a 10% target of 3,143 lb/year) and the total reduction needed is:

\[
\text{Total load reduction} = 10\% \text{ Non-urban} + (10\% \text{ Urban})/\text{Uncertainty Ratio}, \text{ yields a total of 3,607 lb/year reduction from non-urban NPS. This translates to approximately 12.5% reduction needed from Septic systems to offset the reductions in urban NPS.}
\]

4.4. Credit Certification and Verification

Credits generated using the above procedure needs to be formally certified and verified prior to getting into a transaction. A number of examples have been developed by state agencies in other trading programs (Breetz et al., 2004) for credit verification and registration. This is particularly important in point source to NPS trading, where the credits become an integral part of the point source’s NPDES permit application. In the LIS context, it must also be emphasized that this step is among the implementation-level elements that must be pursued subsequent to the completion of other pre-planning elements.

The certification process can begin with a written request from seller or third-party to NYSDEC or CTDEP to certify a pollutant reduction activity, prior to beginning that activity. A 30-day review period is commonly seen in other programs and is recommended here also for determining technical acceptability and consistency with LIS TMDL and additional regulations to meet source water protection or address local waterbody impairments. This process ensures that the regulatory agency is fully on-board with the initiation of pollution reduction activity.

For NPS projects involving agricultural, forestry or urban stormwater, the review can be performed by University extension staff (Cornell University for NY and University of Connecticut for CT), State Conservation Agencies and Departments of Agriculture, USDA NRCS, City/County engineer or their consultant, and the LIS EPA office.
Approval of generated credits must be done through verification of the pollution reduction activity by the regulatory or its designated agency. This starts with a verification plan that outlines how the verification will be performed (data requirements, verification agency (e.g., NRCS, extension services in universities, or a contractor), and guidelines for additional data collection should the verification effort fail.

The first step in verification is the development of detailed documentation on BMP/LIDs installed and maintained by the generator, which can be performed by a qualified and approved third party professional. This inspector must have the education, knowledge and experience to determine if the BMP/LID is properly installed, operated and maintained to achieve the required nutrient reductions. Examples verification techniques can include a review of engineering plans, photographic documentation of the installed BMP/LIDs along with specific actions undertaken (e.g., reductions in the number of fertilizer bags used in comparison to baseline or a truck that was weighed to haul manure/litter used for seasonal fertilizer application).

As second step, the verification agency must perform a combination of record keeping, monitoring, inspection of sites, self-certifications and performance of compliance audits. Some agencies such as West Virginia have established an additional step called registration, that essentially tracks the verified credits into valid contracts that can be used in a NPDES permit for the participating POTW. Approval and trading of credits can be done through a website or an on-line marketplace such as NutrientNet. This will enhance the transparency aspects of the trading process, which is vital to the integrity and acceptability of outcomes among various stakeholders. Many trading programs have emphasized the importance of openness, allowance of adequate time for review and feedback, public outreach, and periodic updates throughout the trading process to ensure its success. With the advent of internet-based marketplaces such as NutrientNet and informational sites such as Environmental Trading Network, the public outreach and education programs can be designed with relatively minimal effort.

Verification and approval is another key step in a trading program where liability rules need to be established to guide compensation decisions when specific sources of pollution are subjected to litigation for non-compliance in a court of law. Strict liability and negligence are two frameworks used in other trading programs. Pollution sources can be held absolutely
liable for payment of any damages that occur under strict liability. Under a liability rule based on negligence, a credit generator is held liable only if the generating organization fails to operate under the standards of due care. Due care can be assessed in terms of either performance-based outcomes or in terms of a credit generator’s actions and documentation.

Credits approved by the regulatory agencies (NYSDEC and CTDEP) are eligible for trading with permitted effluent limits for point sources or other NPS loads. For point sources, the NPDES permittee (POTW) is responsible to ensure that the credits are adequate to meet their limits and report through their discharge monitoring report (DMR) or another acceptable documentation for the number of credits that are applied towards its NPDES permit compliance. Permittees are responsible for assuring adherence to the terms of their credit purchase agreements. Where applicable (e.g., “no-net increase” in nutrient load requirement), in accordance with nutrient reduction requirements of a facility’s NPDES permit, permittees can be required to obtain credits to offset additional nutrient loadings from all new or expanded discharges (customers) contributing to the POTW.

4.5. Design of Incentives for NPS Trades

Three types of incentive designs are seen in the literature: expected runoff, input/technology-based and performance-based. Each of these designs has certain advantages and disadvantages as summarized below.

*Expected runoff:* A regulatory agency may require development of a mathematical model to simulate runoff from each NPS location, monitor the physical processes to estimate the consequent runoff generated. Tax/subsidies can be designed based on this runoff volumes and rates, which is similar to a design flow in NPDES permit for POTWs. The main problem is that this incentive is quite a complex task, and demands significant information compilation by the regulatory agency or trading parties (Shortle et al., 1998).

*Input and Technology-based incentives:* Input-based incentives can be in the form of taxes imposed on polluting inputs (e.g., fertilizers and pesticides), and subsidies for purchases of pollution control equipment. Overall administrative and enforcement costs are relatively low, which make such policies very attractive for implementation. The relationship between pollution level, inputs, and technology used is very uncertain and varies among nonpoint
polluters (due to difference in landscape and production process). Therefore, inputs and technology are imprecise approximation for the runoff levels.

*Performance-based incentives:* The most logical targets of performance-based incentives are runoff from the field and ambient water quality. Theoretically, incentives based on runoff are most appealing since the price for pollution can be applied directly to the polluter. Unfortunately, those policies are not feasible due to the diffuse nature of NPS; runoff from a particular farm cannot be monitored at a reasonable cost.

In the LIS context, the runoff-based incentive design is most promising, since the existing mathematical models can be modified to develop quantity and quality of runoff from NPS sources at parcel or neighborhood scales to support the trading evaluations. Integration of a multiobjective paradigm or ecosystem service/valuation with this runoff-based design will provide the framework to handle both water quality and water-air quality NPS trades, which is one of the expectations set forth by the OBH stakeholders. Stephenson and Shabman (2011a) and Ribaudo et al. (2010) provide frameworks for water quality trading and permitting, and Lal et al. (2009) provides approaches and tools for integrated water-air trading and permitting.

### 4.6. Specific Considerations for Non-urban NPS Controls

With high levels of administrative and monitoring costs and performance uncertainty, the agricultural and other non-urban NPS credits have turned out to be more expensive than the values purported in the literature. For example, agricultural NPS credit in Virginia can be more than $100 per pound of nitrogen (Stephenson et al., 2010), as compared to less than $5 for point source nitrogen credit in Connecticut (CTDEP, 2009). Part of the issue in some trading programs is related to agricultural sources needing to implement lower-cost BMP/LIDs to meet certain performance thresholds before they become eligible to trade. As such, tradable credits have to be created with higher-cost BMP/LIDs (Stephenson et al., 2010).

While the point sources may not oppose to investing resources elsewhere in a watershed to achieve controls, the regulatory framework has stricter stipulations for non-compliance in their NPDES permits. Market-like principles (discussed in the next section) are more effective in securing meaningful and certifiable reductions in NPS loads. Some special considerations are suggested below, which can help in engaging agricultural and other non-urban nonpoint sources effectively in a trading process:
• Engage trusted contacts (e.g., NRCS) to serve as liaisons with the agricultural community;
• Regulatory framework and clear legal authority are key to success in a community-based trading initiative;
• Approaches that emphasize practices or actions that will be in the best interest of the farm, the farmer and landowner are likely to be well received;
• Good or bad publicity must be avoided, since the farming community may shy away from programs that are regulatory in nature and receive scrutiny by the media and other public; and
• Private contracts with trading credit users or credit banks will be better models than inclusion of farmers directly in a point source permit. Service agreements between user and generator define any issues between both parties, and participation by a third party (banker or USDA NRCS) minimizes these risks.

Some important lessons learned for establishing non-urban NPS trades and water quality trading banks can be seen in Siems et al. (2005) and the Chesapeake Bay process, EPA (2001).

4.7. Mitigation of Financial and Legal Liability

For trades involving both the point and nonpoint sources, the concern on legal responsibility for non-compliance of NPS controls can be mitigated by potentially exploring watershed-based or other group-based permits. This has been successful in minimizing legal and financial risk when multiple point sources are involved in point-source trading. For example, a bubble permit for Westchester County POTWs collectively governs the NPDES compliance for all of these plants together. However, caution must be exercised and innovative mechanisms are needed to extend this concept to groups of point and nonpoint sources within a management zone or tier. When designed effectively, these programs will provide more flexibility for trades within the group and transfers the liability from an individual POTW to a group of sources.

A second approach used in some trading programs to mitigate liability is the establishment of direct contracts between point source (potential buyer) and nonpoint sources (credit generator/seller). Contractual agreements between the generator and buyer spell out how to install BMP/LIDs, follow O&M protocols and monitor to ensure pollutant load reductions are equivalent to the traded point source load after accounting for trading and uncertainty
ratios. Formation of a third-party to facilitate the trade or manage through a banking system will reduce the number of contracts to be established, thereby reduce the administrative cost and review timeframe.

Financial assurances have been used extensively in the wetland credit banking programs. This is another option available to trading among point and nonpoint sources or between nonpoint sources. Duration of credits, say 5-years or lifespan of BMP/LIDs, will determine the validity of assurances. After this duration, new trading agreement with appropriate financial assurances will need to be developed. Two forms of assurances can be formulated:

(a) A credit generator to establish financial assurance with the credit buyer, to an amount equivalent to the estimated costs for BMP/LID failure and its corrective action. Partial payments made by the buyer towards future credits and incremental release of the financial assurance will encourage the generator to promptly complete the BMP/LID projects. If there is any default from the seller’s side, there would be adequate funds with the generator to complete corrective actions and management of BMP/LIDs or purchase credits from another seller. A regulatory agency can allow extra time for project completion if such situations arise, to reduce the liability of a credit buyer; or

(b) A credit generator to establish financial assurance directly with the regulator, who in turn would release the financial assurance incrementally as project elements are completed. This would incentivize the seller to complete BMP/LIDs promptly and commit to long-term O&M required over the lifetime of a trade agreement.

A major concern expressed by Fang et al., (2005), Stephenson et al. (2010) and Stacey (2006) is that the costs of NPS controls are quite expensive than those purported in the literature. In-kind services and grants from federal or other agencies have been some of the reasons for underestimation. Monitoring requirements and administrative processes contribute to actual NPS control costs in excess of $100 per pound of nitrogen (Stephenson et al., 2010). A traditional market-based framework would mostly lean towards point source controls and avoid NPS controls.

With the added ecological and watershed-wide benefits, a market-like framework will be more appropriate, given its practical outlook on demand uncertainty and dealing with thin markets (Shabman and Scodari, 2004; Shabman and Stephenson, 2007). This has elements of a market but do not focus on the market being driven by participants as they face incentives. The
market-like process involves private NPS credit generators compete with each other to sell credits to a POTW or another NPS. Competitive aspects of this process focus on credit quality (type of BMP/LIDs implemented to generate credits) and the assurances offered by a seller that the credits were generated to provide more ecologically sound or watershed-wide benefit, and the price requested for the credit generation. This type of bidding process has found success in solar energy generation credit tracking and transactions, and a similar competitive process on price and quality can address the thin market problem.

4.8. Specific Considerations for Urban Stormwater

Drainage areas adjacent to the Sound on both New York and Connecticut portions are dominated by urban or suburban landuses and this poses unique challenges due to the highly varying volume and peak runoff rates and the pollutant load generation and transport from source areas (NYSDEC, 2010). Some additional guidance is provided here on the selection of BMP/LIDs to address pollution from urban stormwater.

A number of stormwater controls can be effective in reducing TN loads from drainage areas tributary to the Sound. Table 4-2 lists BMP/LIDs effective for water quality protection as suggested in the NYSDEC stormwater manual (NYSDEC, 2010). Almost all of these are structural practices (e.g., filtration, infiltration, runoff peak or volume control, ponds, wetlands, and manufactured technical devices) requiring feasibility evaluation, engineering design and construction, O&M, and permitting. Capital and O&M costs of individual controls can be significant, however, they are usually designed to treat runoff volumes or pollutant loads generated from drainage areas much larger than the controls’ actual footprints to make them more cost-effective. The land areas for implementation of such controls in urban areas of this watershed can be very expensive and also the site selection needs to ensure that enough water can be brought to the BMP/LID locations in order to provide treatment.

Both CT and NY are in the early stages of an MS4 permitting program for controlling pollution from urban stormwater. NYSDEC (2010) provides options for individual MS4 systems to either act alone or come together to meet the TMDL requirements for specific watersheds (impaired for phosphorus, nitrogen or pathogens). A group of municipalities can come together to estimate the baseline pollutant load from their entire system and can install BMP/LIDs to reduce baseline load by the required percent reductions, instead of each municipality having to do installations within their own areas.
Table 4-2. BMP/LIDs Effective for Water Quality Improvement

<table>
<thead>
<tr>
<th>Group</th>
<th>Practice</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond</td>
<td>Micropool Extended Detention Pond (P-1)</td>
<td>Pond that treats the majority of the water quality volume through extended detention, and incorporates a micropool at the outlet of the pond to prevent sediment re-suspension.</td>
</tr>
<tr>
<td></td>
<td>Wet Pond (P-2)</td>
<td>Pond that provides storage for the entire water quality volume in the permanent pool.</td>
</tr>
<tr>
<td></td>
<td>Wet Extended Detention Pond (P-3)</td>
<td>Pond that treats a portion of the water quality volume by detaining storm flows above a permanent pool for a specified minimum detention time.</td>
</tr>
<tr>
<td></td>
<td>Multiple Pond System (P-4)</td>
<td>A group of ponds that collectively treat the water quality volume.</td>
</tr>
<tr>
<td></td>
<td>Pocket Pond (P-5)</td>
<td>A stormwater wetland design adapted for the treatment of runoff from small drainage areas that has little or no baseflow available to maintain water elevations and relies on ground water to maintain a permanent pool.</td>
</tr>
<tr>
<td>Wetland</td>
<td>Shallow Wetland (W-1)</td>
<td>A wetland that provides water quality treatment entirely in a wet shallow marsh.</td>
</tr>
<tr>
<td></td>
<td>Extended Detention Wetland (W-2)</td>
<td>A wetland system that provides some fraction of the water quality volume by detaining storm flows above the marsh surface.</td>
</tr>
<tr>
<td></td>
<td>Pond/ Wetland System (W-3)</td>
<td>A wetland system that provides a portion of the water quality volume in the permanent pool of a wet pond that precedes the marsh for a specified minimum detention time.</td>
</tr>
<tr>
<td></td>
<td>Pocket Wetland (W-4)</td>
<td>A shallow wetland design adapted for the treatment of runoff from small drainage areas that has variable water levels and relies on groundwater for its permanent pool.</td>
</tr>
<tr>
<td>Infiltration</td>
<td>Infiltration Trench (I-1)</td>
<td>An infiltration practice that stores the water quality volume in the void spaces of a gravel trench before it is infiltrated into the ground.</td>
</tr>
<tr>
<td></td>
<td>Infiltration Basin (I-2)</td>
<td>An infiltration practice that stores the water quality volume in a shallow depression, before it is infiltrated into the ground.</td>
</tr>
<tr>
<td></td>
<td>Dry Well (I-3)</td>
<td>An infiltration practice similar in design to the infiltration trench, and best suited for treatment of rooftop runoff.</td>
</tr>
<tr>
<td>Filtering Practices</td>
<td>Surface Sand Filter (F-1)</td>
<td>A filtering practice that treats stormwater by settling out larger particles in a sediment chamber, and then filtering stormwater through a sand matrix.</td>
</tr>
<tr>
<td></td>
<td>Underground Sand Filter (F-2)</td>
<td>A filtering practice that treats stormwater as it flows through underground settling and filtering chambers.</td>
</tr>
<tr>
<td></td>
<td>Perimeter Sand Filter (F-3)</td>
<td>A filter that incorporates a sediment chamber and filter bed as parallel vaults adjacent to a parking lot.</td>
</tr>
<tr>
<td></td>
<td>Organic Filter (F-4)</td>
<td>A filtering practice that uses an organic medium such as compost in the filter, in the place of sand.</td>
</tr>
<tr>
<td></td>
<td>Bioretention (F-5)</td>
<td>A shallow depression that treats stormwater as it flows through a soil matrix, and is returned to the storm drain system.</td>
</tr>
<tr>
<td>Open</td>
<td>Dry Swale (O-1)</td>
<td>An open drainage channel or depression explicitly designed to detain and</td>
</tr>
</tbody>
</table>
This bubble-permit concept can be extended to provide a basis for creation and trading of credits from MS4 systems, provided the following minimum requirements are met. If the BMP/LIDs exceeded the minimum requirements, the excess nitrogen reductions can be used with appropriate trading and uncertainty ratios to convert to credits that can potentially be used in the trading process.

- Develop estimates of nitrogen loads based on most recent landcover/landuse information, and compare with estimates provided in the baseline conditions for LIS TMDL is based;
- Ensure that BMP/LIDs are maintained very well and proper O&M activities are performed on high density stormwater controls;
- Develop a public education program to inform citizens, business, and industry of methods to reduce nutrient loading including education on home fertilizer usage;
- Develop a mapping program which includes storm sewers, waters of the state, land use, and sanitary sewers; and
- Develop a program to detect and remove illicit discharges to the stormwater system.

In the urban areas adjacent to the Sound, there are several factors that will limit urban NPS to become a potential generator of credits that can be sold to non-urban NPS. Such factors include the high cost of land for BMP implementation and dynamically varying flow and pollutant loads due to higher percent imperviousness in urban areas. Pollutant calculations shown under the “Credit Generation” section can be used to compute loads and the reductions to meet a bubble or collective permit that the NYSDEC MS4 program (NYSDEC, 2010) allows. Similar provision is needed from CTDEP to facilitate group-based permits in CT. On the other hand, the urban NPS can potentially generate credits cost-effectively to trade with small POTWs. Similarly, the non-urban sources can generate credits that can be traded with urban NPS or small POTWs.

The trading ratio is 1 (one) in Saugatuck River watershed, being very closer to the western end of LIS. With the application of uncertainty ratio of 0.5, two pounds of nitrogen from urban
or non-urban NPS must be generated to offset 1 (one) pound of nitrogen for the potential buyer.

4.9. Specific Considerations for Groundwater

Significant amount of nitrogen reaches the Sound through groundwater sources (Scorca and Monti, 2001; Mullaney et al., 2002). Nutrients infiltrating into the groundwater reappears in streams as base loads and the residence times are in the range of two to more than 50 years (Mullaney et al., 2006). This source is the most challenging from a control standpoint, as the benefits will be seen only after a long-term and after investing significant financial resources. With this, the groundwater source is not recommended for inclusion in the trading. Following issues can guide the states and LISO in terms of how to control or reduce the nitrogen loads from this source through measures that can be undertaken on a short to long-term basis:

- Encourage adoption of process-based BMP/LIDs (e.g., raingarden, constructed wetlands, and bioretention) to uptake nutrients instead of infiltrating into groundwater for recharge or otherwise; and
- Evaluate the need and potential costs associated with treatment technologies for removing nitrogen from groundwater (e.g., Permeable Reactive Barrier, alternative septic systems, and POTW expansions, and in-stream wetland in upper reaches with high septic system density).

A major reason for nominal 10% in NPS load reduction in the LIS region is due to the high levels of TN loads being generated by baseflows in streams and septic system failures (see Appendices C and D). While the baseflow loads are challenging from a reduction standpoint, the septic systems can be targeted for TN reductions during dry periods and failed systems during wet weather. Monitoring of concentrations in observation wells is recommended to get a better picture of this problem and undertake appropriate actions subsequently.
This summary was developed primarily from Undated White Paper (see weblink in the references, Appendix E) that discussed the following trading programs in detail. Only those programs that involved nutrient trading are included in this summary. This is aimed at providing context on some key lessons learned that can be useful to the LIS community. It is important to note that none of the water quality trading schemes found in this review has successfully implemented a nonpoint to nonpoint source trade, although the point to nonpoint source trades can be seen more commonly in these programs.

**Lake Dillon Trading Program**

**Sources:** This first trading program in the country involving NPS trading was established by the State of Colorado in 1984. POTWS to increase their waste load capacity for an expanding population and NPS to reduce their loads triggered this program (Breetz et al., 2004).

**Lead Agency:** Water Quality Control Commission, Colorado Department of Public Health and Environment

**Cost Savings:** The economic analysis indicated that POTWs in this area could cut their average annual cost of reducing phosphorous by about $1.5 Million (50% if they funded NPS reductions) to offset their increase in wasteload instead of investing in facility upgrades.

**Program Development and Sustenance:** This program was based on attainment of ambient water quality standards and credits received were based directly on the amount of phosphorus reduced by each specific practice installed (Stephenson and Shabman, 1996). A trading ratio of 2:1 was set between point and nonpoint sources, and 1:1 for trades between two nonpoint sources (Breetz et al., 2004). Since NPS are not under Clean Water Act regulations in most cases, the point sources involved are held liable for compliance with trades (Sohngen, 1998).

Two trades involving conversion of septic systems to sewer connections for treatment at POTWs have occurred and more than 10 nonpoint sources have generated credits which have been banked but not used (Environomics, 1999). The market structure supports bilateral negotiations between buyers and sellers of credits.

**Weblink:** [www.cdphe.state.co.us/regulations/wqccregs/100271dillonreservoir.pdf](http://www.cdphe.state.co.us/regulations/wqccregs/100271dillonreservoir.pdf) (accessed in July 2010).

**Boulder Creek Trading Program (Colorado)**

**Sources:** Point to nonpoint source trades (for nitrogen) between POTW and in-stream...
projects.

**Lead Agency:** City of Boulder

**Cost Savings:** Approximately $3-7 Million by deferring full nitrification modifications

**Program Development and Sustenance:** Un-ionized ammonia levels in the stream caused water quality violations for warm water aquatic life protection. Stream restoration projects that would reduce sediment loads and improve water quality were considered equivalent to nitrification at POTW to reduce ammonia levels. These projects included: streambank stabilization, riparian restoration, development of pool habitat, narrowing/deepening the channel, returning natural sinuosity, restoring ring wetlands habitat, rerouting irrigation return flows through developed wetland (USEPA 1996).

**Weblink:**

**Maryland Trading Program**

**Sources:** Point to nonpoint source trades (for both phosphorus and nitrogen) between POTWs and mainly agricultural sources.

**Lead Agency:** Maryland

**Cost Savings:**

**Program Development and Sustenance:** Trading consisted of two parts: (a) generation of agricultural NPS credits through selling and exchange of agricultural NPS credits through buying. These agricultural credits can then be used for point-NPS or NPS to NPS trading (Maryland Nutrient Trading Program, MDA). Credits may only be applied as offsets in the year in which they are generated and cannot be banked for future years

For agricultural operations, certain BMPs like riparian buffers and livestock fencing, along with cover crops, reduced fertilizer application, and manure export qualify for credits but only after: (a) being certified and inspected by MDA; (b) being built and operated by USDA and NRCS specifications; and (c) annually verified by technically competent reviewers. Tradable BMPs were grouped into three types:

i. BMPs with approved (well documented and widely used) effectiveness: e.g., riparian forest buffers with continuous no-till, riparian grass buffers, wetland restoration, tree planting, cover crops, off stream watering with or without fencing, off stream watering,
fencing and rotation grazing, animal waste management systems for livestock and poultry, and barnyard runoff control and loafing lot management;

ii. BMPs that require technical review: dairy precision feeding, precision agriculture, conservation – tillage precision grazing, poultry litter transport water control structures, stream restoration, cropland conservation, enhanced nutrient efficiency, and commodity cover crops; and

iii. Other innovative BMPs with limited effectiveness information: ammonia emission reductions, algal turf scrubber, oyster aquaculture, carbon sequestration, and alternative crops.

This program has an online marketplace to facilitate trading. Only approved BMPs can be used at this time, but the other two classes will be reviewed/approved on a case-by-case basis. Interstate trading is allowed within basins and legally binding contracts are established between credit generator, credit user and credit aggregator. Annual inspection processes evaluate the accountability and functionality of the BMPs employed in the credit generation process. There is complete public transparency with regard to the public registry of credits. [Weblink: www.mda.state.md.us/nutrad/](http://www.mda.state.md.us/nutrad/) (accessed in July 2010).

**Great Miami River Watershed, Ohio**

Sources: Over 80 percent of the private land in the Great Miami River watershed in Ohio is in agricultural use and there are 314 regulated point sources.

Lead Agency: The Miami Conservancy District (MCD), a regional government agency, serves as non-regulatory third party broker. MCD obtains credits through contract with agricultural producers who implement BMPs and then aggregates and sells to point sources under a separate contract. MCD also establishes rules for the approval of transactions, including trading ratios (to insure against uncertainty), certification of credits, liability and recovery of funds from failed projects.

Cost Savings: About $314-385 million to the utility rate payers over the next 20 years and providing substantial funding to local farmers in exchange for improved conservation practices.

Program Development and Sustenance: EQIP funds contribute to this program, so USDA Farm Service Agency helps assure that farmers are eligible for EQIP. The County Soil and Water Conservation Districts participated in program development, advised and supported farmers to identify and install BMPs, and help quantify credits for the program. USDA NRCS also participated in program development and helps to quantify credits. About five to 10
percent of the BMPs are monitored each year. This adds to program administrative cost but provides some assurance that producers are complying with their contracts.


**Alpine Cheese Company, Sugar Creek, Ohio**

Sources: The Alpine Cheese Company that had to reduce the phosphorus levels from 225 parts per million (ppm) to 1 ppm, and agricultural community.

Lead Agency: The Holmes Soil and Water Conservation District provided technical assistance to farmers in implementing BMPs, brokered transactions, and developed measures for conservation and cost-share.

Program Development and Sustenance: Alpine filtered their phosphorous down to 3 ppm, and then provided funding to pay local farmers to reduce phosphorous to remove the remainder. Ohio State University did monitoring, research, planning, and public education.

Weblink:

**Kalamazoo River Demonstration – Michigan**

Sources: Eight percent of the watershed is urban, with about 57 percent in crops and livestock pasture, 21 percent forested, and 3 percent wetland. Over 50 NPDES permitted point source dischargers including municipal wastewater treatment plants and industrial sites.

Lead Agency: A Steering Committee consisting of state and local regulatory agencies, industrial/municipal dischargers, farmers, agricultural organizations, local environmental interest groups, and consultants.

Cost Savings: First year capital cost of $292/lb of phosphorus for point source and $8.18-372.23 for NPS, and five-year cost of $58.40 for point source and $1.64-193.59 for NPS.

Program Development and Sustenance: This program requires NPS participants to reduce two pounds of phosphorous for each one pound credited for the point source permit, to account for uncertainties and geographical distance between trading parties. Initial resistance was overcome by providing accurate public information and employing a broad-based Steering Committee that included government and farming organizations. The steering committee serves as the “bank” for credits and sells to point sources that contribute funding to support the project.

Lower Boise River Effluent Trading

Sources: Primary driver was a restrictive TMDL that would require up to an 80 percent reduction in Phosphorous loads from the POTW. Trade was between POTW and agricultural sources.

Lead Agency: Idaho Clean Water Cooperative, a non-profit group.

Cost Savings: Approximately $10-15/lb of phosphorus removal, based on the point source cost of $12-17/lb and NPS cost of $2-20/lb (Environomics, 1999).

Program Development and Sustenance: The Idaho Soil Conservation Commission created a list of surface irrigated cropland BMPs approved for credits, including sediment basins, filter strips, irrigation systems, constructed wetlands, and crop sequencing. Trades could be between point sources, directly between point and non-point, or between a point source and an organized group of NPS (such as an irrigation district). The use of irrigation districts as potential brokers or aggregators suggests how local government, private, or non-profit groups representing (and having the trust of) the agriculture community may be able to play an important role.


(OR)
yosemite.epa.gov/r10/oi.nsf/Webpage/Lower+Boise+River+Effluent+Trading+Demonstratio+Project/$FILE/summary.pdf

Rahr Malting Company - MN

Sources: The Rahr Malting Company in association with farming community.

Lead Agency: Liability resided with Rahr, but state and local agencies assisted in BMP monitoring.

Cost Savings: $4-18/lb of phosphorus control for treatment enhancement, versus $2.10/lb for four NPS projects.

Program Development and Sustenance: Due to the TMDL regulations for phosphorus, Rahr went ahead with this trading program to reduce upstream pollutant loads. Rahr worked with the Coalition for Clean Minnesota River (a broad-based local group) to identify potential trades. Using a ratio of two pounds reduced for each one pound credited as an offset, as of January 2002 it had exceeded its required goal of offsetting 150 pounds/day of CBOD5 with direct trades at four sites up the river for total offsets of 204 pounds/day.
Red Barn Trading Company, PA
Sources: Agricultural operators and the Township of Fairview in York County, PA.
Lead Agency: x
Cost Savings: Township’s cost was 75 percent less than the $6.4 million that would have been required to upgrade its existing sewage treatment system.
Program Development and Sustenance: Red Barn Trading Company is a private credit trading service and acts as broker, working with its existing client base of farmers to help them produce credits that will be certified under the new Pennsylvania Chesapeake Bay Watershed program. The Township of Fairview became the first municipality in the Chesapeake Bay Watershed to meet its water quality improvement requirements entirely through water quality trading.
Weblink: www.redbarntrading.com/ (accessed in July 2010)

Southern Minnesota Beet Sugar Cooperative - MN
Sources: The Southern Minnesota Beet Sugar Cooperative (SMBSC) and the farming community.
Program Development and Sustenance: The SMBSC is a farmer-owned cooperative whose members grow sugar beets and created a trust fund of $300,000 to implement non-point projects. SMBSC contracts with landowners in the Minnesota River Basin to accomplish the offsets and is required to monitor the results.

Chesapeake Bay Nutrient Trading – VA, MD, PA & DC
Sources: All point sources and non-point sources in the geographical areas of Virginia, Maryland, Pennsylvania, and Washington, DC to reduce nutrients in the bay.
Program Development and Sustenance: A collective cap was established on nitrogen and phosphorous with formal allocations for each state and basin. The guidelines specify that the buyer should be ultimately responsible for complying with its own permit requirements, should be given time to correct for noncompliance when a seller defaults, and should be able to take legal action against the defaulting seller. Nonpoint monitoring should also include annual site visits to assure BMPs are still functioning, with credits calculated annually. An
online trading Registry called NutrientNet may become a mechanism for identifying trading partners. (See: http://www.nutrientnet.org.)

Weblink: tinyurl.com/ChesapeakeBayWatershed (accessed in July 2010).

New York City Watershed Program - NY

Sources: New York City water supply reservoirs’ watersheds that cover some 1,900 square miles. New York owns less than 10 percent of the land, the balance belonging to some 77,000 local and additional summer residents and over 350 farms in the area.

Lead Agency: New York City Department of Environmental Protection

Cost Savings: Not assessed, since the program was not designed to achieve certain phosphorus load reductions at minimal cost, but to allow development to happen that might otherwise be prohibited.

Program Development and Sustenance: It was estimated that the cost of building a water treatment facility was between $3 and $8 billion. Annual operating costs would be in the hundreds of millions. The Watershed Agricultural Council (www.nycwatershed.org/index.htm) works with the farm community to implement BMPs. An enhanced CREP program pays the full cost of CREP installation and provides a bonus for signing. Riparian practices can pay as much as 150 percent of the cost of installation.


Tar-Pamlico Basin - NC

Sources: Point and nonpoint source discharges to the Tar-Pamlico river basin in North Carolina.

Lead Agency: Tar-Pamlico Basin Association (TPBA)

Cost Savings: Original estimates of $50-100 Million for point source vs. $11.8 Million for agricultural BMPs. This has been quoted as an example where point source costs were over-estimated initially.

Program Development and Sustenance: The Tar-Pamlico Basin Association (TPBA) is a group of point source dischargers in North Carolina who have a joint cap for nitrogen and phosphorous and represent some 94 percent of the point source discharge flows in the Basin. If they exceed their joint cap, they are required to pay a fixed per-kilogram price ($29/kg in 2004) to the North Carolina Agricultural Cost Share Program. This program then pays farmers up to 75 percent of the cost of installing BMPs that address these pollutants. TPBA provided $1.4 million to this program for demonstration projects, estuary nutrient modeling and trade identification.
Fox-Wolf Basin Pilot Watershed Trading Program, WI
Sources: POTWs and agricultural sources, contributing to the Fox-Wolf basins that discharge to Lake Michigan’s Green Bay.
Lead Agency: Fox-Wolf Watershed Alliance (FWWA)
Cost Savings: Average phosphorus control cost of $73/lb for point sources vs. $26/lb for agricultural BMPs. Later assessments revealed that only the Lower Fox had this level of cost savings and the Upper Fox did not show a significant cost saving for NPS controls.
Program Development and Sustenance: The pilot trading projects were initiated in 1997 to promote extensive research and trade exploration to achieve stringent phosphorus limits of 1mg/l for point sources. However, earlier economic and feasibility evaluations turned out to be in favor of point source controls until the TMDL would be established in 2003. Early estimate of the trading ratio was 2:1, but the state mentioned as much as 10:1 in some discussions.

Red Cedar River Nutrient Trading Pilot – City of Cumberland, WI
Sources: The City of Cumberland, WI and farmers in the Red Cedar River watershed tributary to the Hay River. About 93% of phosphorus from NPS and 18 municipalities contribute point source pollution in this watershed.
Lead Agency: Various parties including City of Cumberland.
Cost Savings: $35,000 for point source vs. $20,000 for NPS phosphorus reductions.
Program Development and Sustenance: The city pays farmers to use no-till on lands that test high for phosphorous and nutrient management planning to avoid building an expensive upgrade for their sewage treatment plant. The Barron County Land Conservation Department serves as liaison with the farmers and verifies the BMPs for the program. The program pays $18.50/acre for no-till, and $15/acre for conservation tillage, $3/acre for contour farming, $35/acre for buffer strips, and $3/acre for nutrient management plan.

In addition to the above, there are some statewide or regional guidance manuals published recently, that can be useful to the LIS community:
Pennsylvania Final Trading of Nutrient and Sediment Reduction Credits – Policy and Guidelines (EQB, 2010): This is a statewide policy currently in place in Pennsylvania and facilitates reduction of pollutant loads through nutrient and sediment trading dealing with multiple pollutants, including but are not limited to nutrients and carbon ([tinyurl.com/PAPolicyfortrading](tinyurl.com/PAPolicyfortrading)). The first credit auction took place recently, and the auction procedure is a market-like approach where the individual sellers can post their generated credits and seek for potential buyers.

West Virginia Water Quality Trading Framework (WVDEP, 2009): This is a statewide NPS trading policy and it supports load reduction methods for multiple pollutants potentially including nutrients, metals, or cross-pollutant trading for dissolved oxygen ([wwwri.nrcce.wvu.edu/programs/pwqb/index.cfm](wwwri.nrcce.wvu.edu/programs/pwqb/index.cfm)).

Virginia DEQ’s guidance for Agricultural Community (VADEQ, 2008): A statewide guidance document aimed specifically at the agricultural landowners and the potential partners, POTWs, for exploring NPS trades in the Chesapeake Bay watershed.

State of Idaho Guidance (IDEQ, 2010): This is a statewide NPS trading guidance document aimed at supporting initiatives for multiple pollutants including nutrients and sediment.
APPENDIX B. PERFORMANCE AND COST INFORMATION FOR BMP/LIDs

Urban Stormwater Controls

Capital and O&M costs of stormwater controls can help in evaluating the cost comparisons with equivalent control of point or other nonpoint sources. Cost information was reviewed from multiple sources such as the EPA’s Stormwater Menu of BMPs, EPA Preliminary Data Summary of Urban Stormwater BMPs, cost information from existing BMPs in the area, and the cost calculations carried out on the basis of guidelines provided by the EPA (Muthukrishnan et al., 2004) and escalated based on some recent project construction costs in the New York City metropolitan area.

In addition, some case studies from PlaNYC (2008) were reviewed for the BMP/LIDs such as green roofs, porous pavements, and rain barrels. The suggested initial and O&M costs of BMP/LIDs, not including the cost of land acquisition and permitting, are summarized in Table B-1.

<table>
<thead>
<tr>
<th>BMP</th>
<th>Capital Cost per unit ($)</th>
<th>O&amp;M Cost per unit ($)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Pond/Wetland</td>
<td>5.1 - 8.5</td>
<td>0.9 – 1.5</td>
<td>Cubic Feet</td>
</tr>
<tr>
<td>Dry Pond</td>
<td>2.6 – 6.8</td>
<td>0.4 – 1.2</td>
<td>Cubic Feet</td>
</tr>
<tr>
<td>Bio-retention</td>
<td>8 - 20</td>
<td>2 – 5</td>
<td>Cubic Feet</td>
</tr>
<tr>
<td>Rain Barrel/Cistern</td>
<td>7 - 8</td>
<td>1-2</td>
<td>Gallon</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>6.20</td>
<td>0.8</td>
<td>Square Feet</td>
</tr>
<tr>
<td>Grassed Swale</td>
<td>0.56</td>
<td>0.20</td>
<td>Square Feet</td>
</tr>
<tr>
<td>Green Roof</td>
<td>20-28</td>
<td>5-7</td>
<td>Square Feet</td>
</tr>
<tr>
<td>Infiltration Devices</td>
<td>4 – 8</td>
<td>1-2</td>
<td>Square Feet</td>
</tr>
<tr>
<td>Filter Strip</td>
<td>1-4</td>
<td>500</td>
<td>Acre</td>
</tr>
<tr>
<td>Sand Filter</td>
<td>6-10</td>
<td>1-3</td>
<td>Cubic Feet</td>
</tr>
</tbody>
</table>

Another key parameter in the selection of urban stormwater controls is their effectiveness to achieve the desired pollutant (TN) reduction targets. The removal efficiencies are suggested for TN and TP in Table B-2, compiled by reviewing various literatures and using best professional judgment based on literature values. Removal efficiencies for some practices were not suggested where the performance information reported in the literature was very limited.
Table B-2. Suggested Values for Pollutant Removal Efficiencies of BMP/LIDs

<table>
<thead>
<tr>
<th>BMP/LID</th>
<th>Water quality performance - Percent removals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN</td>
</tr>
<tr>
<td>Bioretention</td>
<td>40</td>
</tr>
<tr>
<td>Constructed Wetland</td>
<td>30</td>
</tr>
<tr>
<td>Dry Pond</td>
<td>25</td>
</tr>
<tr>
<td>Grasped Swale</td>
<td>25</td>
</tr>
<tr>
<td>Green Roof</td>
<td>53</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>70</td>
</tr>
<tr>
<td>Rain Barrel/Cistern</td>
<td>25</td>
</tr>
<tr>
<td>Wet Pond</td>
<td>30</td>
</tr>
<tr>
<td>Riparian Buffers</td>
<td>30</td>
</tr>
<tr>
<td>Filter Strip with level spreader</td>
<td>20</td>
</tr>
<tr>
<td>Sand Filter</td>
<td>30</td>
</tr>
</tbody>
</table>

Sources: CWP (2007); NYSDEC Manual (2010); CWP (2005); CWP (2008); CH2M HILL (2008)

Non-urban Nonpoint Sources

Field-scale cost information was compiled from two primary sources corresponding to Chesapeake Bay and Gulf of Mexico programs, supplemented by CH2M HILL (2008) and escalated to reflect higher costs in the Northeastern/New England regions. Tables B-3 and B-4 show the cost and removal efficiencies for commonly adopted non-urban BMP/LIDs. Cost data for some of BMP/LIDs are not provided due to either lack of information in the literature or highly specific numbers that can be pertinent to some regions. Local NRCS offices can be the best resources to obtain specific guidance on those practices.

Table B-3. Suggested Values for Non-Urban BMP/LID Costs

<table>
<thead>
<tr>
<th>BMP</th>
<th>Cost per unit ($)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Till</td>
<td>1-2</td>
<td>Per lb of TN reduced</td>
</tr>
<tr>
<td>No Till and Fertilizer Reduction</td>
<td>3-4</td>
<td>Per lb of TN reduced</td>
</tr>
<tr>
<td>No Till, Fertilizer Reduction, Hay Only</td>
<td>6-9</td>
<td>Per lb of TN reduced</td>
</tr>
<tr>
<td>Agricultural Grass Buffer</td>
<td>2-3</td>
<td>Per lb of TN reduced</td>
</tr>
<tr>
<td>Animal Waste Management/Runoff Control</td>
<td>5-10</td>
<td>Per lb of TN reduced</td>
</tr>
<tr>
<td>BMP/LID</td>
<td>Percent removals</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>Animal Waste Management – Livestock</td>
<td>75   75</td>
<td></td>
</tr>
<tr>
<td>Animal Waste Management – Poultry</td>
<td>14   14</td>
<td></td>
</tr>
<tr>
<td>Cereal Cover Crops</td>
<td>30   7</td>
<td></td>
</tr>
<tr>
<td>Nutrient Management Plan</td>
<td>3-20 5-10</td>
<td></td>
</tr>
<tr>
<td>Riparian Grass Buffers</td>
<td>25   45</td>
<td></td>
</tr>
<tr>
<td>Riparian Forest Buffers</td>
<td>40-50 45</td>
<td></td>
</tr>
<tr>
<td>Rotational Grazing/Fencing</td>
<td>20   20</td>
<td></td>
</tr>
<tr>
<td>Agricultural Wetlands</td>
<td>45-55 50</td>
<td></td>
</tr>
<tr>
<td>Advanced Till</td>
<td>-    35</td>
<td></td>
</tr>
<tr>
<td>Horse Pasture Management</td>
<td>20   20</td>
<td></td>
</tr>
<tr>
<td>Mortality Composter</td>
<td>14   14</td>
<td></td>
</tr>
<tr>
<td>Precision Feeding of Daily Livestock</td>
<td>27   17</td>
<td></td>
</tr>
<tr>
<td>Forest Harvesting (erosion control during harvest)</td>
<td>50   50</td>
<td></td>
</tr>
<tr>
<td>Septic System Denitrification</td>
<td>50   -</td>
<td></td>
</tr>
<tr>
<td>Cover Crop</td>
<td>15   7-15</td>
<td></td>
</tr>
<tr>
<td>Land Conversion</td>
<td>40-60 70</td>
<td></td>
</tr>
<tr>
<td>Strip Cropping/Contour Terracing</td>
<td>50   50</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C. Baseline TN Calculations for the Saugatuck Watershed

Several modeling approaches have been developed for the Saugatuck River watershed from past studies (NYSDEC and CTDEP, 2000; AQUA TERRA and HydroQual, 2001; Moore et al, 2004; and Farley and Rangarajan, 2006). Almost all of these efforts used other watersheds such as the Norwalk River and Salmon River to develop global parameters and apply for remaining watersheds including the Saugatuck using parallel-watershed approaches. In order to support this pilot watershed trading analysis, the most recent model application (using ArcView based Generalized Watershed Loading Functions (AVGWLF) from Farley and Rangarajan (2006) was resurrected and local flow and water quality data were used to calibrate it. Brief details on this model are provided here and the reader is referred to Farley and Rangarajan (2006) for additional information.

GWLF, developed by Cornell University (Haith et al., 1992), is the fundamental block of AVGWLF model. It has the following attributes and capabilities (Evans et al., 2003):

- Rainfall-runoff relationships account for losses such as evaporation and infiltration
- Sediment erosion is estimated with the Universal Soil Loss Equation (USLE)
- Nitrogen loadings from both point and NPS sources can be quantified through GIS-based land use patterns
- Spatial variability in rainfall is considered, and
- Water quality responses (loadings) to future land use scenarios can be estimated.

The model has the ability to simulate runoff, sediment, and total nitrogen (along with other nutrients such as phosphorus) loads from a watershed given the various land uses (e.g., agricultural, forested, low density, and commercial). The built-in algorithms can account for septic system loads and point source discharges (POTWs and industries). It is a continuous simulation model which uses daily time steps for weather data and mass balance calculations. Sediment and total nitrogen loads are estimated based on the daily water balance, but are tallied to monthly values in the output, allowing monthly comparison of monitored and modeled nitrogen loads. Figure C-1 depicts the components of the GWLF model, and the latest version 7.2.3 of the AVGWLF was used in this study.
Watershed Model Calibration

In Farley and Rangarajan (2006), the average TN loads from different sources were developed using a parallel-watershed approach. Also, the entire Saugatuck River basin was delineated into four sub-basins representing the portion upstream and downstream of the reservoir and the two tributaries.

In this project, the watershed was initially divided into seven sub-basins. When the data from USGS gage #01209105 became available, the Aspetuck River sub-basin was divided into two basins to calibrate the model to the data at that gage. Sub-regional and local basin delineations available from UCONN MAGIC database were used to delineate the sub-basins, shown in Figure C-2.
Landuse data obtained from the UCONN MAGIC database was used to construct the physical attributes of sub-basins. The 1995 dataset (shown in Figure C-3) was used since the newer 2006 data did not distinguish the high and low density development in urban areas. The northern part of the watershed is mostly covered by forest and southern part of the watershed, the downstream of the Saugatuck Reservoir toward the downstream end of the Saugatuck River including the city of Westport, is highly developed. For the entire Saugatuck watershed, 73% of the watershed is forest, 9% is low intensity urban, and 7% is high intensity urban. Detailed landuse breakdown for each subwatershed is shown in Table C-1.

Figure C-2. Seven Subwatersheds in Saugatuck Watershed
**Figure C-3. 1995 Landuses**

Table C-1. Landuse Breakdown for Each Subwatershed

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Upstream Saugatuck River</th>
<th>Saugatuck Reservoir</th>
<th>Little River</th>
<th>Downstream Saugatuck River</th>
<th>Aspetuck Reservoir</th>
<th>Saugatuck River West Branch</th>
<th>Westport</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>81.3</td>
<td>74.8</td>
<td>77.9</td>
<td>70.3</td>
<td>77.6</td>
<td>75.7</td>
<td>38.6</td>
<td>72.9</td>
</tr>
<tr>
<td>High Intensity Development</td>
<td>2.1</td>
<td>2.6</td>
<td>2.3</td>
<td>9.5</td>
<td>3.8</td>
<td>7.7</td>
<td>26.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Low Intensity Development</td>
<td>5.1</td>
<td>2.1</td>
<td>6.2</td>
<td>11.2</td>
<td>5.8</td>
<td>10.1</td>
<td>26.2</td>
<td>8.6</td>
</tr>
<tr>
<td>Hay/Pasture</td>
<td>6.1</td>
<td>3.2</td>
<td>10.9</td>
<td>4.1</td>
<td>8.1</td>
<td>3.6</td>
<td>3.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Waterbody/wetland</td>
<td>4.5</td>
<td>17.1</td>
<td>2.1</td>
<td>3.9</td>
<td>4.1</td>
<td>2.2</td>
<td>4.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Other</td>
<td>0.9</td>
<td>0.2</td>
<td>0.6</td>
<td>1.1</td>
<td>0.6</td>
<td>0.7</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
There are three active USGS flow monitoring stations in the watershed, a long-term gage at Redding and two others that have been re-activated recently. Table C-2 shows a summary of available data at the three USGS monitoring stations.

Table C-2. Summary of Available Flow and Water Quality Data

<table>
<thead>
<tr>
<th>USGS ID</th>
<th>Location</th>
<th>Period of Data Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>01208990</td>
<td>Saugatuck River near Redding, CT</td>
<td>Current</td>
</tr>
<tr>
<td>01209500</td>
<td>Saugatuck River near Westport, CT</td>
<td>July 2009 - Current</td>
</tr>
<tr>
<td>01209005</td>
<td>Saugatuck River below Saugatuck Reservoir near Lyons Plain, CT</td>
<td>November 2008 - Current</td>
</tr>
<tr>
<td>01209105</td>
<td>Aspetuck River at Aspetuck, CT</td>
<td>November 2009 - Current</td>
</tr>
</tbody>
</table>

Hydrologic calibration was performed using 15-years of continuous flow data from January 1981 through December 1995 available at the Redding gage. Bi-monthly data of nitrogen concentration were available approximately bimonthly at USGS monitoring station at Redding (see Figure C-4). TN concentration at Redding was very low and consistent because the watershed is mostly covered by forest. That was a limitation to characterize watershed scale in-stream TN concentration.

Specific comparisons of simulated and observed flow values included: Figure C-5 - time-series comparison of daily streamflow volumes (cubic feet per second, cfs); Figure C-6 - cumulative flow volumes (cfs X day); and Figure C-7 – monthly TN mass computed as flow times concentration using monitored and modeled values. Only concurrent data available in monitored and modeled values are shown here. Flow data at the location downstream of the reservoir is heavily impacted by the reservoir operations and was not useful for calibration.
Figure C-4. Observed TN Concentrations at the Redding Gage
Figure C-5. Flow Comparison at the Redding Gage
Figure C-6. Cumulative Flow Comparison at Redding (1981 – 1995)
Figure C-7. Monthly TN Load Comparison (1985 – 1992)
Baseline annual TN loading from each subwatershed is summarized in Table C-3 and the pie-chart showing contribution from each landuse is illustrated in Figure C-8. The results were calculated from the entire calibration period (1985 – 1995) and annual average is shown for all sources except for the point source and septic systems. AVGWLF had a programming glitch for computing TN loads from septic systems, therefore, the calculation was performed separately using a unit area loading concept (12 grams of TN unit load per day per capita).

<table>
<thead>
<tr>
<th>TN load (lb/year)</th>
<th>Aspetuck</th>
<th>Little River</th>
<th>Saugatuck Reservoir</th>
<th>Downstream Saugatuck River</th>
<th>West Branch</th>
<th>Upstream Saugatuck River</th>
<th>Westport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay or Pasture</td>
<td>1,538</td>
<td>574</td>
<td>253</td>
<td>255</td>
<td>361</td>
<td>1,003</td>
<td>51</td>
</tr>
<tr>
<td>Cropland</td>
<td>103</td>
<td>50</td>
<td>14</td>
<td>62</td>
<td>36</td>
<td>51</td>
<td>184</td>
</tr>
<tr>
<td>Forest</td>
<td>776</td>
<td>226</td>
<td>363</td>
<td>253</td>
<td>399</td>
<td>766</td>
<td>163</td>
</tr>
<tr>
<td>Wetland</td>
<td>74</td>
<td>12</td>
<td>36</td>
<td>20</td>
<td>26</td>
<td>47</td>
<td>3</td>
</tr>
<tr>
<td>Transition</td>
<td>1,029</td>
<td>297</td>
<td>139</td>
<td>508</td>
<td>603</td>
<td>1,670</td>
<td>503</td>
</tr>
<tr>
<td>Low Intensity Development</td>
<td>483</td>
<td>132</td>
<td>76</td>
<td>319</td>
<td>435</td>
<td>376</td>
<td>940</td>
</tr>
<tr>
<td>High Intensity Development</td>
<td>4,031</td>
<td>645</td>
<td>1,218</td>
<td>3,475</td>
<td>4,228</td>
<td>1,988</td>
<td>9,779</td>
</tr>
<tr>
<td>Erosion from Stream Bank</td>
<td>154</td>
<td>13</td>
<td>26</td>
<td>50</td>
<td>76</td>
<td>113</td>
<td>194</td>
</tr>
<tr>
<td>Groundwater</td>
<td>53,204</td>
<td>16,673</td>
<td>11,066</td>
<td>15,521</td>
<td>21,175</td>
<td>37,575</td>
<td>27,852</td>
</tr>
<tr>
<td>Septic Systems</td>
<td>24,711</td>
<td>4,720</td>
<td>9,576</td>
<td>13,494</td>
<td>16,911</td>
<td>22,642</td>
<td>30,679</td>
</tr>
<tr>
<td>Total Load</td>
<td>86,104</td>
<td>23,341</td>
<td>22,767</td>
<td>33,958</td>
<td>44,249</td>
<td>66,233</td>
<td>70,347</td>
</tr>
</tbody>
</table>
Figure C-8. Distribution of TN Loads Based on Various Sources
Appendix D. Baseline TN Calculations for the Oyster Bay Harbor Watershed

Very limited modeling effort has been pursued for this second pilot watershed in Nassau County, New York. HydroQual (2003) used the Center for Watershed Protection’s Watershed Treatment Model to estimate pathogen loads to support a TMDL development for Oyster Bay Harbor (OBH). Similarly, an USEPA Stormwater Management Model (SWMM) was used to characterize pathogen loads from the Mill Neck Creek (MNC) drainage area. Subsequently, the Friends of the Bay used a spreadsheet tool in 2008 to estimate pollutant loads to support a watershed plan development.

In this project, the previously developed SWMM model was expanded to the entire drainage area tributary to OBH and MNC and nitrogen loadings were calculated for the entire area. Drainage area to OBH and MNC is shown in Figure D-1.

Landuse data available in the EPA BASINS database (2002) was used, which was developed based on the GIRAS data published by USGS. Figures D-2 and D-3 show the landuses in the watershed and a percentage summary, respectively.
In the western and southern part of the watershed (e.g., Kentuck Brook and Upper White’s Creek), recharge basins are widely used to capture stormwater runoff and facilitate infiltration into the groundwater (aquifer system). The State of the Watershed Report (Friends of the Bay, 2009) shows areas connected to the recharge basins in the OBH watershed. In general, these areas are considered as self-contained (i.e., 100% of runoff sent to recharge basins) except for some large storms. Runoff during a large storm may overwhelm the recharge basin volume and overflow the excessive runoff into the waterways. In this project, the recharge basin drainage areas were considered as self-contained and those were excluded in the SWMM model.

Oyster Bay Hamlet and portions of the villages of Upper Brook are served by sanitary sewers (Figure D-1) and transport sanitary waste to the Oyster Bay District Sewage Treatment Plant (OBDSTP). The plant introduced an advanced wastewater treatment facility and has been fully operational since March 2006. The plant has the capacity of 1.8 MGD and current average flow rate is about 1.25 MGD. For the areas served by the sewer service district, the unit area loads for TN were reduced in comparison to the load numbers used for unsewered areas. Details for unit loadings are provided in the section below.

Flow and water quality data are available at an USGS station located at the downstream end of MNC. Daily flow data were available since 1937, while the laboratory measured water quality data were available from 1966 to 1996. In addition, The Friends of the Bay (FOB) has been conducting monitoring in the OBH, including the concentrations of Ammonia (NH3), Nitrate/Nitrite (NO3, NO2), and Organic Nitrogen. Data available for the period from 2004 to 2009 were provided by FOB. The measured TN data at the downstream end of MNC (Site 15) was used to support water quality calibration. Hourly rainfall data available at the NOAA station in Mineola (ID 305377) was used in the hydrology model.

Baseflow observed at the USGS station had seasonal fluctuation. Annual average flow rate in 1999 was about 7.2 cfs; and the flow was 5 – 15% higher than average during winter and early spring, while the flow was lower during summer by about 10%. Unit baseflow rate per acre was calculated on a monthly basis and assigned to individual sub-basins of the OBH watershed.
Figure D-2. Landuse Distribution

Figure D-3. Percentage Distribution of Landuses
USGS's long term observed data (1973 – 1996) shows there was seasonal fluctuation in TN concentrations at MNC. TN concentrations in summer were generally lower than those in winter. Seasonal fluctuations in nitrogen concentrations reflect chemical reactions and biological activity in stream (Scorca and Monti, 2001), so they may not due to the fluctuation in loadings. Seasonal fluctuations were not considered in this project.

Total Nitrogen unit loading values for groundwater flow and stormwater runoff were separately assigned in the model for each land use. Table D-1 summarizes the assigned unit loading values.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>GW TN Conc. (mg/L)*</th>
<th>EMC TN Conc. (mg/L)***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>1.2 (1.8)**</td>
<td>2.4(4.0)**</td>
</tr>
<tr>
<td>Forest</td>
<td>0.13</td>
<td>0.75</td>
</tr>
<tr>
<td>Agriculture</td>
<td>4.75</td>
<td>4.2</td>
</tr>
<tr>
<td>Water/Wetland</td>
<td>0.13</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* Based on Farley and Rangarajan (2006)
** 1.2 for sewered system (Spruce Run Stormwater Study), 1.8 for unsewered system
*** 4.0 for unsewered system in Oyster Bay

Figures D-4 and D-5 show the calibration results for flow and TN concentration. Both flow and TN values matched well with the observed data.
Figure D-4. Modeled vs. Observed Flow at MNC Gage (1999)
Figure D-5. Modeled vs. Observed TN Concentrations at Mill Neck Creek

Modeled vs. Observed TN Concentration at Mill Neck Creek

Concentration (mg/L)

Days

Figure D-5. Modeled vs. Observed TN Concentrations (2006-2009)
The calibrated SWMM model was then used to estimate annual water and TN discharges in the runoff and baseflow into OBH. As seen in Figure D-6, the estimated TN loads in runoff is about 26% of the total, while the estimated runoff is only about 14% of the total.

![Figure D-6. Runoff and Baseflow Comparison at MNC (1999)](image)

Septic systems contribute significant TN loads into the OBH. Septic systems are widely used in the OBH watershed except in Oyster Bay Hamlet and some portions of the unincorporated Villages of Upper Brookville served by sanitary sewers that transport sanitary waste to the Oyster Bay District Sewage Treatment Plant. During normal operations, nitrogen from septic systems gets into groundwater and when failures occur, it can reach surface water also.

Annual nitrogen loadings were calculated from estimated number of septic system in the watershed and typical unit loading values. The State of the Watershed Report provides an estimate of the number of septic system in the watershed. Among the total 9,963 units in the report, numbers from Cold Spring Brook (1,926), Cold Spring Harbor (830), and Lloyd Neck (110) were subtracted as they discharge into the Cold Spring Harbor and considered the remaining 7,097 units to be part of the OBH watershed.

Based on literature review, a value of 2.4 capita per system was used as to estimate septic system serviced population (e.g., EPA STEPL model). Using the Watershed Treatment Model’s suggested nitrogen loading of 9 g/day/capita, usage of 100 gallons/capita/day and an assumption of 30% failure in septic system, the annual TN loading can be calculated as:
7,097 (units) * 2.4 (capita/unit) * 9.0 (g/day/capita) * 365 (day/yr) / 454 (g/lb)
= 123,200 lb/year.

Table D-2. Distribution of TN Loading for Each Watershed

<table>
<thead>
<tr>
<th>Data</th>
<th>Sum of TN GW Loading (lb/yr)</th>
<th>Sum of SWMM Wash-off TN (lb/yr)</th>
<th>Total TN Loading from Septic System (lb/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bailey Arboretum</td>
<td>1,485</td>
<td>989</td>
<td>4,027</td>
</tr>
<tr>
<td>Beaver Brook</td>
<td>15,975</td>
<td>5,357</td>
<td>23,446</td>
</tr>
<tr>
<td>Centre Island</td>
<td>2,566</td>
<td>1,534</td>
<td>7,130</td>
</tr>
<tr>
<td>Kentuck Brook</td>
<td>8,449</td>
<td>1,582</td>
<td>8,263</td>
</tr>
<tr>
<td>Mill Neck Creek</td>
<td>3,010</td>
<td>2,322</td>
<td>31,429</td>
</tr>
<tr>
<td>Mill River</td>
<td>6,685</td>
<td>1,484</td>
<td>15,131</td>
</tr>
<tr>
<td>Oyster Bay Harbor</td>
<td>3,255</td>
<td>1,758</td>
<td>6,014</td>
</tr>
<tr>
<td>Tiffany Brook</td>
<td>4,453</td>
<td>1,285</td>
<td>11,470</td>
</tr>
<tr>
<td>Upper White’s Creek</td>
<td>4,296</td>
<td>267</td>
<td>16,194</td>
</tr>
<tr>
<td>White Creek</td>
<td>1,009</td>
<td>1,002</td>
<td>610</td>
</tr>
<tr>
<td>Grand Total</td>
<td>51,183</td>
<td>17,578</td>
<td>123,712</td>
</tr>
</tbody>
</table>

Figure D-7 shows the relative distribution of septic system, groundwater and urban stormwater runoff from various subwatersheds contributing to the Oyster Bay Harbor.
Figure D-7. Distribution of TN Loads Based on Various Sources
APPENDIX E. REFERENCES


CCMP – Comprehensive Coastal Management Plan, accessed in [www.longislandsoundstudy.net](http://www.longislandsoundstudy.net) (July 2010)


EPA(2003), Final Water Quality Trading Policy.


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WERF (2002a) Nitrogen Credit Trading in Maryland: A Market Analysis for Establishing a Statewide Framework, 97IRM5E

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