WATER INTEGRATION FOR SQUAMSCOTT EXETER (WISE)

Preliminary Integrated Plan
Draft Technical Report

March 29, 2015

Prepared By:

Geosyntec consultants

National Estuarine Research Reserve System

University of New Hampshire

cbi Consensus Building Institute

Rockingham Planning Commission

Prepared For:

Towns of Exeter, Stratham, and Newfields, New Hampshire

WATER INTEGRATION FOR SQUAMSCOTT EXETER (WISE)

PRELIMINARY DRAFT

Prepared for

Towns of Exeter, Stratham, and Newfields, New Hampshire

The Science Collaborative of the National Estuarine Research Reserve (NERR)

March 29, 2015

TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS

AOC	Administrative Order on Consent
CSO	Combined Sewer Overflows
CIP	Capital Improvement Plans
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
I/I	Inflow and Infiltration
IP	Integrated Planning
GBNNPSS	Great Bay Nutrient Nonpoint Source Study
GI	Green Infrastructure
LID	Low Impact Development
MEP	Maximum Extent Practicable
NHDES	New Hampshire Department of Environmental Services
NLM	Nitrogen Load Model
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint source pollution
NRCS	Natural Resources Conservation Service
MS4	Municipal Separate Storm Sewer System
O&M	Operations and Maintenance
ORIWMP	Oyster River Integrated Wateshed Management Plan
PREP	Piscataqua Region Estuaries Partnership
PTAPP	Pollution Tracking and Accounting Pilot Program
PV	Present Value 50 year
SSO	Sanitary Sewer Overflows
SWMM	EPA Stormwater Management Model
UNH	University of New Hampshire
WISE	Water Integration for the Squamscott-Exeter
WWTF	Wastewater Treatment Facility

ACKNOWLEDGEMENTS

The WISE project was made possible from funding through the University of New Hampshire National Estuarine Research Reserve System Science Collaborative, made possible through the National Oceanic and Atmospheric Administration. We are deeply grateful to the Science Collaborative whom shared their vision on the power of meaningful collaboration amongst stakeholders to jointly work towards common goals. We would like to express our appreciation to all those who participated in and provided feedback during the course of this Project.

Coordinating Team

Robert Roseen, Ph.D., P.E., D.WRE
Geosyntec Consultants
Portsmouth, New Hampshire

Alison Watts, Ph.D., P.G.
University of New Hampshire
Durham, New Hampshire

Renee Bourdeau, M.S.
Geosyntec Consultants
Portsmouth, New Hampshire

Paul E. Stacey
Great Bay NERRs
Greenland, New Hampshire

Doug Thompson
Consensus Building Institute
Cambridge, Massachusetts

Eric Roberts
Consensus Building Institute
Cambridge, Massachusetts

Cliff Sinnott
Rockingham Planning Commission
Exeter, New Hampshire

Theresa Walker
Rockingham Planning Commission
Exeter, New Hampshire

Steve Miller
Great Bay National Estuarine Research Reserve
Greenland, New Hampshire

Project Team

Jennifer Royce Perry, P.E.
Director Exeter Public Works
Exeter, New Hampshire

Sylvia von Aulock
Town of Exeter, Planning Director
Exeter, New Hampshire

Paul Vlasich, P.E.
Town of Exeter, Engineer
Exeter, New Hampshire

Paul Deschaine
Town of Stratham, Town Administrator
Stratham, New Hampshire

Lincoln Daly
Town of Stratham, Town Planner
Stratham, New Hampshire

Clay Mitchell
Town of Newfields, Town Planner
Newfields, New Hampshire

Don Clement
Town of Exeter, Board of Selectman
Exeter, New Hampshire

Bill Meserve
Town of Newfields, Representative
Newfields, New Hampshire

Mark Voorhees
MS4 Program
EPA Region 1, Boston, Massachusetts

Newton Tedder
MS4 Program
EPA Region 1, Boston, Massachusetts

Dan Arsenault
Municipal Permits Section, EPA Region 1
Boston, Massachusetts

David Pincumbe
Municipal Permits Section, EPA Region 1
Boston, Massachusetts

Ted Diers
Watershed Management Bureau Administrator
NH DES, Concord, New Hampshire

Matt Wood
Water Quality Specialist
NH DES, Concord, New Hampshire

Richard Langan
Director, NERRS Science Collaborative
Durham, New Hampshire

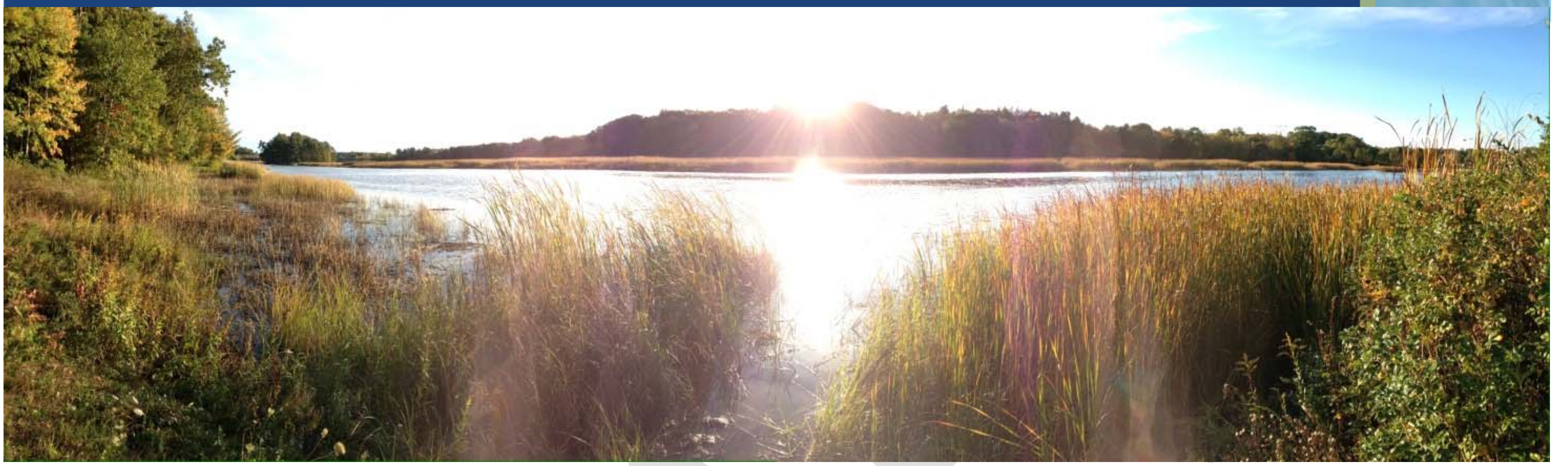
Kalle Matso
Program Manager, NERRS Science Collaborative, Durham, New Hampshire

Special Thanks

Nathan Merrill, Stuart Farm, Stratham, New Hampshire
Doug Scamman, Scamman Farm, Stratham, New Hampshire
Kirk Scamman, Scamman Farm, Stratham, New Hampshire
Brandon Smith, US Department of Agriculture
Cory Riley, Reserve Manager, Great Bay NERR
Tom Gregory and Steve Jones, UNH Jackson Lab
Michelle Daley and Jody Potter, UNH Water Resources Research Center
Pete Richardson, Town of Exeter Conservation Commission
Kristen Murphy, Town of Exeter
Phyllis Duffy, Town of Exeter
Dean Peschel, Great Bay Municipal Coalition
Bill Arcieri, VHB Consultants
David Cedarholm, P.E., Former Town of Durham Engineer
Ed Leonard, P.E., Wright-Pierce, Portland, Maine

WATER INTEGRATION FOR THE SQUAMSCOTT-EXETER (WISE)

EXECUTIVE SUMMARY



What is WISE? In March 2015 the Water Integration for Squamscott-Exeter (WISE) project completed an Integrated Planning framework for three coastal communities including Exeter, Stratham, and Newfields to provide recommendations for affordably managing permits for wastewater and stormwater. The project has received tentative approval to fulfill the Nitrogen Control Plan requirements for Exeter and overlapping MS4 requirements for both Stratham and Exeter pending some critical next steps. This was accomplished by making use of a new flexibility in EPA permitting called Integrated Planning. The project bridged legal and technical gaps through a collaborative process working with regulators and municipal staff to develop a product that stakeholders and regulators trust and support. The project quantified the economic and performance advantages of municipal collaboration and integration of water resource planning. Success of this new approach depends upon leadership by municipalities, trust in the process an outcome, technical capacity and innovation, and regulatory flexibility. The process has included officials from the Towns of Stratham, Newfields, and Exeter working with a team from Geosyntec Consultants, the University of New Hampshire, Rockingham Planning Commission, Consensus Building Institute, and the Great Bay National Estuarine Research Reserve with funding was provided by the NERRS Science Collaborative.

What is Integrated Planning? Integrated Planning is a new EPA approach that allows a flexibility in permitting of wastewater and stormwater controls to plan for most cost effective measures first while still meeting regulatory standards that protect public health and water quality. Green infrastructure is a key integrated planning strategy for nutrient and stormwater management and enables management of stormwater as a resource and supports other economic benefits and quality of life. Integrated planning is being shown to have great cost-efficiencies through the comprehensive management of wastewater, stormwater and nonpoint sources throughout the nation.

Geosyntec consultants | University of New Hampshire | Rockingham Planning Commission | National Estuarine Research Reserve System Science Collaborative | cbi Consensus Building Institute

March 2015

Why this Project? New Hampshire coastal communities have experienced rising populations resulting in an increase in development and stormwater and wastewater discharge to the Great Bay. As communities respond to new federal permit requirements for treating and discharging stormwater and wastewater, meeting regulatory requirements requires innovative ways to find effective and affordable means to meet water quality goals. The neighboring towns of Stratham, Newfields, and Exeter, New Hampshire share a history of collaboration. They share a regional school district, management of hazardous waste, and town recreation programs. More recently, representatives from the Towns of Stratham and Exeter have been working together to discuss sharing water and wastewater infrastructure and services. Integrated Planning for nutrient management could be a logical next step.

Major Findings

- Since 1960 Exeter, Newfields, and Stratham have experienced substantial population growth of 98%, 128%, and 602% and a 20 year increase in impervious cover of 108%, 177%, and 138% respectively.
- The Squamscott River has an average Total Nitrogen concentration (0.77 mg/L), more than double draft criteria, and has lost 100% of its eelgrass cover since 1948.
- A new pending MS4 (stormwater) permit combined with a new 2012 wastewater permit substantially increases municipal requirements for Nitrogen management.
- An Integrated Planning approach that satisfies elements of both the MS4 and wastewater permits reduces existing loads by 60% (56 tons N) and was estimated to provide around 50% cost avoidance from traditional permitting for the three communities.
- The incremental cost to increase reduction from 53 to 74% for nitrogen load by WW and NPS management is an increase in $159 million (62% increase).
- Annual nonpoint costs to Stratham are estimated to be $65,000 for town controlled properties and $60,000 for private sector for a total of almost $2 million over 30 yrs for the municipality. Estimated cost for wastewater for Stratham to join Exeter is $6,035,000.
- Annual nonpoint costs to Exeter are estimated to be $163,000 for town controlled properties and $122,000 for private sector for a total of almost $4.9 million over 30 yrs for the municipality.
- Annual nonpoint costs to Newfields are estimated to be $23,000 for town controlled properties and $21,000 for private sector for a total of almost $690,000 over 30 yrs for the municipality.
- Watershed wide, estimated costs are approximately 10% for stormwater and 90% for wastewater both for construction and operation.
- Communities of Exeter, Stratham and Newfields contribute ~50% of the Nitrogen Load from 24% of the watershed area.
- Nearly 50% of the nitrogen load in the watershed comes from upstream communities, and water quality goals for the Squamscott-Exeter cannot be attained without broader participation throughout the watershed.

Lessons Learned/How to Use This Plan

This plan is intended to serve as a guide for the towns of Exeter, Stratham and Newfields to support nitrogen load reduction, permit compliance, and ultimately ecosystem recovery in the Great Bay estuary which could fulfill permit requirements for a Nitrogen Control Plan. Municipal officials in each community could use the plan to guide local and watershed decisions around water quality and permit compliance. Detailed analyses of alternatives, calculated load reduction and associated costs, coupled with monitoring and tracking to document progress provide assurance that selected actions will support overall permit compliance and restoration goals. For the Integrated Plan to receive EPA approval some critical next steps will be required.

Project Contacts

Geosyntec

Robert Roseen, Project Director
603-686-2488 rroseen@geosyntec.com

Renee Bourdeau, Project Manager
603-205-8051 rbourdeau@gesoyntec.com

University of New Hampshire

Alison Watts, Watershed Science Lead
603 862-0585 Alison.Watts@unh.edu

National Estuarine Research Reserve

Paul Stacey, Research Coordinator
603-294-0146 Paul.Stacey@wildlife.nh.gov

Rockingham Planning Commission

Cliff Sinnott, Executive Director
603-778-0885 csinnott@rpc-nh.org

Theresa Walker, Town Liaison
603-778-0885 twalker@rpc-nh.org

Town of Exeter

Jennifer Perry, DPW Director
603-773-6157 perry@exeternh.gov

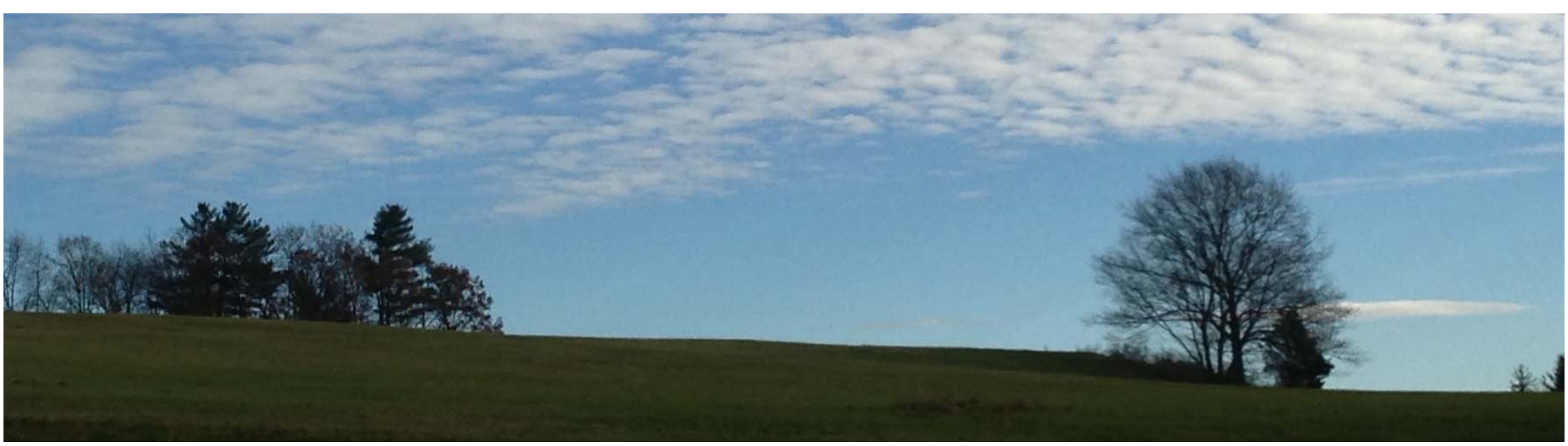
Town of Stratham

Paul Deschaine, Town Administrator
603-772-7391 pdeschaine@strathamnh.gov

Town of Newfields

Clay Mitchell, Town Planner
603-608-2521 planner@newfieldsnh.gov

Website: www.WISENH.net



1. INTRODUCTION AND BACKGROUND

1.1 Overview

This document introduces the goals, background and primary elements of an Integrated Plan for the Lower Exeter and Squamscott River in the Great Bay estuary in southern New Hampshire. This Plan will support management of point and nonpoint wastewater sources in the communities of Exeter, Stratham and Newfields, and identifies and quantifies the advantages of the use of green infrastructure as a critical tool for nitrogen management and how collaboration between those communities could form the basis for an integrated permit application. The Plan will help communities meet new wastewater and stormwater permit requirements and improve water quality in the Squamscott River and the Great Bay, while supporting the economic viability of participating communities. This Plan has received tentative approval from EPA that it would fulfill the 2018 Nitrogen Control Plan requirements for Exeter and some future draft MS4 requirements for both Stratham and Exeter pending some critical next steps. The collaborative process used to develop this Plan was designed to provide decision makers at the local, state and federal levels with the knowledge they need to trust the Plan's findings and recommendations, and to enable discussions between stakeholders to continue.

This Plan includes the following information to guide local response to new federal permit requirements for treating and discharging stormwater and wastewater:

- Sources of annual pollutant load quantified by type and community;
- Assessment and evaluation of different treatment control strategies for each type of pollutant load;
- Assessment and evaluation of nutrient control strategies designed to reduce specific types of pollutants;
- Evaluation of a range of point source controls at the wastewater treatment facility based on regulatory requirements;
- Costs associated with a range of potential control strategies to achieve reduction of nitrogen and other pollutants of concern; and

- A preliminary implementation schedule with milestones for target load reductions using specific practices for specific land uses at points in time;
- Recommendations on how to implement a tracking and accounting program to document implementation;
- Design tools such as BMP performance curves for crediting the use of structural practices to support nitrogen accounting requirements.
- Next Steps for how to complete this Plan which has received preliminary EPA approval.

1.2 Coastal Management Problem

Like many other coastal regions, the Great Bay watershed has experienced population growth and an associated increase in development that has threatened the water quality and health of Great Bay. Impervious cover, residential landscaping and altered hydrology, including storm and sanitary sewer systems, have increased land runoff and wastewater discharged to the Great Bay Estuary. In 2009, NHDES concluded that the Squamscott and ten other sub-estuaries in the Great Bay Estuary were impaired by nitrogen, and in 2009 the Great Bay was placed on the CWA Sec. 303(d) list of impaired and threatened waters (NHDES, 2009).

In response to these findings communities and agencies in the region are working on developing nutrient management strategies and solutions that will support attainment of ecosystem goals in an effective and affordable manner. The focus of this study is on nitrogen pollutant loading in a portion of one Great Bay watershed. It also provides context and an example for collective action in an integrated watershed management framework. The benefits are quantified in this subwatershed as a cost and performance benefit.

1.3 Integrated Planning Goals in the Squamscott-Exeter Watershed

This Integrated Plan provides strategic planning and implementation of regulated point (discharges of both treated waste water and storm water) and unregulated nonpoint source (diffuse runoff and groundwater discharge) management for the three communities. The primary goal of this Plan is to support municipal efforts to:

- *Integrate planning and management of stormwater, wastewater, and nonpoint sources to facilitate cost-effective water quality management.* The plan provides load reduction, cost and benefit information for likely scenarios, and develops recommended implementation strategies for each scenario.
- *Monitor and assess progress towards environmental goals.* Recommended monitoring in the Squamscott and targeted tributaries will document ecosystem improvements, calibrate modeled loads, and track progress towards watershed load reduction.
- *Document compliance and ensure that all tracking, accountability and legal requirements are being met*. The tracking and accounting tool can be used to track progress towards permit goals under either individual or an integrated permit.
    - *Develop and sustain collaborative arrangements among communities to collectively and effectively meet local water resource needs.* The plan quantifies the cost differential between several levels of inter-municipal cooperation, including full integration of permit

requirement between all three towns, to separate permit compliance from each municipality.

- *Incorporate adaptive management founded on the best available scientific information and understanding of the interaction among stressors, management and the local ecosystem.* Monitoring of ecosystem response and tracking of load reduction targets will be used to evaluate progress towards restoration, and to support key decisions in the WWTF upgrade timeline.

1.4 Management of Uncertainty

Ecosystem restoration is an inherently uncertain process; ecosystem health and the role of nutrients and other impacts from urbanization are complex, and the time to recovery may be decades or longer. Management practices, based on best available science, will be applied to point and non-point sources of nitrogen, and nutrient reduction will be tracked and monitored and will lead to a greater understanding over time. Some aspects of ecosystem response, such as chlorophyll-a reduction in the Squamscott may occur very rapidly, while others, including long-term recovery of eelgrass have a much higher uncertainty. Permit requirements, on the other hand, require substantive assurance that goals will be met. EPA is required to issue permits that address a “reasonable potential to cause or contribute to impairments”, while communities and residents naturally want a high level of confidence in the outcome of substantial investments in wastewater and stormwater.

Long-term implementation schedules and adaptive management are one means for communities and regulators to manage uncertainty in environmental management. A long-term schedule combined with monitoring supports an iterative process of management actions which reduces uncertainty over time and has potential cost savings. The phased effluent requirements in the administrative order on consent (AOC) specifically allow the Town of Exeter to submit a justification for an effluent limit higher than 3mg/l, based on progress towards target reductions and positive ecosystem trends. In this manner “when” or “if” management actions such as the requirement to operate the wastewater facilities at 3 mg/l will be informed by future information as to the need to achieve the designated uses of Primary Contact Recreation and Aquatic Life Use Support. The adaptive management process also provides a long-term strategy to address concerns about uncertainty in the understanding of the relative significance of nitrogen and its role in declining estuarine health.

1.5 Town, Agency, and Stakeholder Collaboration

This Plan was developed by a team of municipal leaders, engineers, scientists and agency representatives. It incorporates information and feedback from a wide range of stakeholders, and all participants have actively contributed to and reviewed these results. This collaborative foundation supports a Plan which could guide effective nutrient management in the region, and ultimately support attainment of permit requirements and ecosystem goals.

The towns recognize the value of inter-municipal collaboration and have a long history of collaboration that augurs well for future collaborative success and Integrated Planning for nutrient management could be a logical next step. They share a regional school district, the management of hazardous waste, and town recreation programs. The Towns of Exeter and

Stratham completed a co-funded inter-municipal wastewater treatment study (RPC 2012). The RPC study is in part based on the idea that future collaboration can help communities meet the needs of addressing aging infrastructure (Exeter and Newfields), new wastewater and MS4 permit requirements, nonpoint source management, facilities installation and upgrades, and support economic growth in the commercial districts. Stratham and Newfields are, for example, pursuing water and wastewater to support economic development goals along Route 108, which connects the three towns. Stratham in particular has redevelopment goals for a town center which are impeded by wastewater capacity.

2. REGULATORY FRAMEWORK

In response to the 2009 nitrogen impairment listing, new and revised discharge permits in the Great Bay watershed are subject to additional constraints related to nitrogen. The primary municipal permits, and the focus of this Plan, are National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment facilities, and Municipal Separate Storm Sewer Discharge (MS4) permits for stormwater.

2.1 Great Bay and Exeter-Squamscott River Regulatory Status

EPA is required to develop criteria (numeric or narrative) based on a determination that there exists a reasonable potential to cause or contribute to an impairment[1]. This determination is based on 'the best available science' at the time, which acknowledges that although our understanding of an ecosystem is necessarily incomplete, further delay in corrective measures will clearly contribute to increasing degradation. Permits may be issued to comply with numeric or narrative criteria. In 2009 NHDES developed draft numeric nutrient criteria for the protection of eelgrass and low dissolved oxygen conditions. In the absence of final numeric criteria EPA asserts the obligation and authority to issue effluent limitations based on narrative criteria and in 2012 EPA issued final WWTF discharge permits in Newmarket and Exeter based on a narrative TN nutrient criteria and a reasonable potential analysis. A 2014 Peer Review was critical of the draft numeric criteria after which the criteria were dropped as part of a 2014 settlement agreement between NHDES and the Municipal Coalition[2]. The standard upon which the Peer

---

[1] Pg. 143, Section 5. Reasonable Potential Analysis and Effluent Limit Derivation, EPA. (2012). "Authorization to Discharge Under the National Pollutant Discharge Elimination System, The Town of Exeter, New Hampshire, Squamscott River." NPDES Permit No. NH0100871, Office of Ecosystem Protection, U.S. Environmental Protection Agency, Region I, Boston, Massachusetts.

[2] April 2014, Settlement Agreement between the Great Bay Municipal Coalition (Portsmouth, Dover, Rochester, NH) and the State of New Hampshire.

Review was tasked to review the draft numeric criteria was in part…" whether the available data support the conclusion that excess nitrogen was the primary factor that caused (1) the decline of eelgrass populations…"[3] This determination as the "primary factor that caused" is a higher standard than a "reasonable potential to cause or contribute". In 2012 the Environmental Appeals Board and 2013 the Supreme Court upheld the basis for this finding by EPA in determining effluent limitations[4].

2.2 NPDES Wastewater Permit and Administrative Order on Consent

EPA Region 1 issues individual facility-specific permits for the discharge of treated domestic and industrial wastewater in the State of New Hampshire. Under these individual permits, the discharges will be limited and monitored by the permittee. Of the three WISE watershed communities, the Towns of Exeter and Newfields operate and discharge treated domestic wastewater.

In 2012 after several years of study and negotiations, EPA issued a new NPDES discharge permit to the Town of Exeter with a total nitrogen (TN) effluent limit of 3 mg/l. The Town subsequently negotiated an Administrative Order on Consent (AOC) (Table 2-1) with the EPA that allows a staged approach to TN reduction which allows 5 years to construct a facility which will treat nitrogen to meet a limit of 8 mg/l TN, followed by continued upgrades and reductions in TN. The AOC requires tracking and monitoring to ensure that load reductions goals and ecosystem response are on target.

The Town of Newfields owns a WWTF operated by a Water and Sewer District. The facility is currently operating under an expired permit (issued March 1, 2007, expired February 29, 2012) and expects a new permit in the near future. The District anticipates that the updated permit will require nitrogen controls, and nonpoint source reduction consistent with the Exeter NPDES permit. The District has conducted a pilot study, in partnership with NHDES, which suggests that modifications to the current system, which incorporate fixed bed reactors, may provide enhanced nitrogen removal to 5mg/l.

An alternative strategy for both communities involves connecting to a regional treatment plant located outside the municipality. Current discussion include a regional facility and outfall in Portsmouth or Newington, or (for Newfields) a tie-in to an upgraded facility in Newmarket.

[3] Pg 46, section b) from the "Joint Report of Peer Review Panel-Great Bay Estuary", February 13, 2014 Victor J. Bierman, Robert J. Diaz, W. Judson Kenworthy, Kenneth H. Reckhow.

[4] (2012). "Upper Blackstone Water Pollution Dist. v. EPA." F. 3d, Court of Appeals, 1st Circuit, 9.

Table 2-1. Summary of Town of Exeter Administrative Order of Consent

Effective Date	AOC Element	Completion/ Submittal Date	Consequences for Non-Compliance
Effluent Limitations			
March 1, 2013	Comply with the interim total nitrogen effluent limitations ('report') and monitoring requirements contained in Attachment 1.a to the AOC	June 30, 2019 or until 12 months after substantial completion of the WWTF (whichever is sooner)	Exeter must fund, design, construct, and operate additional treatment facilities to meet the NPDES Permit limit of 3 mg/l as soon as possible and no later than 5 years from determination of non-compliance
June 30, 2016	Initiate construction of the WWTF's necessary to achieve interim effluent limits (8mg/l) set forth in AOC Attachment 1.a	Construction must be substantially completed by June 30, 2018	
June 30, 2019	Comply with the interim total nitrogen effluent limit (8mg/l) and monitoring requirements contained in AOC Attachment 1.a		
Tracking Tools			
March 1, 2013	Track all activities that affect total Nitrogen load to the Great Bay Estuary, including (but not limited to): • New/modified septic systems; • Decentralized WWTFs; • Changes to the amount of effective impervious cover; • Changes to the amount of disconnected impervious cover; • Conversion of existing landscape to lawn/turf and other new or modified BMPs.	Throughout schedule of compliance	

Table 2-2. Summary of Town of Exeter Administrative Order of Consent Effective March 1, 2013

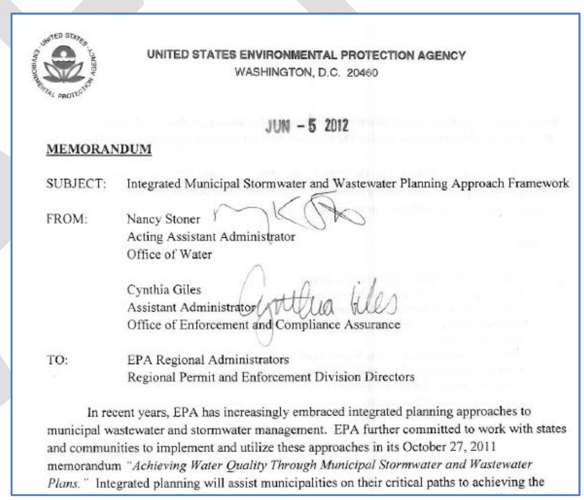
Effective Date	AOC Element	Completion/ Submittal Date	Consequences for Non-Compliance
Coordination Elements			
March 1, 2013	Coordinate with the NHDES, other Great Bay communities and watershed organizations in NHDES's efforts to develop and utilize a comprehensive subwatershed-based tracking/accounting system for quantifying nitrogen loading changes from Exeter to the Great Bay Estuary	Throughout schedule of compliance	
March 1, 2013	Coordinate with the NHDES to develop a subwatershed community based nitrogen allocation		
Control Plans			
March 1, 2013	Submit an annual Total Nitrogen Control Plan Report to EPA and NHDES (Section E.1).	January 31, 2014	
March 1, 2013	Submit a Total Nitrogen Nonpoint and Point Source Stormwater Control Plan to EPA and NHDES. Plan shall include a 5-year schedule for implementing specific control measures (Section D.4).	September 30, 2018	
March 1, 2013	Submit an Engineering Evaluation that includes recommendations for the implementation of any additional measures necessary to achieve compliance with the NPDES Permit, or a justification for leaving the interim discharge limit set forth in Attachment 1.a in place (or lower the interim limit to a level below 8.0 mg/L but still above 3.0 mg/L) beyond that date. (Section E.2) Items include: • Total Nitrogen concentrations in the Squamscott River and downstream are trending towards targets, • Documented significant improvements in dissolved oxygen, chlorophyll a, and macro algae levels, • Non-point source and stormwater point source reductions achieved are trending towards targets and mechanisms in place to ensure continued progress.	December 31, 2023	

2.3 Municipal Separate Storm Sewer System

Under the MS4 program, operated by EPA, towns with urbanized areas as defined by the US Census are required to obtain permit coverage for their stormwater discharges. The Towns of Exeter and Stratham are subject to the requirements of EPA's NH Small MS4 General Permit for stormwater discharges. The Town of Newfields received an MS4 permit waiver in 2013, but understands that MS4 requirements may be applied under future permit cycles. The permit expired in 2008 and is expected to be reissued by 2016. EPA released a draft permit in 2013 which contained new provisions for the 6 Minimum Measures (MM): 1) Public Education and Outreach, 2) Public Participation/Involvement, 3) Illicit Discharge Detection and Elimination, 4) Construction Site Runoff Control, 5) Post-Construction Runoff Control, 6) Pollution Prevention/Good Housekeeping. MM5 includes new requirements to develop Water Quality Response Plans (WQRPs) for stormwater outfalls that discharge to impaired water bodies. The WQRPs will assess all significant discharges to determine if they could contribute to the waterbody impairment and identify BMPs and a schedule for implementation to address the impairments.

2.4 EPA Integrated Planning Framework and Watershed Based Planning

The June 2012 EPA memorandum, "Integrated Municipal Stormwater and Wastewater Planning Approach Framework" provides guidance for EPA, States and local governments to develop and implement effective integrated plans that satisfy the CWA. The framework outlines the overarching principles and essential elements of a successful integrated plan which includes:


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN - 5 2012

MEMORANDUM

SUBJECT: Integrated Municipal Stormwater and Wastewater Planning Approach Framework

FROM: Nancy Stoner
Acting Assistant Administrator
Office of Water

Cynthia Giles
Assistant Administrator
Office of Enforcement and Compliance Assurance

TO: EPA Regional Administrators
Regional Permit and Enforcement Division Directors

In recent years, EPA has increasingly embraced integrated planning approaches to municipal wastewater and stormwater management. EPA further committed to work with states and communities to implement and utilize these approaches in its October 27, 2011 memorandum *"Achieving Water Quality Through Municipal Stormwater and Wastewater Plans."* Integrated planning will assist municipalities on their critical paths to achieving the

- Maintaining existing regulatory standards that protect public health and water quality.
- Allowing a municipality to balance CWA requirements in a manner that addresses the most pressing public health and environmental protection issues first.
- The responsibility to develop an integrated plan rests on the municipality that chooses to pursue the approach. EPA and/or the State will determine appropriate actions, which may include developing requirements and schedules in enforceable documents.
- Innovative technologies, including green infrastructure, are important tools that can generate many benefits, and may be fundamental aspects of municipalities' plans for integrated solutions.

The elements in the WISE plan are consistent with guidance issued by EPA to support integrated permit planning, as well as the Agency's nine-element watershed plans (Table 2.3)

Table 2-3. Comparison of EPA Integrated Planning (IP) Guidance Elements and EPA Nine-Element Watershed Planning.

EPA Integrated Planning Guidance Elements	EPA Nine-Element Watershed Planning
Element 1: A description of the water quality, human health and regulatory issues to be addressed in the plan	Element a: Identify causes and sources of pollution
Element 2: A description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance	Element b: Estimate pollutant loads and expected load reductions
Element 4: A process for identifying, evaluating, and selecting alternatives and proposing implementation schedules	Element c: Describe management measures that will achieve load reduction Element d: Identify technical and financial assistance, and relevant authorities Element f: Project schedule Element g: Interim, measurable milestones
Element 5: Measuring success, which may include evaluation of monitoring data, information developed by pilot studies and other studies and other relevant information	Element i: Monitoring
Element 6: Improvements to the Plan	Element h: Identify indicators to measure progress
Element 3: A process which opens and maintains channels of communication with relevant community stakeholders	Element e: Information/education component

2.5 Municipal Regulations

For the Integrated Plan to be effective, future regulations will need to be adopted by Stratham and Exeter that include: 1) provisions for new and redevelopment projects to require nitrogen controls, and 2) a means for tracking changes in significant land use activities that will impact the nitrogen load to surface waters. The communities of Stratham and Exeter are participating in PTAPP (the Pollution Tracking and Accounting Pilot Program) which intends to develop a uniform approach and means that can be used by communities for MS4 and AOC tracking and accounting.

The Towns of Exeter, Stratham, and Newfields have a range of existing land use regulations and policies designed to protect water quality, including shoreland and buffer ordinances, stormwater management regulations, land conservation programs, storm drain stenciling projects, and educating residents about properly disposing of pet waste and the proper application of lawn fertilizers.

The Piscataqua Region Estuaries Partnership (PREP) recently completed an assessment of local land use regulations and programs related to natural resources protection in the watershed. The March 2015 Piscataqua Region Environmental Planning Assessment report (PREPA) includes an evaluation of water quality protection regulations in the 52 communities in New Hampshire and Maine that comprise the watersheds for the Great Bay and Hampton/Seabrook estuaries..

The Town of Newfields adopted stormwater management standards in 2014 (based on the SWA model ordinance), a conservation subdivision ordinance, and increased shoreland buffer protection. The PREPA Report recommends Newfields increase buffers to 100' for all waterbodies, adopt 100' fertilizer application buffers for all waterbodies, and increase setbacks for septic systems and structures to 100' from wetlands.

Stratham started the process of revising the site plan and subdivision review regulations based on the SWA Model Ordinance in 2014 with the intention of completion during 2015, has adopted regulations to protect vegetated buffers along shorelands and maintains an active land conservation program. The PREPA Report recommends that Stratham increase buffers to 100 feet for tidal wetlands, increase setbacks for septic systems and primary structures to 100 feet for freshwater wetlands, and adopt the Southeast Watershed Alliance Model Stormwater Management Regulations.

Exeter has a draft tracking and accounting form developed that would be used to support the tracking and accounting reporting requirements of the AOC and is exploring stormwater ordinance revisions. The Town has designated Prime Wetlands per NH RSA 482-A:15, adopted buffer requirements of 100 feet on 1st and 2nd order rivers and 150 feet on third and fourth order and tidal rivers, established septic system setbacks and primary structure setbacks ranging from 150 feet to 300 feet. The PREPA Report recommends Exeter adopt fertilizer application buffers for all surface waters, increase the no vegetation disturbance to 100' on tidal wetlands, and adopt the Southeast Watershed Alliance Model Stormwater Management Regulations.

2.5.1 Southeast Watershed Alliance Model Stormwater Management Regulations

The Southeast Watershed Alliance developed model stormwater standards in 2012 to provide minimum, consistent, and effective model stormwater management standards for communities in the Great Bay. These standards are intended to address some of the requirements for communities subject to MS4 permit. The model standards include 7 critical core elements:

Element A: Applicability Standards
Element B: Minimum Thresholds for Applicability
Element C: Best Management Practices
Element D: Applicability for Redevelopment
Element E: Stormwater Management Plan Approval and Recordation
Element F: Maintenance Criteria
Element G: Inspection of Infrastructure

2.6 Additional Regulatory Considerations

Additional Clean Water Act regulatory mechanisms which may be applied in the future include implementation of a Total Maximum Daily Load (TMDL) and Residual Designation Authority (RDA).

A TMDL is the amount of a pollutant, such as nitrogen, that can be discharged to a water body or segment that will meet water quality standards and support designated uses, such as fishable and swimmable. Prior to TMDL development, as is the case for the Great Bay watershed, management activities are directed to reduce pollutant loads relevant to an identified impairment from all permitted activities. TMDLs are generally written by the state water management agency, in this instance NHDES and must be approved by EPA. In the TMDL analysis, monitoring data, models and other assessment tools are used to quantify the present pollutant loading condition, primary sources, and management targets from those sources that will meet water quality standards. Two major waste sources are generally defined, and allocations set: 1) a wasteload allocation (WLA), which is generally defined as the sum of the pollutant load discharged from all "discrete conveyances" contributing to the impairment, such as discharge pipes or ditches and is regulated under a NPDES permit; and 2) a load allocation (LA), which is the sum of the remaining sources such as runoff, groundwater and atmospheric deposition that are more diffuse and not subject to regulation under a NPDES permit. This division occasionally causes confusion as certain classes of stormwater are regulated under the various stormwater permits (i.e., MS4, industrial stormwater, and construction stormwater) that were previously considered non-point sources. But, because they come under a permit, they become part of the WLA; nearly identical storm water sources in non-MS4 areas are not regulated and remain in the LA and are not subject to an NPDES permit in most cases. Truly diffuse sources, especially those transported in the groundwater such as nutrients from septic systems are solidly in the LA even if they originate in an MS4 area.

RDA and Anti-degradation allow a broader application of the law to extend regulatory authority to additional categories or sources of pollution that are determined by the permitting authority to be causing or contributing to water quality standards violations. Residual designation has been only been applied by EPA Region 1 (New England), and only in a few locations including Portland, Maine and the Charles River in Boston. In these instances RDA is used to address sources of pollution not covered under existing programs such as communities outside of the MS4 jurisdiction, and large impervious areas such as malls and shopping centers.

2.7 Impaired Waters

The Clean Water Act requires each state to submit a list of impaired waters to the U.S. Environmental Protection Agency every two years. Listing of impaired waters (303d list) includes surface waters that:

- Are impaired or threatened by a pollutant or pollutant(s),
- Are not expected to meet water quality standards within a reasonable time even after application of best available technology standards for point sources or best management practices for nonpoint sources and,
- Require development and implementation of a comprehensive water quality study (i.e., called a Total Maximum Daily Load or TMDL study) that is designed to meet water quality standards.

Maps of the 2008 surface water impairments for the three towns are provided in Appendix H: Maps of Surface Water Quality Impaired Waters. As of the final 2008 listing, the impaired waters within the Town of Exeter include: Dudley Brook; Norris Brook; Little River; Squamscott River; Wheelwright Creek- Parkman Brook; Exeter River; Colcord Pond; and Little River – Scamen Brook. Under the MS4, Exeter is required to manage the drainage area and infrastructure to receiving waters and implement controls to reduce sources of impairments.

The impaired waters within the Town of Stratham include: Squamscott River; Squamscott River tributary to Stuart Dairy Farm; Winnicutt River including Barton Brook, Thompson Brook and Marsh Brook and Cornelius Brook; and Wheelwright Creek – Parkman Brook.

Many of the streams in town of Newfields (and in the region) are listed as impaired for mercury; other specific impairments include the Squamscott River and an unnamed tributary to the Squamscott River (near Rt 108, impaired for bacteria).

3. WATERSHED STATUS AND ASSESSMENT

The communities of Exeter, Newfields, and Stratham have all experienced substantial growth during the past 50 years. Understanding and mitigating impacts due to population increase, changes in land use and cover, and imperviousness are an essential element of effective management strategies. Since 1960 all of these towns have experienced substantial population growth of 98%, 128%, and 602% and a 20 year increase in impervious cover of 108%, 177%, and 138% respectively for Exeter, Newfields, and Stratham (Figure 3-1).

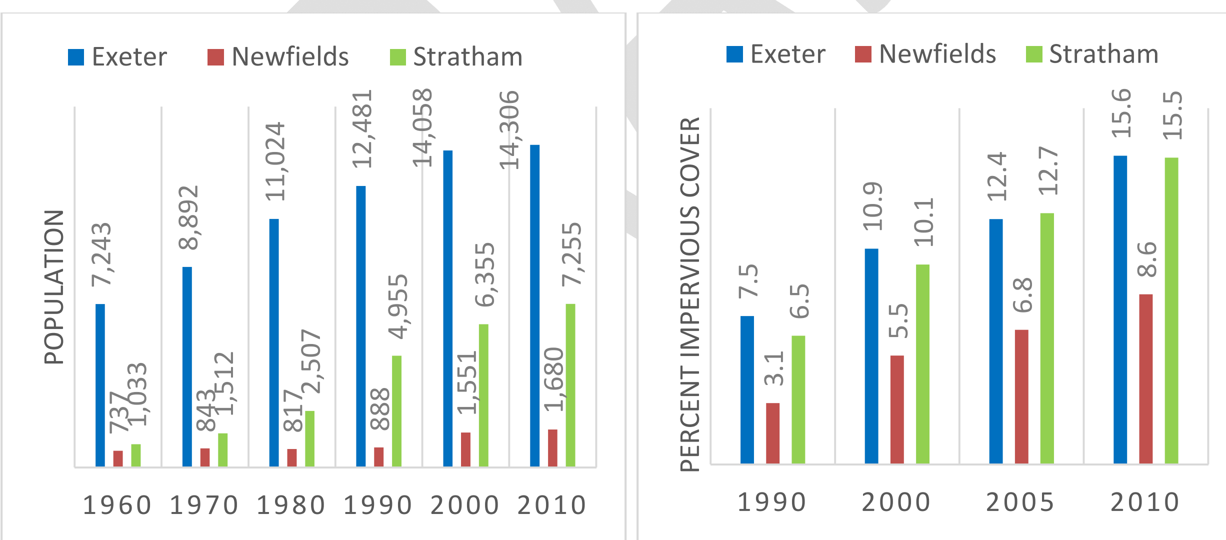


Figure 3-1. Population and Impervious Cover changes in the Towns of Exeter, Newfields and Stratham

The growth trends in the area will require planning efforts and administrative tools to protect water quality. The communities are all in need of cost-effective strategies from meeting permit requirements to assist in balancing the range of competing municipal demands.

Under the WISE project, a watershed level load model was developed to quantify the baseline load from point and nonpoint sources to the Squamscott-Exeter estuary. The model examines the load source and assigns ownership of these loads within each municipality. The results represent a baselines assessment for the municipalities to quantify the economic and performance advantages of integration of water resource planning both at the municipal and inter-municipal level.

3.1 Environmental Assessment

Monitoring and research conducted by various university, local, state and federal programs and projects have documented stresses in the Great Bay system. Prominent drivers of change include watershed modification and development resulting in increased impervious cover, increased nutrient and pollutant load from a rapidly growing coastal population, ecosystem instability and loss of diversity caused by invasive species, habitat destruction, disease, and others. Each stress drives additional physical, chemical and biological pressures on the Great Bay system, that have effects on environmental, lifestyle and economic benefits valued by the local communities. Environmental indicators used by the National Estuaries Program to identify and track ecosystem health clearly illustrate an ecosystem in trouble. In the most recent *State of Our Estuaries 2013* report (PREP, 2013), 12 of 16 indicators showed a declining or cautionary condition. Impervious cover, an indicator of development, shows a long-term increasing trend which is related to condition indicators including nutrient concentration, eelgrass, dissolved oxygen, and macroalgae that show either no improvement, or continued quality decline.

3.1.1 Designated Use and Nitrogen Load Targets

In absence of an approved TMDL target it was necessary to assume a subwatershed goal from which to base the nitrogen control strategies. The nitrogen loads listed in the 2012 Exeter and Newmarket NPDES Permits that are protective of eelgrass and dissolved oxygen were used as upper and lower targets. The permits include a Reasonable Potential Analysis that present the basis for the narrative nutrient criteria that describe a weight of evidence from 4 other similar jurisdictions and the DO and eelgrass targets from the NHDES 2009 draft numeric nutrient criteria for the Squamscott and Lamprey Rivers. The criterion for aquatic life use support in the Squamscott River for total nitrogen for maintaining dissolved oxygen levels is 0.45 mg/l, eelgrass habitats is 0.30 mg/l, and lists load targets of 140 tons and 88 tons respectively. The aquatic life use support criteria proposed by NHDES are consistent with EPA, Massachusetts', and Delaware's guidance.

3.1.2 Modeling Approach for Non-Point Nitrogen Load

To understand the pollutant load inputs from the Squamscott-Exeter subwatershed to the estuary, a watershed-scale pollutant load model and budget were developed, which provides the average annual load to the estuary from nonpoint and point sources for the subwatershed and by Town.

The pollutant load model was developed building on a number of existing studies and methods to account for surface water and groundwater loads to the estuary (Breaults et al 2002, NHDES 2014, VHB et al 2014, Valiela et al 2000, Exeter 2014). The various components are summarized below:

- Stormwater Load Model (Unattenuated), (SWMM5);
- Septic System Load Model (GBNNPSS);
- Agricultural Load Model (NRCS/WISE/GBNNPSS/ORIWMP);

- o Attenuation in pathways in groundwater and surface water (GBNNPSS/NLM); and
- o WWTF Load (Exeter/Wright Pierce).

The model was developed using a hydrologic response unit (HRU) approach, idealized 1-acre representative parcels, with varying combinations of land use, soil type, and impervious cover. Precipitation data from a local gage is used to perform a continuous rainfall-runoff simulation of the HRUs to estimate the amount of stormwater volume generated by each HRU. A full description of the modeling methodology is located in Appendix 8.2.

Unattenuated stormwater quality load was calculated using event mean concentrations (EMCs) or buildup and wash off functions specific to a land use type, for total nitrogen, total phosphorus, total suspended solids, and fecal coliform. Unattenuated load represents the pollutant load washed off the surface prior to any natural attenuation that occurs as the load migrates towards the receiving water. Once stormwater migrates from the surface on which it was initially generated, natural attenuation occurs as the water travels across pervious surfaces and vegetated buffers and through streams and natural waterways. Attenuation is caused by particulate settling, filtering, and biological uptake. By accounting for natural attenuation, the pollutant load which ultimately arrives at the receiving water can be estimated. Annual loads presented in this section have been adjusted to account for the estimated level of impervious surface disconnection in each town.

The modeled hydrologic response units (HRUs) are idealized catchments used in the model to estimate the amount of storm water runoff generated by precipitation. There are eight distinct HRUs representative of each combination of four hydrologic soil groups (HSG) and two imperviousness conditions (fully impervious and fully pervious). The HRUs are also used to generate water quality pollutant loads. In SWMM, a single catchment can be used to model multiple pollutants simultaneously. By treating the runoff quality from a given land use as a distinct pollutant in SWMM, a single HRU is capable of modeling the storm water runoff quality from multiple land uses in a single model run. In this respect, an HRU is not used to model a single specific land use, but to model all land uses that share the soil type and impervious cover of the given HRU.

The annual load derived from the use of septic systems was based on estimates provided by NHDES in the GBNNPSS. The process used to arrive at estimates of septic system loads is explained in Appendix G of GBNNPSS. NHDES delineated regions serviced by municipal sewer systems based on direct information from regional municipalities and information in the USGS Water Demand Model for New Hampshire Towns. The population outside of these service areas, as determined by 2010 US Census block data, was assumed to use septic systems for waste disposal. A per-capita excretion rate of 10.6 lb N per year was multiplied by the population using septic systems to calculate a nitrogen load to groundwater from septic systems. Water Demand Model for New Hampshire Towns (Hayes and Horn, 2009).

Agricultural loading data on the application of chemical fertilizer and manure were used to refine the estimate of nitrogen loading from agricultural surfaces. The USDA National Agricultural Statistics Service (NASS) Crop Type geospatial data layer was used to quantify the area of various crop types within the watershed. Major crops in the Exeter-Squamscott watershed consisted of corn, alfalfa, hay, and pasture land. Application rate of chemical fertilizer on each of the identified crop types were estimated using values reported in literature sources (Cornell University Cooperative Extension Agronomy Fact Sheets, GBNNPSS) and reported by local farmers. The NRCS Manure Calculator was used to calculate the manure generated and used in crop production (Smith 2014). Local farmers provided generous feedback on estimates of the number of animals (cattle, pigs, sheep, etc), the proportions of each crop, harvest number, and type and amount of fertilizer and manure applied. Application rates are determined by the area of each crop type in production to determine an annual deposited chemical fertilizer and manure load in combination with the nitrogen uptake based on crop type, yield, and the number of harvests.

Attenuation rates were applied to all calculated loads to estimate the actual (attenuated) delivered loads to surface waters. Delivery factors from the GBNNPSS are for surface water runoff (87%), groundwater non-septic (10%), septic systems within 200 m of a receiving water (60%), and septic systems farther than 200 m (26%), reflecting the assumption that increased travel times will result in higher rates of natural attenuation.

3.1.3 Modeling Results of Nitrogen Load by Source

For the baseline assessment, the total nitrogen load to the Squamscott-Exeter River subwatershed from the three WISE towns was estimated at 93 tons per year, from both point and non-point sources. Wastewater treatment facilities from Exeter and Newfields, discharging to the Squamscott-Exeter River subwatershed, account for 57.2 tons of nitrogen per year or 61 percent of the total nitrogen load from subwatershed (Wright-Pierce, 2014; GBNNPSS, 2014).

Nitrogen loading to the subwatershed from non-point sources accounted for 39 percent or 36 tons. The non-point sources include stormwater load, groundwater load and septic system load. The total stormwater load from the three towns represents 19 tons per year. Of that 19 tons, 6.1 tons is from natural land uses (i.e., forest, wetlands, ponds) and the remaining 12.9 tons is from other land uses including urban runoff from impervious surfaces, lawns, agriculture and managed turf.

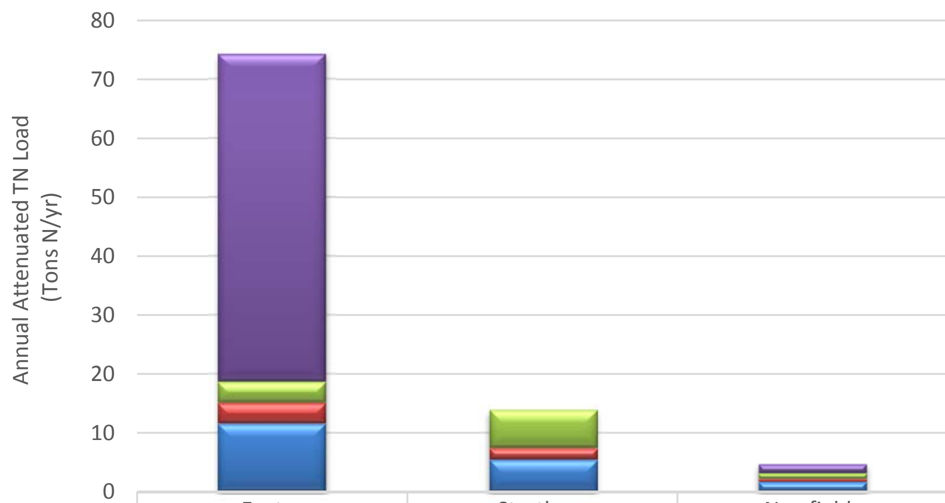
The annual load derived from the use of septic systems is based on estimates provided in the GBNNPSS (NHDES, 2014), which represents 11 tons per year. NHDES delineated regions serviced by municipal sewer systems based on direct information from regional municipalities and information from the USGS.

The groundwater non-septic load, which represents 6 tons per year, refers to nitrogen which originates from deposition on the ground surface and which is transported to the aquifer via infiltration. This quantity was not calculated in the WISE model, and relied on calculations performed by NHDES as part of the GBNNPSS.

The 93 tons is distributed between the three towns as presented in Figure 3-2. Exeter contributed the largest load, 74.5 tons per year or 80% of the total annual load, with the WWTF contributing the largest load (57 tons) followed by stormwater runoff (12 tons). The Town of Stratham contributes 14 tons per year (15% of the total annual load), with septic systems contributing the largest load followed by stormwater runoff. The Town of Newfields contributes 4.6 tons per year (5% of the total annual load), with stormwater runoff and wastewater contributing nearly equal loads.

The three WISE towns account for 24% of the total land area within the Squamscott-Exeter watershed. The upper portion of the watershed includes 9 towns with no current WWTFs or MS4 permits. Including the upper watershed communities, the total TN load to the Squamscott-Exeter watershed is 182 tons per year (Figure 3-3). The additional 89 tons from the upper watershed towns is primarily from the developed portions of the watershed (72.3 tons) and the remaining from the undeveloped natural portions of the watershed (16.6 tons). The unregulated upper watershed towns contribute 48% of the total load to the estuary and attainment of water quality goals for the Squamscott-Exeter watershed will require broader participation from these communities.

The baseline load from the watershed is 182 tons per year and exceeds both the dissolved oxygen load target (140 tons) and eelgrass target (88 tons). The regulated communities contribute 93 tons, an amount greater than required to meet the eelgrass target.



	Exeter	Stratham	Newfields
Wastewater Treatment Facility	55.7	0	1.6
Groundwater (Septic)	3.6	6.5	0.9
Groundwater (non-septic)	3.5	2.0	0.5
Stormwater	11.7	5.5	1.7

Figure 3-2. Annual Attenuated Load by Town; Total subwatershed load = 93 Tons per year

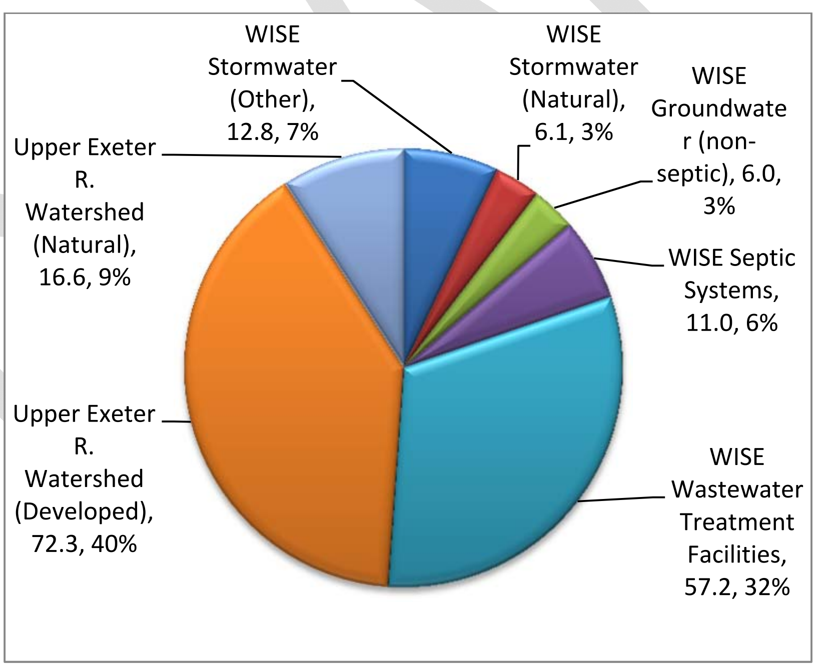


Figure 3-3. Baseline attenuated load (tons/year) from point and non-point sources from Squamscott-Exeter watershed; Total watershed load =182 Tons per year.

3.1.4 Agriculture and Its Role in Nitrogen Management

Involving farmers and the agricultural community in the review of WISE data and development of recommendations was important to the Project Team as agricultural land use and associated best management practices provide unique opportunities to reduce nutrient loads. As population and corresponding development have increased in the region, the number of farms and the amount of actively farmed acres has significantly decreased. Data from the USDA Census of Agriculture indicate a 75% reduction in farmland in Rockingham County between 1954 and 2012. Population in the County increased 321% in the same period. Hay production decreased 77%, corn production decreased 70%, and orchards decreased 74%. The number of cattle and calves decreased 81% and the number of chickens decreased by 99%. Over the same period, the number of horses in the region increased 285%, providing municipalities with an opportunity to engage horse owners and stable operators in a discussion about the need for proper manure management. Both the Rockingham County Conservation District and the Natural Resource Conservation Service can provide site specific manure management plans.

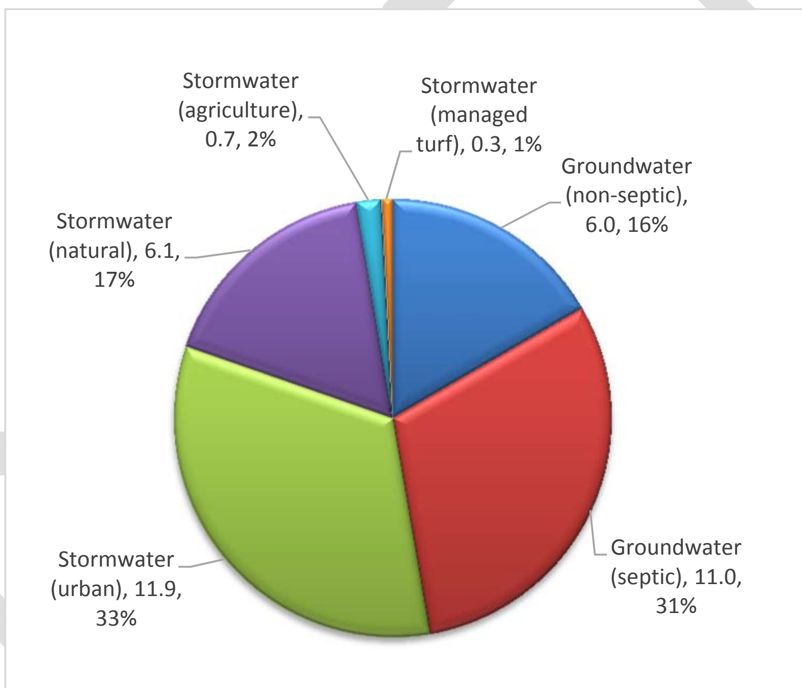


Figure 3-4. Annual attenuated load (tons/year) from non-point sources from 3 WISE communities =36 Tons per year.

Hundreds of acres of land in the subwatershed are still actively farmed, supporting hay, grain, vegetable crops, and livestock. Manure produced by livestock is spread on fields in Exeter, Stratham and Newfields that are farmed for livestock feed. Farmers work to achieve a balance to match livestock feed demands with manure production and crop demand to minimize need for expensive chemical fertilizer. Data collected for WISE indicates agriculture accounts for 2% of the annual attenuated total nitrogen load in the subwatershed, or 0.7 tons/year.

Consultation with farmers in the three towns and with staff from the Natural Resource Conservation Service and NHDES provided the Project Team with information on the best management practices being applied to farmland, including the use of cover crops, vegetated and wooded buffers, slow release nitrogen on fields, the planting of alfalfa as a nitrogen fixer, and the development and implementation of Comprehensive Nutrient Management Plans (CNMP). CNMPs are conservation plans unique to livestock operations. These plans document practices and strategies adopted by livestock operations to address natural resource concerns related to soil erosion, livestock manure and the disposal of organic-by-products. The development of a CNMP begins with a comprehensive engineering and conservation planning resource assessment of current site conditions. Farm operators work with NRCS to develop management options, including manure handling, transfer and storage, spreading manure on cropland, preventing soil erosion, and protecting water quality.

Buffers are a well-known cost effective planning tool for the protection of water resources. The New Hampshire Shoreland Protection Law and local zoning ordinances place strict requirements on what can be built (and how it will be built) in sensitive areas adjacent to wetlands and surface waters. In the instance of existing agricultural areas, this issue must be balanced with the pressure upon the farms, and the modest contribution of agriculture to the watershed nitrogen load. Some of the most productive farming lands exist in the valley bottoms closest to surface waters and limiting use of these areas could be financially disastrous for farms. Establishing and maintaining riparian or fenced buffers for grazing livestock is an important tool that will allow the continued farming of these productive areas and reduce impacts. When developing new farm land, the protection of existing buffers from livestock should be one of the first nutrient management practices considered.

One of the clear messages from the stakeholder groups during this process was that this community places a high value on protecting the remaining farms and that residents see the agricultural character as part of the fabric of the community. Keeping farms viable will prevent more sensitive land from being converted to development that places greater burdens on the estuarine system's health.

3.2 Municipal Infrastructure

A description of existing wastewater and drainage systems (i.e., stormwater) for each of the three Towns are described below. This summary includes: 1) characterization of their existing wastewater and drainage infrastructure; and 2) characterization of inputs and outputs from the infrastructure systems. Appendix E: Septic System Maps for Exeter, Stratham, and Newfields includes draft maps for each community.

3.2.1 Town of Exeter Infrastructure

The Town of Exeter has a well-established water, wastewater and drainage infrastructure. The Town's water system is largely built out and serves a large portion of the Town's population. The town of Exeter withdraws approximately 1.5 million gallons per day from the lower Exeter River, and relies on the quality and volume of flow in the river to support safe drinking water to over 3,000 households. Exeter's wastewater infrastructure includes a lagoon-based wastewater treatment facility, nine pump stations, and approximately 49 miles of collection system piping. However, the Town of Exeter is facing significant infrastructure upgrade needs for both its water and wastewater infrastructure; primarily associated with its treatment plants.

3.2.1.1 Wastewater and Septic Systems

The Town of Exeter owns and operates a wastewater collection, treatment and disposal system which serves the Town of Exeter as well as small portions of the Towns of Stratham and Hampton (Wright Pierce, 2014). The collection system includes 9 pumping stations and approximately 49 miles of sewers and approximately 3,600 wastewater accounts.

The wastewater treatment facility (WWTF) is an aerated lagoon facility with disinfection that was constructed in 1964 and comprehensively upgraded in 1988. The WWTF discharges effluent into a tidally-influence segment of the Squamscott River (Class B), upstream of the Great Bay. The effluent must meet standards set forth in state and federal water quality legislation, including the Clean Water Act. The WWTF effluent quality requirements are contained in a National Pollutant Discharge Elimination System (NPDES) permit which is issued by the US Environmental Protection Agency (EPA).

The Town's wastewater collection system and pump stations are all operating well. Infiltration and Inflow (I/I) is a significant issue in Exeter. This results in extraneous flows being treated at the WWTF on an average basis, as well as significant peak flows after rain events that must be managed by the pump stations and WWTF. The Town is currently constructing pipe replacement, pipe rehabilitation, service line replacement, and drainage improvements in the areas of Town to reduce I/I. Upgrades are also occurring to remedy hydraulic bottlenecks in the collection system.

In October 2014, the Town of Exeter completed a draft Wastewater Facility Plan (Wright-Pierce, 2014), which evaluates the cost for Exeter to upgrade their existing WWTF to comply with their AOC requirements.

The Town of Exeter has subsurface septic systems, which serve approximately 1195 properties or 29 percent of the Exeter properties. Of the total number of septic properties within Exeter, approximately 89 percent are located within the Squamscott-Exeter River watershed; of these properties, approximately 33 percent are located within 200 meters (656 feet) of the Squamscott-Exeter River or its larger tributaries (i.e. approximately 350 properties in Exeter have septic systems and are located within 200 meters of the Squamscott-Exeter River or its major tributaries).

3.2.1.2 Drainage

In 2003, the Town of Exeter was designated as a MS4 community in accordance with the 2000 US Census. Exeter has been operating under the expired 2003 permit since that time. Exeter's MS4 designated area is located south of Route 101 in the urbanized part of Town. The storm sewer system includes miles of stormwater collection system piping ranging from 12 to 48 inch diameter. The storm sewer system contains 1,080 catch basins, drain manholes, 2 treatment units, and 64 stormwater outfalls which drain to waters of the State.

3.2.2 Town of Stratham Infrastructure

The Town of Stratham is characterized by largely rural, residential area, a historic New England town feel, and an agriculturally based culture. The Town of Stratham has no centralized water or wastewater infrastructure and almost all of the homes and commercial facilities in Town use wells for their potable water supply, with the exception of three locations in Stratham where the

Town of Exeter supplies water, including the business park housing Lindt and Timberland. Fire suppression, with the exception of four commercial developments, is provided by dry hydrants tied into local ponds and cisterns.

Wastewater management is provided with individual on-site subsurface disposal systems (i.e., septic systems). In 2010, the Town of Stratham passed a new zoning ordinance establishing the Gateway Commercial Business District overlay district. The Gateway District had been discussed within the Town of Stratham for over five years, and was established to "enhance the economic vitality, business diversity, accessibility, and visual appeal of Stratham's built environment, in a manner that is consistent with the landscape and architecture of the Town's agricultural tradition."

The new zoning encourages greater density development within the Gateway District using a village-style developed environment comprised of closely spaced structures housing a mix of retail, commercial, and residential uses. In order for the Gateway District to succeed, it is acknowledged that centralized water, fire suppression, and wastewater services are required.

3.2.2.1 Wastewater and Septic Systems

The wastewater generated by residents and businesses in the Town of Stratham is currently managed entirely by subsurface septic systems. In 2011, the Town completed a preliminary report entitled *Wastewater Management Concept Plan* (Wright-Pierce, 2011), to evaluate the feasibility of a wastewater collections system for the Town's primary commercial corridor, General Commercial District (GCM), along Route 108 (Portsmouth Avenue) and extends 800 feet on either side of Route 108 north of Route 101 to Bunker Hill Avenue. This plan looked at the Town installing sewers and a wastewater treatment facility in the Town of Stratham. The plan included a stepwise approach to:

1) Install sewers up to Frying Pan Lane and construct a new forcemain and wastewater treatment plant with a groundwater discharge disposal field;
2) Expand sewers up to Bunker Hill Avenue;
3) When flows dictate, expand the groundwater discharge disposal field; and
4) Expand sewers to the Town Center.

In 2012, an Intermunicipal Water and Wastewater Systems Evaluation Study (Kleinfelder, 2012) was completed for the Towns of Exeter and Stratham to provide an analysis of the costs and benefits of a cooperative approach to meet the future water and wastewater needs of the two towns. This approach looked at the cost and benefits of Stratham using Exeter's wastewater treatment facility, as opposed to building their own, as outlined in the 2010 concept plan and is discussed in 3.2.4 Inter-Municipal Water and Wastewater Management.

The Town of Stratham does not have a municipal sewer system and is entirely dependent on septic systems for wastewater treatment. Of the total number of Stratham properties, which are serviced by septic systems, approximately 66 percent are located within the Squamscott-Exeter River watershed. Of these, approximately 27 percent are located within 200 meters of the Squamscott-Exeter River (or its major tributaries). In the summer of 2014, Geosyntec reviewed all of the available septic system records at the Stratham Planning and Zoning Department; 51

properties were identified, which are located within 200 meters of the Squamscott-Exeter River (or its major tributaries) and are most likely greater than 25 years old.

3.2.2.2 Drainage

The Town of Stratham is a newly designated MS4 community as per the 2010 Census. The MS4 designated area is comprised primarily of the residential part of town and excludes the commercial district. It is widely recognized that future stormwater management efforts will need to include the commercial district in large part because the district has a very high impervious cover and has tremendous redevelopment potential. The drainage areas and infrastructure conveying stormwater to these impaired waters needs to be managed under the MS4 permit. Outside of the commercial district, Stratham's drainage infrastructure consists primarily of country drainage (i.e., roadside swales) and does not include an extensive network of catch basins, manholes and pipe network.

3.2.3 Town of Newfields Infrastructure

3.2.3.1 Wastewater and Septic Systems

The Newfields wastewater plant is owned and operated by the Water and Sewer District and serves approximately 170 households (30% of the town population). The District encompasses residences and businesses in the downtown area adjacent to the Squamscott River. In 2014, the District was expanded to add a connection to the Rt 108 corridor, anticipating future growth in that region. The extension also provides the potential for future transfer of septic systems to wastewater treatment. The Town of Newfields has subsurface septic systems, which serve approximately 555 properties or 68 percent of the Newfields properties. Of the total number of septic properties within Newfields, approximately 59 percent are located within the Squamscott-Exeter River watershed; of these properties, approximately 31 percent are located within 200 meters of the Squamscott-Exeter River or its larger tributaries (i.e. approximately 100 properties in Newfields have septic systems and are located within 200 meters of the Squamscott-Exeter River or its major tributaries.

3.2.3.2 Drainage

The Town of Newfields is a newly designated MS4 community as per the 2010 Census, but has received a waiver under the current permit cycle. The remaining land area drains to the Piscassic, and ultimately the Lamprey River. The drainage areas and infrastructure consists primarily stormwater drains in the urbanized downtown, and country drainage (i.e., roadside swales) in other areas.

3.2.4 Inter-Municipal Water and Wastewater Management

In 2012, an Inter-municipal Water and Wastewater Systems Evaluation Study (Kleinfelder, 2012) was completed for the Towns of Exeter and Stratham to provide an analysis of the costs and benefits of a cooperative approach to meet the future water and wastewater needs of the two towns. Both Towns have significant water and wastewater needs to meet their desired goals and obligations, and many key decisions on how the towns will meet these needs will need to be made. Exeter is facing up to $60 million in infrastructure investment and Stratham is facing over $30 million. If there is untapped water or wastewater capacity that can be shared, cooperation between the two towns could benefit both.

The Study clearly showed that both towns would benefit financially by pursing the Inter-municipal option or District option over the independent options. The study recommends that the towns focus on the development of an inter-municipal agreement (IMA). Currently the towns are in negotiations to establish an inter-municipal agreement; however, regional wastewater options are also being pursued in parallel, as discussed in Section 3.2.5.

3.2.5 Regional Wastewater Treatment

In November 2014, the Towns of Exeter and Stratham hired Underwood Engineers to conduct a study to evaluate a regional wastewater treatment strategy (Underwood, 2014). The study evaluates the scope and costs necessary for the conveyance of wastewater to the City of Portsmouth's Pease WWTF. Based on this study, the recommended next steps were to (1) compare regional costs from the study to those presented in the Exeter WWTF plan; (2) continue to discuss opportunities with Portsmouth; and (3) monitor Portsmouth's discussion on conveying Pierce Island's sanitary waste to Pease, which may have additional cost incentives to a regional Pease option. Revised costing numbers are expected from Portsmouth in May of 2015 at which time the regional and local options will be further reviewed.

4. PRELIMINARY NITROGEN CONTROL PLAN

The Preliminary Nitrogen Control Plan detailed in the following sections is intended to meet the requirements of the NPDES Permit No. NH0100871 and associated Administrative Order on Consent and the requirements for Post Construction Stormwater Management (Minimum Measure 5) in the 2013 draft NH Small MS4 permit. As per the AOC Section D.4, *a Total Nitrogen Non-point Source and Point Source Stormwater Control Plan*, shall include:

- *5 year schedule for implementing specific control measures as allowed by state law to address identified non-point source and stormwater Nitrogen loadings in the Town of Exeter that contribute total nitrogen to the Great Bay estuary, including the Squamscott River.*
- *If any category of de-minimis non-point source loadings identified in the tracking and accounting program are not included in the Nitrogen Control Plan, the Town shall include an explanation in the Plan of any such exclusions. The Nitrogen Control Plan shall be implemented in accordance with the schedules contained therein.*

A Nitrogen Control Plan includes a plan to implement total nitrogen non-point source and point source controls. Detailed in this section is a comprehensive watershed-scale Nitrogen Control Plan for the 3 regulated communities with specific implementation of nutrient control measures to meet permit requirements and achieve water quality improvements. The Nitrogen Control Plan evaluates numerous management scenarios and presents a recommended Preliminary Implementation Schedule to meet the receiving water quality targets established in the Exeter AOC and the requirements for Post Construction Stormwater Management (Minimum Measure 5) in the 2013 draft NH Small MS4 permit.

This Nitrogen Control Plan addresses the necessary requirements outlined in the AOC including:

- The pounds of total nitrogen discharge from the WWTF during the implementation period;
- A description of the WWTF operation changes;
- A description of the non-point source controls;

- A description of the total pounds of nitrogen removed from point and non-point sources;
- A description of the adaptive monitoring to track and account for reductions in total nitrogen; and
- A description of the tracking and accounting system.

4.1 Management Scenarios

A range of management scenarios were evaluated for both wastewater and non-point source strategies over three different permitting and planning scenarios. The scenarios include:

(1) Subwatershed Integrated Planning (IP) – evaluates the three towns working together to develop an integrated plan to manage their four permits. The pollutant loads and costs are compiled by subwatershed.

(2) Traditional Permitting (T) – evaluates the three towns working independently to manage their permits (i.e., silo approach). The permits (i.e., wastewater and MS4) within the towns are managed separately and credit across permits is not considered.

(3) Town Integrated Planning for Exeter (EX) – evaluates the Town of Exeter using an integrated plan to manage their two permits (i.e., wastewater and MS4).

The permitting scenarios were evaluated for a range of management scenarios (Table 4-1) which consider varying WWTF load targets, receiving water load targets and non-point source sizing criteria. Additional management scenarios were evaluated and are presented in Appendix 8.2 and considered additional WWTF load targets and non-point source implementation to meet receiving water load target goals. The management scenarios assume that the WWTFs are in the process of meeting the regulatory milestones outlined in the AOC, by designing a WWTF Plan to operate at 8 mg/L by 2019. The WWTF targets in all scenarios with the exception of IP-3/5/8 are to be implemented during a single permit cycle. Scenario IP-3/5/8 has an implementation schedule across multiple permit cycles and begins with 8 mg/l at 2019, transitions to 5 mg/l at 2029, and ends at 3 mg/L by 2042. The extended implementation schedule allows for ecosystem monitoring and adaptive management at each critical stage and for participation by upper watershed communities. This is described in greater detail in Section 0. The receiving water load targets will be met by a combination of point source reductions due to the upgrades made to the WWTF and through implementation of non-point source controls which are required under by the WWTF AOC and the MS4 permit.

Under the management scenarios a receiving water load target of 88 tons per year was used, which is the target for protection of eelgrass. This load target is for the entire Squamscott-Exeter River watershed, not just the subwatershed comprised of the three towns (Exeter, Stratham and Newfields).

Table 4-1. Management scenarios listed by wastewater limits and stormwater criteria

Scenario ID	Planning Level	WWTF Concentration Target (mg/L)	Non-point Source Sizing Criteria
IP-3/5/8	Integrated Planning	Phased from 8mg/L @2019, to 5 mg/L @ 2029 and 3mg/L @ 2042	Maximum Extent Practicable (MEP)
IP-3	Integrated Planning	3 mg/L @2019 (w/ Stratham WW District)	Maximum Extent Practicable (MEP)
IP-5	Integrated Planning	5 mg/L @2019	Maximum Extent Practicable (MEP)
IP-RO	Integrated Planning	<1 (Regional Outfall)	Maximum Extent Practicable (MEP)
EX-3	Town of Exeter Integrated Planning	3 mg/L @2019	Maximum Extent Practicable (MEP)
EX-5	Town of Exeter Integrated Planning	5 mg/L @2019	Maximum Extent Practicable (MEP)
T-5	Traditional Permit	5 mg/L @2019	MS4 1" WQV for all developed areas
T-3	Traditional Permit	3 mg/L @2019	MS4 1" WQV for all developed areas
T-RO	Traditional Permit	<1 (Regional Outfall)	MS4 1" WQV for all developed areas

The non-point source sizing criteria varies by the permitting scenario. Under the two Integrated Planning scenarios (IP and EX), the integrated planning framework allows the permittee the ability to credit across permits and for flexibility on the sizing requirements of stormwater best management practices for non-point source control. Therefore, the level of non-point source controls necessary to meet the receiving water quality load target was evaluated for varying water quality volume sizes, as described in Section 4.2, and level of implementation based on the highest unit performance and least cost mix of management strategies or to the maximum extent practicable (MEP) and described in Section 4.2.

Under the Traditional Permitting (T) scenarios with a receiving water load target of 88 tons per year are evaluated through implementation of non-point source management strategies to meet the requirements under the MS4 permit and by standards in the New Hampshire Stormwater Manual (NHDES, 2008), which requires sizing stormwater BMPs to capture and treat the volume from a 1 inch storm. The Traditional Permitting scenario does not allow include an MEP analysis or cross permit load reduction crediting.

The management scenarios were evaluated for the pollutant load reduction capability to the estuary and the economic impact of the scenario on the Towns. The management scenarios were then compared to determine the most viable path forward for the Towns, whether it be an integrated planning scenario or a traditional permitting path and the pros and cons of each of the scenarios.

Point sources were evaluated first and for each WWTF design load target the pollutant load reductions and the economic cost to implement and maintain that system were estimated. The design loads and costs of the WWTF targets were taken from the Draft Exeter Wastewater

Treatment Facilities Plan (Wright-Pierce, 2014) for the Exeter WWTF upgrades and for the Regional Outfall from the regional wastewater study (Underwood, 2014).

The point source load reductions were subtracted from the baseline pollutant load for the watershed (182 tons) and compared to the receiving water quality goal target (88 tons) to determine the non-point source control load target necessary to meet the estuary water quality pollutant load targets.

An analysis was conducted to determine the cost of installation and implementation of non-point source strategies for achieving a full range of reductions including management of all impervious areas and significant sources. To evaluate this, a linear optimization (LO) model was developed which analyzes a range of pollutant load reduction targets with a range of land use types, soil types, non-point management measures and capture depth sizes.

4.2 Optimization and Maximum Extent Practicable

One of the core elements of integrated planning is the allowance that a permittee can take credit for actions associated with one permit (i.e., wastewater) and may also receive credit in another (i.e., MS4). For example, installation of green infrastructure (i.e., biofiltration to treat road runoff, or drywells to treat roof tops) for non-point source management under the WWTF permit would also satisfy requirements for Post Construction Stormwater Management (Minimum Measure 5) in the 2013 draft NH Small MS4 permit . This has the potential to be more economical than traditional permitting because it satisfies elements of both the MS4 and wastewater permits and it helps manage the uncertainty of environmental response.

Integrated planning also allows for flexibility as to when and what nutrient management measures are implemented so long as the goal is the protection of public health and water quality. This approach allows for the use of various sizes (i.e., capture depths) of nutrient controls to allow for a greater number of smaller systems in replace of fewer systems designed to treat larger volumes.

To use this approach, an optimization model was developed which selects the most cost effective management measures for a range of increasing load reduction. The optimization model runs repeatedly, changing the target load reduction with each iteration. It evaluates the nitrogen control strategies based upon user defined constraints including available land for implementation, pollutant load reduction capability based on capture depth of the nutrient control measure; and cost to implement the strategy. This is first applied at the system level to develop a series of BMP performance curves. It is next applied at the land use scale to identify the most cost effective options for each particular land use. The optimization is then conducted at the watershed scale for the range of nutrient control measures, and the range of land uses. The optimization process is then repeated for each of the management scenarios described in Table 4-1 to determine total cost of implementation. Figure 4-1 illustrates one of the Project tools that is intended to be used by designers when reporting nitrogen load for a development proposal. Example 1 below illustrates the process of how optimization of the size of a bioretention system can occur based on varying the capture depth of the water quality volume. Example 2 and Figure 4-2 illustrate how the optimization occurs at a residential land use scale.

An example of optimization at the watershed scale is presented as a Pareto curve in Figure 4-3 as annual load reduction vs. implementation capital cost. The Pareto curve illustrates the concept of diminishing returns (i.e. the most cost-effective options are pursued first) and each additional pound of nitrogen reduction will have a higher differential cost. Higher target load reduction amounts result in BMP combinations that have a higher average cost per acre treated. Figure 4-3 was used to define the “maximum extent practicable” for the implementation of non-point sources for each of the management scenarios.

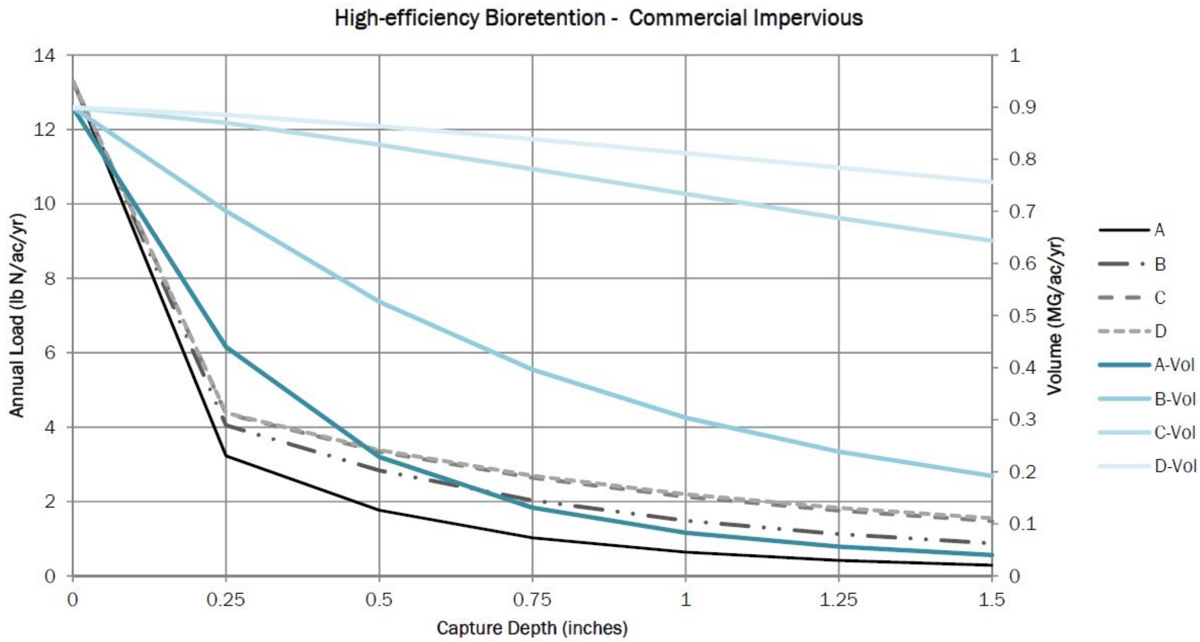


Figure 4-1. BMP Performance Curve for high-efficiency bioretention on commercial impervious areas illustrating annual exported load (lbs Nitrogen/acre/year) and volume (million gallons/acre /year) based on water quality volume (aka capture depth)

Example 1: BMP optimization for high-efficiency bioretention at 0.25" and 1" water quality volumes

From the BMP performance curve for a high-performance bioretention we can see that 4 systems designed to treat a 0.25" water quality volume in replace of one system to treat a 1" water quality volume would remove an additional 27 lbs of Nitrogen per year at nearly equivalent costs, or approximately 315% greater optimization. A single system treating a 1" water quality volume for 1 acre will remove approximately 12.7 lbs N/acre/year. Whereas 4 smaller systems across 4 acres designed to treat 0.25" water quality volume per acre will each remove 10 lbs N/acre/year for a total of 40 lbs N per year.

Example 2: BMP optimization for a range of nitrogen control measures for residential land use

Figure 4-2 is an example of an optimization for a residential land use which shows the cost to achieve reduction in relation to the nitrogen management practices ordered in terms of cost efficiency. This process enables the identification of the MEP, or the point at which cost effectiveness and pollutant reduction is greatest and the feasibility to implement cost effective and pollutant load reduction management practices begins to decline. In this example, 10,000 pounds of nitrogen can be reduced at a cost of about 7 million dollars ($700 per pound reduced); whereas, 15,000 pounds is at a cost of nearly 44 million dollars ($2,930 per pound reduced).

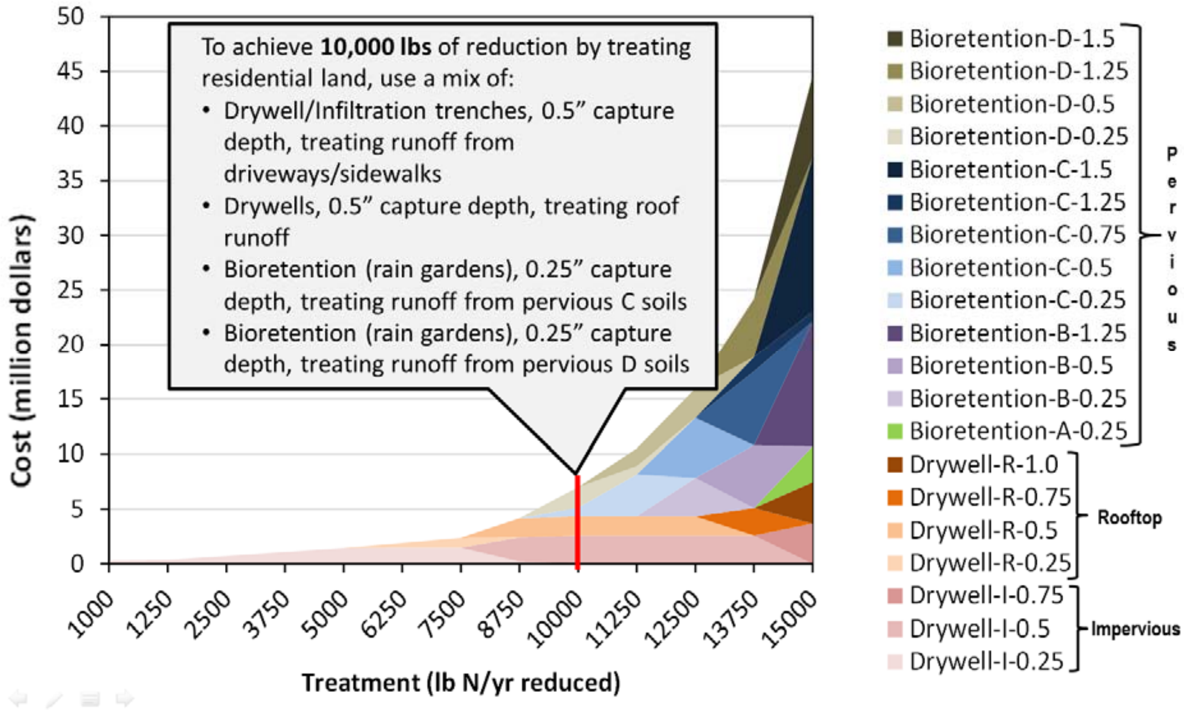


Figure 4-2. Residential-scale BMP optimization example

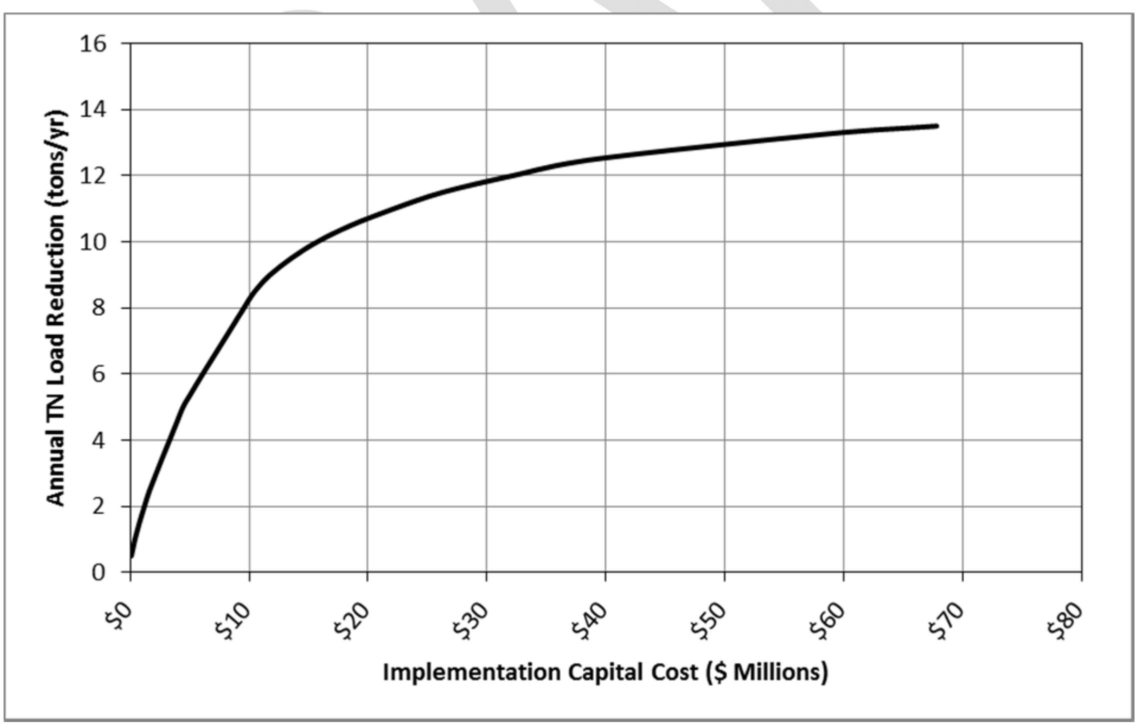


Figure 4-3. Watershed-scale annual total nitrogen load reduction from non-point source management strategies

4.3 Nutrient Control Measures

Nutrient control measures, or BMPs, as part of the WISE project focused on both point and nonpoint sources. A matrix of BMPs was developed in collaboration with the three towns to identify BMPs they would accept and felt were feasible in respective land uses (Table 4-2). The management measures, both structural and non-structural, look to reduce pollutant load from wastewater treatment facilities, subsurface septic systems, and stormwater sources including agriculture, managed turf (i.e., golf courses, lawn), impervious and pervious surfaces, residential, commercial/industrial/institutional, roads, and outdoor recreational spaces (i.e., parks). A detailed overview of the nitrogen control measures examined are included in Appendix 8.1.

A wealth of BMP sources exists in the literature and locally at the UNH Stormwater Center and this Plan does not attempt to repeat that information. Furthermore strict adherence to design specifications can limit innovation which will be essential to effective nutrient management in the future. For this reason we encourage the use of performance specifications detailing the nitrogen load reduction required and encouraging innovation in design. A foundation of practices can be found in the New Hampshire Stormwater Manual is from the NHDES website at www.des.nh.gov/organization/divisions/water/stormwater/manual.htm.

Other stormwater practice design standards may be accepted at the discretion of the DPW and may include techniques or practices in use and accepted by other jurisdictions, (ie state agencies, municipalities, EPA) that have been demonstrated to have treatment benefits. This may include promising innovative practices (proprietary and non-proprietary) allowing for the continued advancement of the practice.

As part of the 2013 draft NPDES Small MS4 general permit for New Hampshire, the permit requires management of existing stormwater runoff in impaired watersheds. While new development is required to manage stormwater on-site, existing developments may have been constructed before stormwater management was required or modern criteria were established. Retrofits include new installations or upgrades to existing BMPs in developed areas where improved stormwater treatment is needed.

Table 4-2. Matrix of structural nutrient control measures by land use

CATEGORY		COVER TYPE	STRUCTURAL NUTRIENT MANAGEMENT MEASURES									
			Wet Pond	Gravel Wetland	Subsurface Infiltration	Sand Filter	Biofiltration	High Efficiency Biofiltration	Tree Pits	Raingarden	Dry Well	Permeable Pavement
LAND USE	Residential	Pervious						●		●	●	
		Impervious						●		●	●	
		Roof						●		●	●	
	Residential Subdivision	Pervious					●	●				
		Impervious					●	●				●
		Roof					●	●			●	
	Commercial/ Industrial/ Institutional	Pervious	●	●	●	●	●	●	●			
		Impervious	●	●	●	●	●	●	●			●
		Roof			●		●	●			●	
	Road/ Freeway	Impervious	●	●			●					
	Outdoor/ Other Urban Land	Pervious		●	●	●	●	●	●			
		Impervious		●	●	●	●	●	●			●

4.3.1 Municipal/Commercial/Industrial/Institutional Strategies

The following management strategies in the municipal, commercial, industrial, and institutional sectors were used to manage both roof tops, impervious surfaces and pervious surfaces and include: dry wells, subsurface infiltration, wet ponds, gravel wetlands, porous pavements, biofiltration, and high efficiency bioretention

.

4.3.2 Residential Strategies

In residential areas raingardens, dry wells, gravel wetlands, and porous pavements were identified as the primary strategies. A valuable resource for homeowners includes the *New Hampshire Homeowner's Guide to Stormwater Management, Do-It-Yourself Stormwater Solutions for Your Home (NHDES 2001)*, which provides information on the common causes of stormwater problems and their effects and fact sheets for structural controls that residential homeowners can install to mitigate the effects of stormwater.

NHDES has a program called "Soak up the Rain" which will provide resources for residential homeowners interested in installing LID.


YOUR LAND
YOUR WATER
YOUR SOLUTION

Soak up the Rain

What is Stormwater?

Stormwater runoff is water from rain or melting snow that doesn't soak into the ground. In a forest, meadow, or other natural area, stormwater soaks into the ground and naturally filters through the soil.

When forests and meadows are developed, they are replaced with neighborhoods, shopping centers, and other areas that introduce impervious surfaces such as roofs, roads, parking lots, and driveways.

Impervious surfaces prevent rain or melting snow from soaking into the ground. This creates excess stormwater runoff and stormwater pollution.

Why is Stormwater a Problem?

Excess stormwater runoff and the pollutants that it carries can cause many different problems including flooding, erosion, and water pollution. This can make the water unhealthy for fish and other animals to live in and unsafe for us to swim and play in.

What is Soak up the rain NH ?

Soak up the Rain (SOAK) New Hampshire is a voluntary program with the goal of protecting and restoring clean water in our local lakes, ponds, streams, rivers, and estuaries.

Working with local organizations, SOAK assists home and property owners to:

- Determine if a property is creating stormwater runoff that may be impacting nearby surface waters.
- Make recommendations and a plan for simple improvements including low-cost, do-it-yourself stormwater practices like the ones described in the *New Hampshire Homeowner's Guide to Stormwater Management.*

Pollution in stormwater is the primary cause of water contamination in New Hampshire

All of our homes have the potential to create stormwater runoff. This is because roofs, driveways, and even lawns can prevent rain water from soaking into the ground. The New Hampshire Homeowner's Guide to Stormwater Management was created for homeowners to learn the simple things that can be done to reduce the impacts of stormwater from our homes, while improving our properties at the same time.

Simple activities such as picking up pet waste, minimizing fertilizer use, and maintaining septic systems can reduce water pollution. Do-it-yourself stormwater practices like rain barrels, dry wells, infiltration trenches, and rain gardens can be built to further protect clean and healthy water.

Find out more about how you can soak up the rain at www.soaknh.org.

Want to Learn More?
Find out more about how you can soak up the rain at:
www.soaknh.org
or email jillian.mccarthy@des.nh.gov

A Program of
New Hampshire Department of Environmental Services

Photo source: Think Blue Maine

Figure 4-4. Residential Educational Brochure

4.3.3 Septic System Strategies

Prior to 1967, onsite septic systems were installed without regulatory guidelines or governing restrictions. Before the standards were developed by the Department of Environmental Services (DES), many systems were not installed properly, maintained, or adequately documented. Failing subsurface septic systems exhibit foul odors, wastewater backup, and contribute largely to non-point source pollution of nitrogen and phosphorus. These discharges can be decreased through the implementation of advanced and innovative reduction technologies. Advanced and innovative treatment systems differ from conventional septic systems because they incorporate an additional treatment step to further the removal of nitrogen.

4.3.4 Agriculture Strategies

Nitrogen is one of the most important crop inputs; yet, it is also one of the most complex. It is susceptible to environmental losses, and its effectiveness is impacted by soil types and weather. Feasible and widely used agricultural BMPs identified by stakeholders include slow release fertilizer and the use of cover crops. Slow release fertilizer recommended by UNH Cooperative Extension contains at least 15% of the fertilizer to be of a reduced water solubility that allows the gradual release and uptake of nitrogen and phosphorous which in turn reduces excess nutrient washoff. (https://extension.unh.edu/resources/files/Resource000494_Rep516.pdf)

Cover crops are one of the most valuable management practices available for protecting water quality, especially groundwater quality, from non-point sources of soluble nutrients like nitrate nitrogen. Cover crops reduce soil erosion in several ways. They protect the soil surface from raindrop impact, increase water infiltration, trap and secure crop residues, improve soil aggregate stability and provide a network of roots which protect soil from flowing water (USDA, 2013).

4.3.5 Street Sweeping

Figure 4-5. Trash from street sweeper being dumped. (Source: Chesapeake Stormwater Network)

Frequent street sweeping of the dirtiest roads and parking lots within a community can be an effective strategy to pick up nutrients and sediments from street surfaces before they can be washed off in stormwater runoff (Chesapeake Stormwater Network, 2015). Under the draft NH MS4 permit (EPA, 2013), increases in the frequency of street sweeping and catch basin cleaning were included and protocols for proper disposal of street sweeping and catch basin refuse. Street sweeping and catch basin cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with MS4 permits. For the purposes of WISE, street sweeping and catch basin cleaning was assumed to be completed bi-weekly to maximize reduction of particulates along roadways.

4.3.6 Disconnect, Distribute and Decentralize Impervious Cover

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed impervious area is correlated with a number of negative impacts on our water resources such as increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater (Center for Watershed Protection, 2003).

The amount of runoff and associated pollutants from a project can be reduced by disconnecting impervious surfaces. Disconnection of rooftop down spouts and impervious cover are common practices. Disconnection of impervious surfaces increases the amount of EIC on a site, which allows for filtering and infiltration prior to discharging to the receiving water.

The draft NPDES Small MS4 permits for New Hampshire require regulated communities to estimate the number of acres of impervious area (IA) and directly connected impervious area (DCIA) that have been added or removed each year due to development, redevelopment, and or retrofitting activities.

Why Quantify Your IA & DCIA?

New construction, redevelopment, and restoration activities can change existing IA and DCIA – potentially exacerbating or reducing existing watershed impairments. Understanding watershed imperviousness is important for communities because it:

- Informs management of impaired waterbodies and prioritization of watershed restoration efforts;
- Facilitates investigation of existing chronic flooding and stormwater drainage problems, and avoidance of new problems;
- Indicates potential threats to drinking water reservoirs/aquifers; commercial fisheries, and recreational waters;
- Demonstrates progress toward achieving future **Total Maximum Daily Load (TMDL)** allocations based on impervious cover thresholds;
- Serves as an educational tool for encouraging environmentally sensitive land use planning and **Low Impact Development (LID)**;
- Facilitates equitable derivation of possible stormwater utility fees based on parcel-specific impervious cover; and
- Provides guidance for stormwater retrofit efforts.

Figure 4-6. Impervious Cover Facts (Source: EPA, 2014)

4.3.7 Protection of Sensitive Areas and Valuable Resources/LID Planning

Buffers and riparian corridors are vegetated ecosystems along a waterbody that serve to protect the waterbody from the effects of runoff by providing water quality filtering, bank stability, recharge, rate attenuation and volume reduction, and shading of the waterbody by vegetation (Audubon et.al, 1997). Riparian corridors also provide habitat and may include streambanks, wetlands, floodplains, and transitional areas.

To minimize stormwater impacts, new and re-development projects should avoid affecting or encroaching upon areas with important natural stormwater functional values (floodplains, wetlands, riparian areas, drainage ways and buffers) and with stormwater impact sensitivities (steep slopes, adjoining properties, others) wherever practicable. Development should not occur in areas where sensitive resources exist so that their valuable natural functions are not lost and increasing stormwater impacts.

4.4 Cost and Performance Comparison of Management Scenarios

One of the most significant challenge in management of nutrients for communities is balancing competing resource needs. Some cost estimates developed in light of pending requirements total hundreds of millions of dollars. As part of the Integrated Plan management scenarios were evaluated for both the implementation cost and the water quality load reduction to identify both a range of strategies and an implementation schedule that would be feasible. An essential element of this is the application of nutrient control measures in a manner that prioritizes and applies those with the greatest cost benefit first. To accomplish this management scenarios were evaluated over a range of permitting scenarios to determine cost to implement wastewater upgrades and non-point source controls and assessed for unit cost performance in terms of cost per nitrogen reduction.

Comparisons for the range of management scenarios identified strategies which achieve the greatest benefit for the lowest cost. Using a present worth analysis, annual costs were developed associated with debt service for wastewater and nonpoint source management.

When comparing and evaluating the management scenarios the following list of assumptions were used:

- Operating the WWTF at 3 mg/L or sending the wastewater load to the regional treatment facility does not eliminate the needs for long-term implementation of non-point source controls to satisfy the obligations under the Administrative Order of Consent and the MS4 general permit.
- Under the MS4 program, non-point source controls implemented under the integrated planning scenarios (both IP and EX) can be credited towards meeting Minimum Measure 5: Post-Construction Stormwater Management.
- The use of flexible sizing of structural management measures (i.e., capture depth range of 0.25 to 1.50 inches) can be achieved through an Integrated Planning (IP and EX) scenario. Whereas, under the traditional permitting scenarios, a fixed capture depth of 1.0 inch is used, in accordance with the NH Stormwater Manual.
- Maximum extent practicable is the most cost effective mix of nutrient management measures, including wastewater treatment, non-point source controls and stormwater controls, with flexible sizing over a range of specific land uses.
- Total cost includes capitol cost and operation and maintenance.
- A present worth analysis was conducted for NPS assuming a 2% discount rate and a 50-year present worth implemented over a 30-year schedule. NPS operations and maintenance costs were conservatively estimated to be 5% of the capital cost annually.
- Costs associated with wastewater capital and operations and maintenance were from Wright Pierce (2014) and Kleinfelder (2012).

4.4.1 Cost and Load by Subwatershed for Nutrient Management Scenarios

The management scenarios, presented in Section 4.1, were compared to determine the most cost-effective scenario for managing receiving water load from the three towns and the watershed as a whole. Presented in Table 4-3 are the management scenarios ranked by unit performance based on total 50-year present worth cost and the receiving water total annual load. All the management scenarios trend towards a receiving water load target of 88 tons per year however none achieve that goal. As mentioned previously, the 3 communities cannot achieve the load target without participation from the upper watershed. The scenarios examined achieve between 53% (EX-3) and 74% (T-RO) load reduction.

The total annual receiving water load ranges from 114 tons per year up to 133 tons per year, with the greatest reduction representing the regional outfall (T-RO) with the highest cost to implement at $257 million or $3.75 million per ton of nitrogen reduced (68 tons and 74% reduction). The most cost effective scenario is IP-3/5/8 which phases in wastewater treatment and implements NPS control measures over 2000 acres over 6 permit cycles throughout the subwatershed. This scenario has an annual receiving water load of 126 tons per year (56 tons and 60% reduction) and a total 50-year present worth cost of $105 million or $1.88 million per ton reduced.

The least expensive scenario is EX-5 which has a total 50-year present worth cost of $97.6 million or $1.99 million per ton reduced and an annual receiving water load of 133 tons (49 tons and 53% reduction). This scenario considers only the Town of Exeter and does not include potential WWTF upgrades in Newfields, a wastewater district Stratham or non-point source controls in either of the towns.

Figure 4-7 presents the management scenarios with the relative sources (wastewater, NPS, upper watershed) compared to a baseline watershed load and a pristine (undeveloped) watershed load. The baseline watershed load represents the current condition of the entire watershed including the three towns in the subwatershed and the communities in the Upper Exeter River watershed. The dashed line on the figure represents the receiving water quality load target of 88 tons per year to support eelgrass habitat. The pristine annual load represents the undeveloped watershed condition before human impacts. It can be seen that the three towns alone do not have the ability to reduce the nitrogen load to meet the receiving water quality load target to support eelgrass habitat. The management scenarios evaluated have the potential to provide 53% to 74% reduction in the subwatershed load. from the three towns. As presented in Figure 4-7, the upper watershed load contributes 89 tons per year of nitrogen to the estuary of which a 42% reduction (38 tons) would be required to meet the load target.

Table 4-3. Ranked comparison of scenario unit performance ($$/Ton)

Management Scenario	WWTF Discharge (mg/L)	Wastewater Management District	Wastewater Load (tons N/yr)	NPS Load (tons N/yr)	Load from Upper Exeter R. Watershed (tons N/yr)	Total Load (Tons N/yr)	Cost (Total PV: Capital + O&M, 50 yrs) ($M)	$M/Ton Reduced
IP-3/5/8	Phased from 8 to 5 to 3	YES	10	27	89	126	$105.0	$1.88
EX-5	5	NO	13	31	89	133	$97.60	$1.99
IP-5	5	NO	13	27	89	129	$104.9	$1.99
EX-3	3	NO	8	31	89	128	$112.70	$2.08
IP-3	3	YES	10	27	89	126	$126.4	$2.27
IP-RO	<1	YES	3	27	89	119	$150.6	$2.40
T-3	3	NO	8	22	89	119	$226.80	$3.61
T-5	5	NO	13	22	89	125	$211.30	$3.68
T-RO	<1	NO	3	22	89	114	$257.0	$3.75

Table 4-4 and Figure 4-8 present the management scenario total present value cost broken down by capital cost and operation and maintenance cost for the wastewater treatment facility and non-point source management measures.

Table 4-4. Total 50-Yr Present Value Cost by Subwatershed-Scale

MANAGEMENT SCENARIO	ANNUAL TOTAL LOAD TO RIVER (TONS)	TOTAL COST PV ($M)	WWTF PV CAPITAL COST ($M)	WWTF O&M COST ($M)	NPS CAPITAL COST ($M)	NPS O&M COST ($M)
EX-5	133.1	$97.6	$40.0	$49.0	$4.1	$4.4
IP-5	129.4	$104.9	$41.0	$50.3	$6.6	$7.1
EX-3	127.9	$112.7	$46.0	$58.1	$4.1	$4.4
IP-3	126.4	$126.4	$52.6	$60.2	$6.6	$7.1
IP-3,5,8	126.4	$105.0	$43.8	$47.6	$6.6	$7.1
T-5	124.8	$209.1	$40.0	$49.0	$57.9	$62.1
T-3	119.4	$226.8	$47.2	$59.6	$57.9	$62.1
IP-RO	119.4	$150.6	$48.1	$88.9	$6.6	$7.1

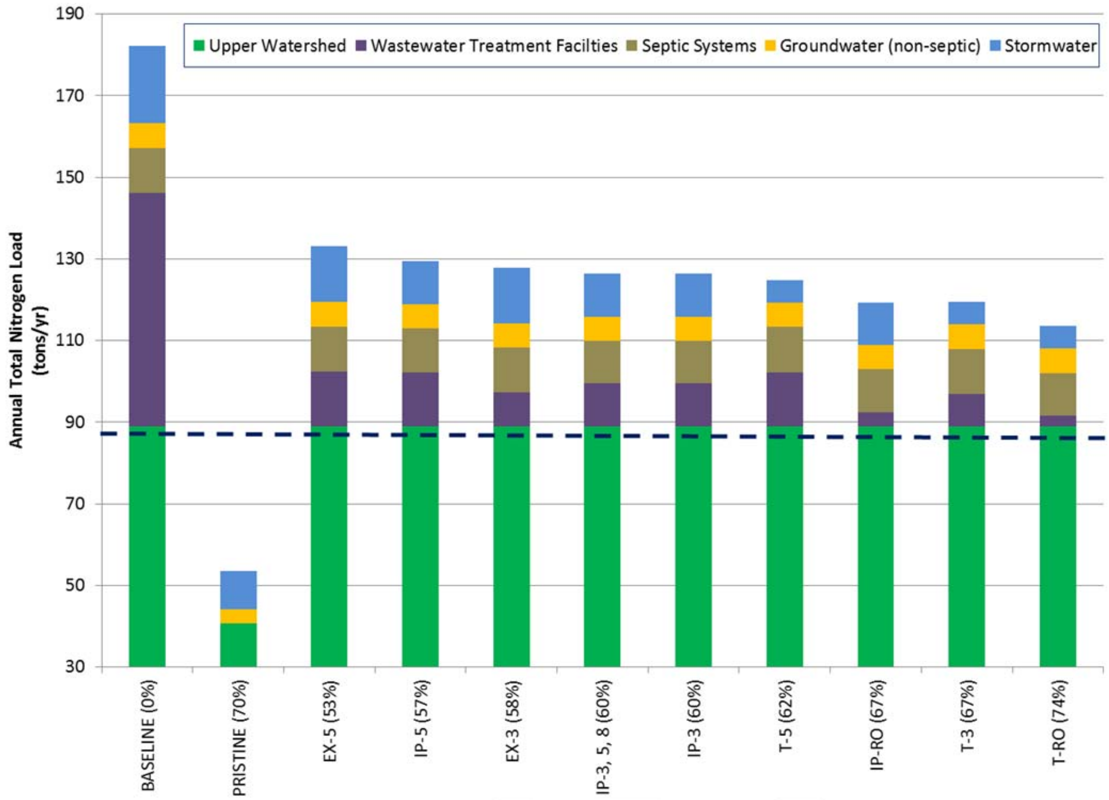


Figure 4-7. Ranked scenario by annual load reduction (% reduction relative to subwatershed load)

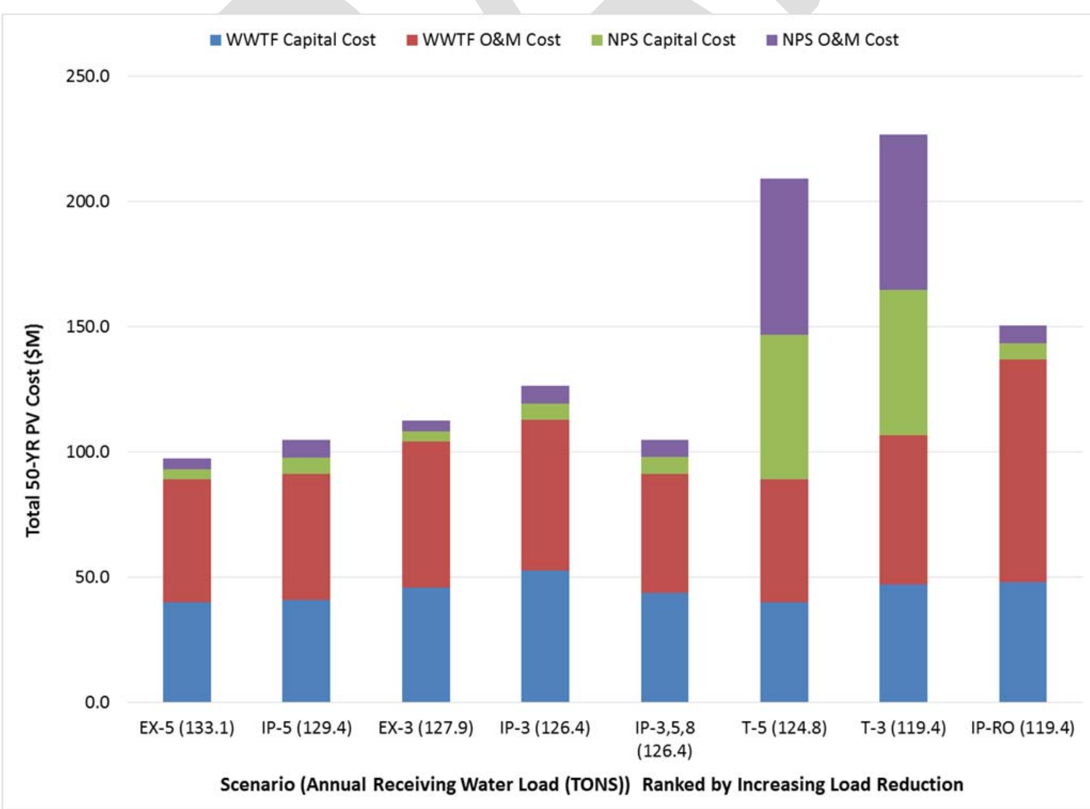


Figure 4-8. Ranked scenarios total PV cost (capital and O&M) for NPS and WW

4.4.2 Cost by Town for Nutrient Management Scenarios

To provide a better understanding of the total cost for municipal planning and decisions making, the management scenario total present value cost was divided up by Town for total cost, capital cost and operation and maintenance cost. Further, the cost is subdivided by implementation costs anticipated to be incurred by private (i.e., commercial, industrial, residential) property owners and by the municipal sector (i.e., roads, parks, municipal buildings) based on estimated area for which the municipality will likely be required to manage. With this approach the total cost of NPS management is covered by the land uses which generate stormwater runoff, both private and municipal sector. The approach assumes that the expenses would be part of the redevelopment cycle as with any code and modernization requirements with which owners and operators are familiar. This type of planning would require revisions to any existing stormwater ordinances and regulations, to require management of nitrogen for new and redevelopment including municipal capital improvement projects that impact stormwater management.

4.4.2.1 Cost Comparison for Town of Exeter

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Exeter is from $94 to $178 million (Table 4-5). The estimated annual cost per year for the Town of Exeter ranges from $3.13 to $5.93 dollars inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for both wastewater treatment and non-point source controls.

All of the management scenarios presented in Table 4-5, with the exception of T-3, use integrated planning with the use of NPS management to the maximum extent practicable through an optimization approach. The T-3 scenario does not include an optimization approach and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are 90% more ($65.3 million), significantly increasing the cost for implementation of this scenario.

Table 4-5. Total 50-Yr Present Value Cost by Scenario for Exeter Individually

Management Scenario	WWTF Total Cost ($M, 50-YR PV)	NPS Total Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Average Annual Implementation Cost ($M, 50-YR PV)
IP-3,5,8	$85.5	$8.6	$94.0	$3.13
IP-5	$89.0	$8.6	$97.6	$3.25
IP-3	$104.1	$8.6	$112.7	$3.76
IP-RO	$121.7	$8.6	$130.3	$4.35
EX-3	$104.1	$8.6	$112.7	$3.76
T-3	$104.1	$73.9	$178.0	$5.93

Presented in Table 4-6 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 50% of the total implementation cost for the management measures. The same is generally true for the wastewater operation and maintenance costs with the exception of the regional outfall scenario, which represents 64% of the total wastewater cost.

Table 4-6. Total 50-Yr Present Value Capital and Operation & Maintenance Cost by Scenario for Exeter Individually

Management Scenarios	WWTF Capital Cost ($M, 50-YR PV)	WWTF O&M Cost ($M, 50-YR PV)	NPS Capital Cost ($M, 50-YR PV)	NPS O&M Cost ($M, 50-YR PV)
IP-3,5,8	$39.5	$46.0	$4.2	$4.4
IP-5	$40.0	$49.0	$4.2	$4.4
IP-3	$46.0	$58.1	$4.2	$4.4
IP-RO	$42.8	$79.0	$4.2	$4.4
EX-3	$46.0	$58.1	$4.2	$4.4
T-3	$46.0	$58.1	$35.2	$38.7

Table 4-7. Total Annual NPS Present Value Cost over 30-Year Plan for Exeter

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3,5,8	$0.285	$0.163	$0.122
IP-5	$0.285	$0.163	$0.122
IP-3	$0.285	$0.163	$0.122
IP-RO	$0.285	$0.163	$0.122
EX-3	$0.285	$0.163	$0.122
T-3	$2.463	$0.816	$1.648

Presented in Table 4-7 are the annual non-point source implementation costs for each of the management scenarios. The proposed integrated planning alternatives (IP and EX management scenarios) have an annual NPS cost of $285,000 for the Town of Exeter (Table 4-7). Based on the results from the optimization model, $163,000 or 57% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $4.89 million over 30-years. An additional $122,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $3.66 million over a 30-year period. Based on the traditional permit scenario (T-3) the Town of Exeter is expected to have an annual $2.46 million cost for implementation and operation and maintenance of non-point source controls, with an expected $816,000 incurred by the municipality and an additional $1.65 million covered by the private sector.

Currently the Town of Exeter has an annual stormwater management budget of $25,000. Under the integrated planning scenarios, the Town's stormwater management budget would increase by 6.5 times the current budget, to meet the non-point source implementation at the maximum extent practicable rate. The traditional permitting alternative would be nearly an increase of 33.6 times the current stormwater budget, which in general terms is not financially feasible or practicable. Therefore, for the Town of Exeter the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

4.4.2.2 Cost Comparison for Town of Stratham

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Stratham is from $3.7 to $35.1 million (Table 4-8). The estimated annual cost per year for the Town of Stratham ranges from $125,000 to $1.17 million inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for wastewater treatment and non-point source controls.

All of the management scenarios presented in, with the exception of T-3, use integrated planning with the use of NPS management to the maximum extent practicable through an optimization approach. The T-3 scenario does not include an optimization approach and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are greater than 80% more ($31.4 million), significantly increasing the cost for implementation of this scenario. Scenarios IP-5 and T-3 do not have wastewater treatment costs as it is assumed that Stratham would continue to operate with septic systems only for these scenarios.

Table 4-8. Total 50-Yr Present Value Cost by Scenario for Stratham

Management Scenario	WWTF Cost ($M, 50-YR PV)	NPS Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Average Annual Implementation Cost ($M, 50-YR PV)
IP-3,5,8	$3.26	$3.7	$7.0	$0.233
IP-5	-	$3.7	$3.7	$0.125
IP-3	$6.0	$3.7	$9.7	$0.323
IP-RO	$12.2	$3.7	$15.9	$0.530
T-3	-	$35.1	$35.1	$1.17

Presented in Table 4-9 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 52% of the total implementation cost for the management measures. The operation and maintenance for the wastewater connection operation and maintenance costs represents 10% of the total wastewater cost.

Table 4-9. Total 50-Yr Present Value Capitol and Operation & Maintenance Cost by Scenario for Stratham

SCENARIO	WWTF CAPITAL COST ($M, 50-YR PV)	WWTF O&M COST ($M, 50-YR PV)	NPS CAPITAL COST ($M, 50-YR PV)	NPS O&M COST ($M, 50-YR PV)
IP-3,5,8	$3.1	$0.2	$1.8	$1.93
IP-5	-	-	$1.80	$1.93
IP-3	$5.5	$0.6	$1.80	$1.93
IP-RO	$4.3	$7.9	$1.80	$1.93
T-3			$16.93	$18.15

Table 4-10. Total Annual NPS Present Value Cost over 30-Year Plan for Stratham

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3,5,8	$0.125	$0.065	$0.060
IP-5	$0.125	$0.065	$0.060
IP-3	$0.125	$0.065	$0.060
IP-RO	$0.125	$0.065	$0.060
T-3	$1.17	$0.605	$0.564

Presented in Table 4-10 are the annual non-point source implementation costs separated by municipal and private sector expense for each of the management scenarios. The proposed integrated planning alternatives (IP) have an annual NPS cost of $125,000 for the Town of Stratham. Based on the results from the optimization model, $65,000 or 52% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $1.95 million over 30-years. An additional $60,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $1.8 million over a 30-year period. Based on the traditional permit scenario (T-3) the Town of Stratham is expected to have an annual $1.17 million cost for implementation and operation and maintenance of non-point source controls, with an expected $605,000 incurred by the municipality and an additional $564,000 million covered by the private sector.

Currently the Town of Stratham does not have an annual stormwater management budget, as they are currently pending receipt of the draft MS4 general permit. Therefore the additional costs associated with the implementation of non-point source controls will be much more favorable under the integrated planning scenarios. The traditional permitting alternative would be nearly an additional increase of 8.3 times the integrated planning amount, which in general terms is not financially feasible or practicable. Therefore, for the Town of Stratham the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

4.4.2.3 Cost Comparison for Town of Newfields

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Newfields are from $3.6 to $13.7 million (Table 4-11). The estimated annual cost per year for the Town of Newfields ranges from $120,000 to $460,000 inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for wastewater treatment and non-point source controls.

All of the management scenarios presented in Table 4-11, with the exception of T-3, use integrated planning with the use of NPS management to the maximum extent practicable through an optimization approach. The T-3 scenario does not include an optimization approach and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are 88% more ($9.7 million), significantly increasing the cost for implementation of this scenario.

Table 4-11. Total 50-Yr Present Value Cost by Scenario for Newfields*

Management Scenario	WWTF Cost* ($M, 50-YR PV)	NPS Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Annual Implementation Cost ($M, 50-YR PV)
IP-3,5,8	$2.6	$1.3	$4.0	$0.13
IP-5	$2.3	$1.3	$3.6	$0.12
IP-3	$2.6	$1.3	$4.0	$0.13
IP-RO	$3.1	$1.3	$4.4	$0.15
T-3	$2.6	$11.0	$13.7	$0.46

* Cost for Newfields wastewater are estimated based on ratios of flow to joining Exeter. Costs for Newfields alone were not available at the time and are assumed to be the same and will need to be updated.

Presented in Table 4-12 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 52% of the total implementation cost for the management measures. The operation and maintenance for the wastewater connection operation and maintenance costs represents 55% of the total wastewater cost.

Presented in Table 4-13 are the annual non-point source implementation costs for each of the management scenarios broken down by municipal and private sector contribution. The proposed integrated planning alternatives (IP) have an annual NPS cost of $44,000 for the Town of Newfields. Based on the results from the optimization model, $23,000 or 52% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $690,000 over 30-years.

Table 4-12. Total 50-Yr Present Value Capitol and Operation & Maintenance Cost by Scenario for Newfields

SCENARIO	WWTF CAPITAL COST* ($M, 50-YR PV)	WWTF O&M COST* ($M, 50-YR PV)	NPS CAPITAL COST ($M, 50-YR PV)	NPS O&M COST ($M, 50-YR PV)
IP-3,5,8	$1.2	$1.5	$0.64	$0.69
IP-5	$1.0	$1.2	$0.64	$0.69
IP-3	$1.2	$1.5	$0.64	$0.69
IP-RO	$1.1	$2.0	$0.64	$0.69
T-3	$1.2	$1.5	$5.33	$5.71

*Cost for Newfields wastewater are estimated based on ratios of flow to joining Exeter. Costs for Newfields alone were not available at the time and are assumed to be the same and will need to be updated. It is presumed that those costs are undervalued for Newfields alone.

Table 4-13. Total Annual NPS Present Value Cost over 30-Year Plan for Newfields

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3,5,8	$0.044	$0.023	$0.021
IP-5	$0.044	$0.023	$0.021
IP-3	$0.044	$0.023	$0.021
IP-RO	$0.044	$0.023	$0.021
T-3	$0.368	$0.190	$0.177

An additional $21,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $630,000 over a 30- year period. Based on the traditional permit scenario (T-3) the Town of Newfields is expected to have an annual $368,000 cost for implementation and operation and maintenance of non-point source controls, with an expected $190,000 incurred by the municipality and an additional $177,000 million covered by the private sector.

Currently the Town of Newfields does not have an annual stormwater management budget, as they received a waiver from the draft MS4 general permit requirements. However, in the future Newfields expects that a waiver may not be granted and therefore the additional costs associated with the implementation of non-point source controls will be much more favorable under the integrated planning scenarios. The traditional permitting alternative would be nearly an additional increase of 7.2 times the integrated planning amount, which in general terms is not financially feasible or practicable. Therefore, for the Town of Newfields the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

4.4.3 Costing of Nutrient Control Measures

To evaluate the cost of each control measure and management scenarios, costing data was collected from typically at minimum 5 sources using local data, design reports and professional judgment (EPA 1999, FB Environmental 2009, Filterra 2011, Herrera 2011, TetraTech 2009, UNHSC 2012, CRWA 2014, Geosyntec 2014) (Appendix 8.1). Costing information varies substantially by area and as such professional judgment was used in the final estimation of the cost range. Cost ranges were scaled based on capture volume. New and redevelopment costs were considered for porous pavements. As such redevelopment costs are total cost while new development costs are a limited cost differential over standard pavement as that would be covered separately. Figure 4-9 presents the cost per pound removed range for the nutrient management strategies evaluated as part of the optimization model. Figure 4-9 presents a single cost for non-structural measures and a cost range, defined by the length of the bar, for structural management measures. The structural practice cost range is defined by the management measure capture depth and the potential for pollutant removal is defined by structural practice type, underlying soil type (i.e., infiltration rate) and land use.

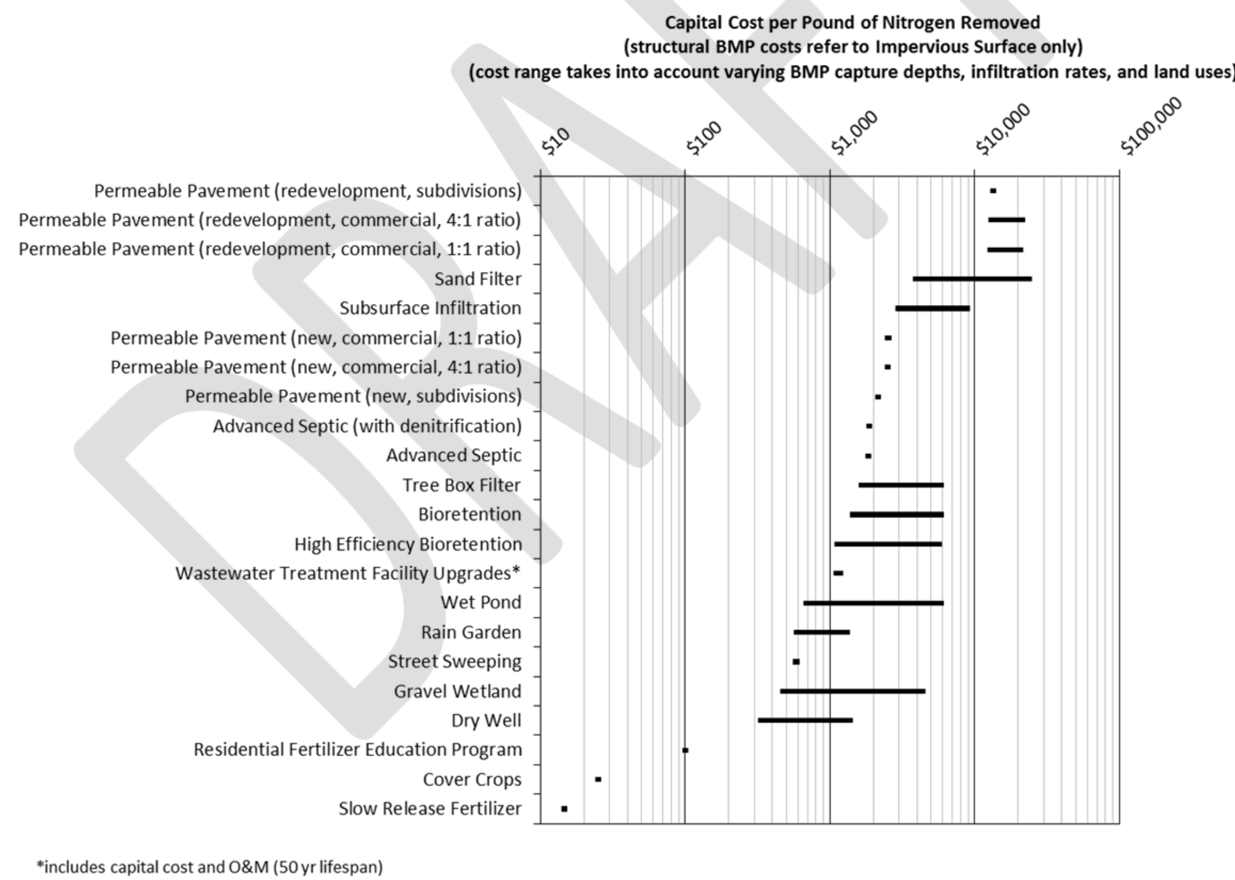


Figure 4-9. Nutrient Management Strategy Capital Cost for Nitrogen Removal

4.5 Recommended Scenario, Preliminary Implementation Plan and Schedule

The recommended alternative for nonpoint source (NPS) and stormwater (SW) management is the integrated planning scenario IP-3/5/8 for the three communities. This scenario achieves a 60% load reduction (56 tons) over a 30 year implementation period with the highest unit cost performance. This would require approximately 67 acres per year treated starting in 2017 with specific target milestones listed in Table 4-14.

Scenario IP-3/5/8 has a phased implementation of both WW and NPS across 6 permit cycles. It begins with 8 mg/L at 2019, transitions to 5 mg/L at 2029, and ends at 3 mg/L by 2042. The extended implementation schedule allows for ecosystem monitoring and adaptive management at each critical stage and for participation by upper watershed communities. The schedule provides approximately 5 years for monitoring at each stage at which point a decision point would occur as whether it is needed to design and build for the next stage over another 5 year period. IP-3/5/8 satisfies elements of both the MS4 and wastewater permits for $105 million which is approximately 50% of the estimated value for individual permitting that assumes no cost sharing of wastewater, and no cost savings in the MS4 achieved by optimization from integrated planning (Table 4-3). IP-3/5/8 is about $7 million less than if Exeter chooses to manage alone. It represents about an 80% reduction in NPS management costs for Stratham and nearly $2.7 million less in wastewater costs. This approach uses combined wastewater at the Exeter wastewater treatment facility for the three communities and least cost mix (MEP) of NPS controls.

The preliminary implementation schedule parallels key milestones in the Exeter Administrative Order on Consent. For the Integrated Plan to receive EPA approval, a formal analyses using established guidance for scheduling by performing a financial capability analyses (FCA) (EPA 2014). An FCA Framework will be conducted to evaluate the impact on residential rate payers using indicators including household income, existing rates and taxes, as well as allowing a flexibility of schedule to be responsive to circumstances unique to a community, while advancing the goal to protect clean water. The schedule will provide metrics and milestones that must be tracked and accounted for and reported in the Annual Report on the Nitrogen Control Plan (NCP).

One of the critical elements of the preliminary schedule is that an extended implementation period makes use of the private sector redevelopment cycle. Specifically as redevelopment occurs enhanced stormwater management measures will be required due to revised municipal stormwater regulations. The revised stormwater regulations will require management of nitrogen for new and redevelopment including municipal capital improvement projects that impact stormwater management. As an example, in Exeter approximately 50% of the improvements would occur in the private sector. The municipal areas are associated with management of NPS for municipally owned and managed land such as parks, schools, roads, municipal offices, and the impervious areas in the urban center typically managed by the municipality. With this approach the total cost of NPS management is covered by the land uses that generate stormwater runoff, both municipal and private sector.

Table 4-14. Preliminary Implementation Schedule and Key Milestones

YEAR	WWTF GOALS	NPS/SW LOAD REDUCTION (TONS)	NPS/SW AREA TREATED (ACRES)	CUMULATIVE LOAD REDUCTION (TONS)	COST ($M)
2016	Design for 8 mg/L	Begin MEP implementation	0	0	$0.5
2019	Operate at 8 mg/L	0.85	200	36.9	$37.3
2023	Design for 5 mg/L	1.98	467	38.0	$45.9
2029	Operate at 5 mg/L	3.68	867	47.6	$61.9
2039	Design for 3 mg/L	6.52	1533	50.4	$83.3
2044	Operate at 3 mg/L	7.93	1867	55.2	$100.6
2046	Operate at 3mg/L, Stratham WW District	8.50 Complete	2000	55.8	$105.0

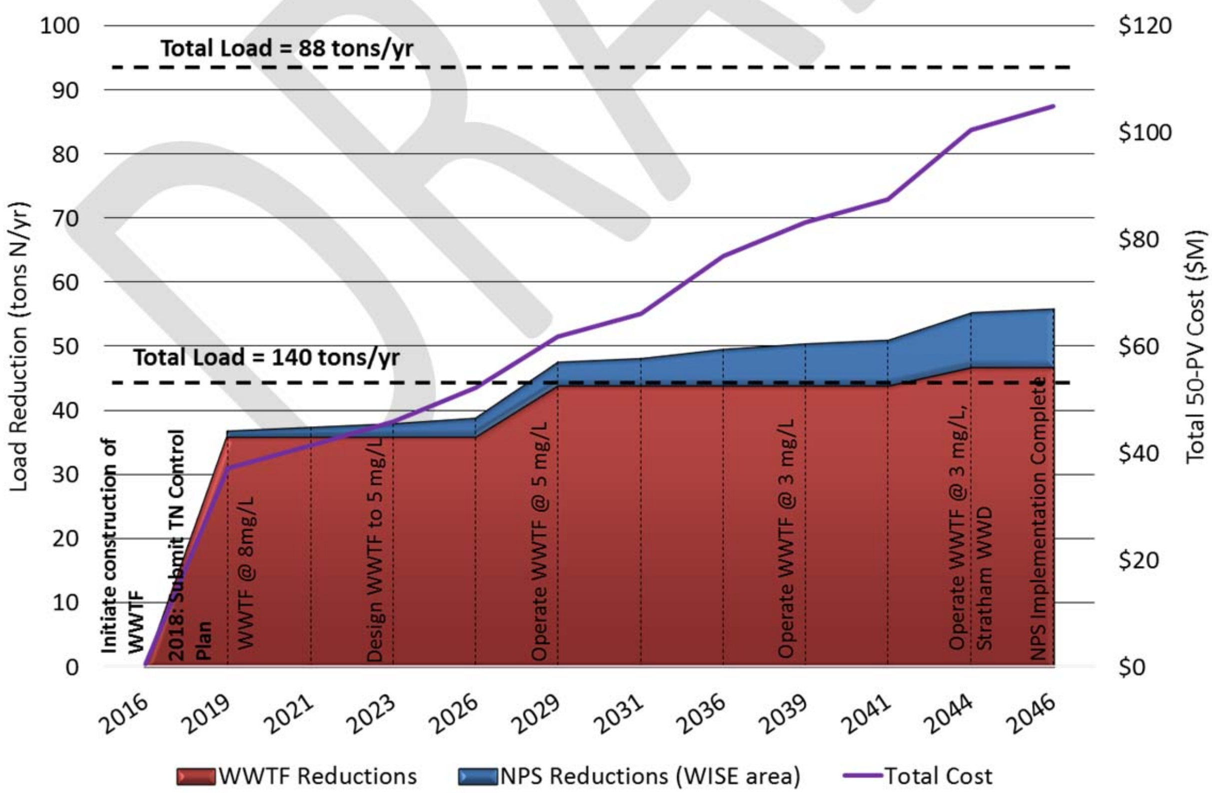


Figure 4-10. Preliminary Implementation Schedule and Key Milestones

4.5.1 Source Areas Identified for Stormwater Management and Retrofit

To achieve the targeted load reduction source areas have been identified that will have the greatest benefit for stormwater management and retrofitting with nutrient control measures. Table 4-15 presents the recommended least cost mix of nutrient management measures selected from the optimization model. Specific land use area targets, nitrogen control measures, and capture depths are presented along with available acreage for tracking purposes. The measures, both structural and non-structural, target a wide variety of land uses and if implemented would provide 17,000 lbs (8.5 tons) of nitrogen removal from 2,000 acres of developed land in the subwatershed. Over a 30 year period approximately 67 acres per year will need to be treated across the three towns, with about half due to redevelopment. The structural measures selected are sized to treat a capture depth or water quality volume equivalent to 0.25-0.5 inches, which is more cost effective than sizing and constructing larger structural measures as the largest pollutant load is typically in the "first flush" of a storm event.

For example, proposed future developments that apply for Town building permits should be directed to use the recommendations below for determining which practices should be considered for their projects. It is in the best interest of the project applicants to follow the recommendations as they represent cost savings that can be achieved when compared with other practices.

Town staff will be Stormwater management is often opportunistic and may not be implemented based on the recommendations below. The recommendations represent the lowest cost alternative which need not be strictly adhered to. Tracking and accounting of retrofit implementation over time will enable adaptive management of the various nutrient control strategies and adjust practices as necessary.

A detailed Implementation Plan with specific details as to location and timing of nitrogen control practices will need to be developed for this Plan to fulfill the AOC requirements and receive EPA approval.

Table 4-15. Proposed Target Areas for Retrofit and Management Listed by Land-Use Use, Area and Water Quality Volume Treated; Total Present Value of NPS Management (including O&M): $13.6 M, Total Load Reduction from NPS Management: 17,000 lb N/yr, Total Acres Treated: 2,000 acres

BMP TYPE	SIZE	LAND USE	COVER	ACRES TREATED	ACRES AVAILABLE	%
Cover Crops	-	Agriculture	-	28	28	100%
Slow Release Fertilizer Program	-	Agriculture	-	253	253	100%
Gravel Wetland	0.25	Commercial	Impervious	104	144	72%
High Efficiency Bioretention	0.25	Commercial	Impervious	29	144	20%
Subsurface Infiltration	0.25	Commercial	Impervious	12	144	8%
Dry Well	0.25	Commercial	Roof	36	36	100%
Gravel Wetland	0.25	Industrial	Impervious	47	47	100%
Dry Well	0.25	Industrial	Roof	25	25	100%
Gravel Wetland	0.25	Institutional	Impervious	94	113	83%
High Efficiency Bioretention	0.25	Institutional	Impervious	19	113	17%
Dry Well	0.25	Institutional	Roof	39	39	100%
Gravel Wetland	0.25	Outdoor and Other Built-up Land	Impervious	30	30	99%
Raingarden	0.25	Residential	Impervious	300	369	81%
Raingarden	0.5	Residential	Impervious	69	369	19%
Dry Well	0.25	Residential	Roof	252	252	100%
Lawn Fertilizer Program	-	Residential	-	-	-	-
Bioretention	0.25	Road	Impervious	112	658	17%
Gravel Wetland	0.25	Road	Impervious	546	658	83%
Street Sweeping Program	-	Road	Impervious	658	658	100%

4.5.2 Guidance for Developing an Implementation Schedule

Scheduling approaches include guidance for CSO management, Integrated Planning, and MS4 implementation.

- Wastewater scheduling typically follows the FCA analysis. "Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development" (FCA Guidance) (EPA 832-B-97-004)
- Integrated planning is using similar info FCA Framework 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements (EPA, 2014)
- MS4 implementation for NH currently does not indicate a specific implementation schedule. No minimum period for an implementation schedule for Post Construction Stormwater Management (Minimum Measure 5) is currently required in the 2013 Draft NH MS4 General Permit. We have heard from EPA in the public forum that an extended period of time will be allowable.
- Similarly, EPA Headquarters, and Region 1 Leadership spoke at the September 2013 NACWA Integrated Planning Workshop in Portsmouth, NH, that extended implementation periods similar to CSO implementation are conceivable in the range of 4 or more permit cycle period. Environmental Monitoring

4.6 Long-Term Operations and Maintenance

To ensure long-term protection of water quality and the effectiveness of best management practices (BMPs), regular inspections and maintenance is necessary. Generally, inspection and maintenance falls into two categories: expected routine maintenance and non-routine (repair) maintenance. Routine maintenance is performed regularly to maintain both aesthetics and their good working order. Routine inspection and maintenance helps prevent potential nuisances (odors, mosquitoes, weeds, etc.), reduces the need for repair maintenance, and insures long term performance.

Under the EPA MS4 Phase II rules, owners and operators of small MS4 facilities are responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions. The rules recommend that all stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity. In addition to regularly scheduled inspections, all BMPs should be checked after each storm event. Scheduled inspections will vary among BMPs. Structural BMPs such as storm drain drop inlet protection may require more frequent inspection to ensure proper operation.

5. MONITORING AND TRACKING AND ACCOUNTING

5.1 Monitoring

This Plan proposes options for monitoring necessary not only to ensure specific legal requirements for tracking management measures and load allocations are met, but also to meet public goals and expectations for environmental quality at targeted locations of interest to residents and managers. The Plan includes monitoring of nutrient concentrations and loads and biological response indicators (e.g., algae). This monitoring strategy will provide an assessment of current conditions and progress towards targets and overall goals. To meet the objective of a monitoring program with enough information to detect changes in water quality and ecosystem improvements in an affordable way, we recommend municipalities take advantage of existing monitoring efforts. This will inform the adaptive management process and the ongoing nutrient control strategies.

5.1.1 Monitoring Objectives

The goal of this monitoring plan is to provide advice and guidance for municipalities to develop an effective monitoring plan. The key is to obtain accurate and informative data across the area of interest over an extended period of time that meets regulatory requirements, assure management goals are being attained, evaluate ecosystem condition, and equitably allocate pollutant loads.

Specific objectives are to:

- Meet existing and expected regulatory requirements associated with discharge from wastewater treatment plants, and expected requirements under a draft MS4 permit;
- Estimate loads from existing sources to prioritize management strategies, allocate responsibility and validate models;
- Support and improve integrated watershed understanding of human-caused ecosystem impacts and their solutions in the Exeter and Squamscott Rivers and Great Bay;

- Support adaptive management opportunities that help ensure cost-effective and productive management strategies and accountability; and
- Support interactive tracking and assessment and potentially provide a framework for "trading" of reduction credits.

5.1.2 Point Source Monitoring

5.1.2.1 MS4 Outfall Monitoring and Interconnection Screening and Sampling

The final Municipal Separate Storm Sewer System (MS4) permit may require outfall monitoring at locations required to meet programmatic requirements including the Illicit Discharge Detection and Elimination (IDDE) program. IDDE screening shall include collection of grab samples and their analysis for *E. coli* (a bacterial indicator for freshwater receiving waters) or enterococcus (an indicator for saline or brackish receiving waters), or some other accepted surrogate indicated of wastewater. These items are being explored to improve the simplicity of initial screening efforts.

Screening and sampling tests for interconnections are required under the IDDE program. IDDE programs must include written procedures for screening and sampling of outfalls and interconnections in the MS4 during dry and wet weather conditions to provide evidence of illicit discharges and sanitary sewer overflows (SSOs). This screening procedure is used for baseline outfall and interconnection screening, confirmatory screenings, and follow-up screening to maintain an inventory of problems and their status.

More detailed discussion of sampling requirements under each of these components is included in Appendix 8.4.

5.1.2.2 WWTF Outfall Monitoring

NPDES permits contain specific requirements for effluent monitoring of wastewater treatment facilities (WWTF) for compliance with permit conditions, and often broader, supplementary monitoring requirements, usually negotiated in the permit writing process or added as a consent agreement that demonstrate progress towards meeting water quality goals. Effluent monitoring is generally prescriptive as to parameters, frequency and methodology, continues for the life of the permit and is technically and legally sufficient to assess compliance with defined discharge criteria and limits. Beyond compliance verification use, any required demonstration of progress towards receiving water goals will likely require a combination of targeted monitoring and administrative tracking of implementation actions.

The new Exeter WWTF permit and associated Administrative Order on Consent (AOC) requires effluent monitoring of total nitrogen at a prescribed frequency "…from March 1, 2013 until June 30, 2019 or until 12 months after substantial completion…" of the Exeter WWTF, whichever is sooner. This provides documented evidence that the Town of Exeter is complying with their interim total nitrogen effluent limit supported by the monitoring requirements outlined in Appendix 8.4. After June 30, 2019 (or 12 months after completion of construction), the average monthly effluent concentrations may not exceed 8 mg TN/L between April 1 and October 31.

5.1.2.3 Squamscott River Monitoring Program

Receiving water monitoring in the Squamscott River (the estuarine portion of the Squamscott-Exeter River system) will document progress required under the Exeter AOC and provide support for adaptive management objectives. The AOC requires the permitee to evaluate and document, with monitoring and administrative tracking, progress towards meeting nitrogen load allocations and attaining water quality goals for aquatic life use support in the estuary, including areas in Great Bay. All source reduction must be documented by monitoring at key locations that will demonstrate the success of collective point, stormwater and nonpoint source management measures (e.g. WWTF upgrade, stormwater control, septic upgrades, buffer implementation etc.). Water quality will also be monitored in the tidal Squamscott and downstream into Great Bay using field chemistry for conventional parameters (e.g., temperature, dissolved oxygen, salinity) and bench chemistry analyses for chemical analytes including nutrients. The AOC further requires that ecological indicators be monitored to assure that progress towards attaining the relevant designated use goal of aquatic life use support is made. Among the indicators required by the AOC are nutrient concentrations, chlorphyll-*a*, macroalgae, and dissolved oxygen but as part of the WISE project the use of other indicators of nutrient enrichment are being considered, and one (attached algae) was tested over the past year.

Project investigators conducted monitoring of the Squamscott-Exeter River for nutrients on two occasions during the summer of 2014 and piloted monitoring studies of attached algae (periphyton) and macroalgae (seaweeds) as potential ecological indicators of nutrient enrichment. Nine stations were established on the main stem and tributaries; six were in the freshwater portions of the Exeter River basin (Haigh Road to Exeter) and the remaining three were in the tidal Squamscott River (below Great Dam to the Squamscott River Railroad Bridge (Appendix 8.4). Additional stations were paired with GBNERR System-Wide Monitoring Program (SWMP) stations including the mouths of the Oyster and Lamprey Rivers and central Great Bay and two comparison stations were set in the Lamprey River at Wiswall Dam and Packers Falls.

The initial sampling results show a general increase in TN in the downstream sections of the river, and increasing downstream load in both tidal and non-tidal waters. These results are consistent with model loads, and are discussed in more detail in the Appendix. Recommended sampling locations, methods and costs are described in detail in the monitoring Appendix, and summarized here.

<u>Focus Area I. Squamscott River</u> involves both monthly grab sampling and long-term installation of a datasonde in the Squamscott River. The recommended location is at the Route 101 bridge, just downstream of the WWTF. Previous monitoring at this location found high levels of chlorophyll-a, and fluctuating oxygen levels, apparently related to effluent discharge from the plant (Hydroqual, 2012). Monitoring here will establish the pre-upgrade baseline and document the anticipated improvements in water quality associated with upgrades to the facility. Monitoring at this location provides crucial information about the impact of the existing facility on the tidal river.

Focus Area II. Exeter/Squamscott Watershed requires measurements at selected locations within the watershed to meet management objectives. These objectives include tracking progress, as required in the AOC permit, but watershed scale improvements are unlikely to be detected in time frames of less than several years, and possibly decades. More immediate objectives are to quantify loads into the system, and identify opportunities for targeted management measures. Potential monitoring locations are listed in Table 4. These locations were selected by the Project team, including municipal representatives, to meet permit requirements, or to answer specific management questions. Several of the identified sites are currently sampled under the VRAP program. VRAP sampling does not always include nutrients, but could be augmented for inclusion in this program.

Focus Area III. Great Bay monitoring measures the overall trends in water quality and ecosystems in Great Bay. Great Bay monitoring has been conducted over the past several decades by several agencies including NH DES, PREP, GBNERR and UNH. However, this monitoring program was designed to provide data for research and assessment of the estuarine system: the existing regional monitoring program was not intended to guide management decisions. As the region moves forward with costly wastewater and non-point source control measures, a deeper understanding of the ecosystem stressors and interactions will guide effective measures that lead to tangible improvements in water quality, and ultimately, to removal of the impairment listing. The sampling methods and locations include nitrogen, dissolved oxygen, marcoalgae and eelgrass. The exact methods and locations will depend on the number of partners and funding available to the monitoring collaborative.

5.1.3 Ecosystem Indicators

Ecological indicators add value, and more certainty of outcome, to water management strategies. Just as the bathroom scale shows that meeting caloric intake targets of a diet has had the desired effect, ecological indicators show that nutrient reductions have the desired ecosystem response. Further, monitoring of living indicators along with a related suite of chemical and physical attributes can:

- Identify emerging habitat and water quality impairments.
- Grow understanding of physical, chemical and biological processes to link cause and effect and support more targeted and effective management.
- Identify ways to protect and restore vital ecosystem services that proactively allow and demonstrate that communities are meeting legal environmental obligations and all incumbent social and economic benefits.
- Identify the potential for restoration so reasonable and effective management targets and strategies can be constructed.

For trend-tracking purposes, and assessment of progress towards attaining designated use support, ecosystem indicators, especially biological indicators provide many advantages, especially as an integrator of all stressors that affect ecosystem health. The data will also inform adaptive management approaches that can home in on adjusted targets that reflect the measured response, and progress, from cumulative implementation activities.

As noted above, the WISE project funded a pilot program to help develop an ecological indicator that addresses a central question of the link between nutrients and water quality in the Region:

The relationship between nutrient, loads concentrations and algae growth. The project team sampled algae abundance and species, in conjunction with nutrient and water quality parameters at locations within the watershed and Great Bay to evaluate a broad ecological indicator under a range of conditions. Methods and water quality results are detailed in Appendix (Monitoring), Although taxonomic results were not finalized in time for inclusion in this report, preliminary chemical indicator data show promise that attached algae are a sensitive indicator of nutrient loading that can provide that elusive link between sources and effects that will support adaptive management and the most effective outcomes for Great Bay at the lowest cost.

5.2 Tracking and Accounting

The Towns are currently or will be soon required to document pollutant load reductions to Great Bay to record progress towards achieving water quality goals. Specific detailed requirements are listed in the AOC and the draft NH MS4. An essential element of this will be developing a system for tracking progress for nutrient control strategies for point-source and non-point source parameters. A second essential element is the accounting for total nitrogen reduction based on the tracking measures.

Tracking and accounting by town staff should be guided by the recommendations of source areas targeted for stormwater management in Table 4-15. Specific land use area targets, nutrient control measures, and capture depth are recommended.

For this to occur there is a need to identify a uniform approach to calculating and crediting reductions associated with the various control strategies. The tracking tools and accounting metrics provided in will provide the Towns with a consistent, watershed-wide method to account for both the existing gray and green infrastructure in place in their communities and provide a process to add new treatment infrastructure and changes of land use. These communities are actively participating in PTAPP for this purpose which should assist in developing strategies to efficiently and effectively address their permit requirements and leverage these existing efforts by the end of 2015.

5.2.1 Relevant Activities for Tracking and Accounting

A number of tracking and accounting resources have been developed for the WISE communities to assist with MS4 and AOC requirements.

- Appendix 8.6 Checklist for NPDES Permit No. NH0100871, Administrative Order on Consent Docket No. 13-010.
- Appendix 8.7 Checklist for 2013 Draft NH Small MS4 General Permit Requirements.

EPA has provided guidance to communities on expected activities for tracking and accounting which are summarized below.

1. Property Use Information
    a. Existing Use
    b. Proposed Use
    c. Is the existing land use being converted to another type of land uses
    d. % of current Land use being converted to another type of land use
    e. Parcel Area (acres)
    f. Existing Total Impervious Cover (acres)
    g. Existing Total Disconnected Impervious Area (acres)
    h. Proposed Total Impervious Area (acres)
    i. Proposed Total Disconnected or Treated Impervious Area (acres)

2. Environmental Sensitivity
    a. Is the property in the Shoreland Protection District?

  b. Name of Receiving Water(s) where stormwater runoff from the property discharges too
  c. Distance from Receiving Water (feet)
  d. Buffer Size
  e. Public or Private waste water. Does the property have a septic system ?
  f. Percent runoff to outfall

3. Septic System Information (if applicable)
  a. Septic System Type
  b. Septic System Size (gallons)
  c. New or Replacement
  d. Date of Installation
  e. Distance of septic system from closest down-gradient or cross-gradient water body
  f. Name of closest down-gradient or cross-gradient water body
  g. Maintenance Requirements
  h. Maintenance Schedule

4. Proposed BMP Information - Treatment for Nitrogen
  a. Calculated Annual Nitrogen Load for entire Parcel (lbs N/year)
  b. Calculated Annual Nitrogen Load to BMP (lbs N/year)
  c. Best Management Practices Type
  d. Assumed BMP Efficiency (% Removal Efficiency)
  e. Calculated Annual Nitrogen Load Reduction (lbs N/year)
  f. Operations and Maintenance Plan
  g. Suggested Maintenance Schedule

Non-structural strategies may include fertilizer controls, street sweeping efforts and good housekeeping measures.

5.2.2 Recommendations for Tracking and Accounting Procedure

A number of possible systems could be developed to facilitate municipal tracking and accounting. The systems range from simple paper-based approaches that would involve less up front resources but would require more time to assemble the necessary reporting information. More complex electronic web-based or database systems would require greater upfront resources but would be capable of generating reports and compiling the necessary accounting elements with greater ease.

5.2.2.1 Paper Based Tracking and Accounting

The simplest approach for tracking and accounting would be to revise the stormwater regulations for the towns and include a requirement for submission of a checklist that would include the vast majority of the tracking elements. The project applicant would have all of the requisite information for *Property Use, Environmental Sensitivity, and Septic System Information.* The applicants engineers would have most of the *Proposed BMP Information and Treatment for Nitrogen.* The nitrogen load and volume reduction calculations can be developed independently or by use of the BMP Performance Curves (Appendix 8.3) The checklist information statistics would then need to be recorded and compiled for annual reporting.

5.2.2.2 Web- Based or Electronic Tracking and Accounting

A more sophisticated approach would be the use of a webbased tracking and accounting system that would require an applicant to submit the requisite items through a webportal. The data would be marked as provisional data until reviewed and approved by municipal staff, presumably in relation to planning board approval of a given project. The webbased system could be built on a database that would be developed to generate reports and statistics for the tracking elements which would in turn be used in annual reporting.

6. RECOMMENDATIONS FOR A PATH FORWARD

The IP has developed the framework for both a Nitrogen Control Plan that could meet the requirements for the AOC as well as including stormwater and nonpoint source management as required by the pending MS4 permit (MM5). Certain additional steps are required for the IP to fully satisfy those two permit elements. Those items are detailed below and include 1) a financial capability analysis to determine the rate at which improvements can be made, 2) a detailed implementation plan with specific details as to location and timing of nitrogen control practices. Once the IP contains these final elements, and is reviewed and approved by EPA, the following items are recommended.

Specific items that should be included in a future comprehensive plan include:

- Wide public input. While the WISE project incorporates extensive input and engagement from municipal officials, and will provide information and tools which should be incorporated into a broader public process, direct public engagement is not part of the project. A community forum is recommend to be held at the end of the project to present the outputs, and initiate a broader public discussion.
- Discussion and planning for long term funding. Sustainable funding is a crucial component of a long term implementation plan.

6.1 Credit Trading

6.1.1 Overview

Nitrogen trading has great potential and has been discussed by resource managers for many years. Some of the greatest potential exists for the preservation of undeveloped areas and protection of riparian buffers to prevent future increases in nitrogen load in the unregulated communities. For nitrogen trading to be an effective mechanism to meet permit requirements and broader water quality goals by drawing in unregulated sources, several guiding principles drawn from the EPA trading policy should be considered (Willamette Partnership, The Freshwater Trust, 2014). Trading should:

1. More effectively accomplish regulatory and environmental goals
2. Be based on sound science
3. Provide sufficient accountability that water quality improvements are delivered
4. Not produce localized water quality problems
5. Be consistent with the CWA regulatory framework

But the challenges of the local setting, which must be amendable to market mechanisms while capably navigating regulatory requirements, should not be underestimated. Stacey (in press) identified eight conditions that were essential to the successful point-to-point source trading program framework in Connecticut:

1. All participating sources must contribute to a common water quality problem
2. The pollutant reduction target (WLA) must be attainable
3. Compelling member benefits from trading, especially economic, must exist
4. Sources must be easily quantified and tracked
5. Credit costs must be based on established and agreed upon protocols
6. Credit costs among participating sources, equalized by trading ratios if appropriate, must be diverse enough to create viable supply and demand conditions
7. Overall implementation cost must be reduced
8. Transaction, administrative and operational costs, including monitoring and tracking, must be low relative to credit prices

The lack of successful trading programs illustrates the policy, legal, and logistical challenges that come to bear. As pointed out by Stephenson et al. (2010), if the market isn't predisposed and robust enough to balance supply and demand and stay under a cap (e.g., a TMDL target or permit limit), the program may shift to an offset program for new growth and will not be able to sustainably remain under a regulatory cap or limit.

6.1.2 Potential Programs in the Exeter-Squamscott Watershed

For trading to move forward in the Squamscott-Exeter watershed, a more detailed assessment would be a first step towards developing a framework, and determining potential success of a program. Based on this study, management actions will need to be devised to meet suggested nitrogen loading targets, which appears to be uncertain for dissolved oxygen and may be out-of-reach for eelgrass. A viable trading market would be challenging on a three municipality basis because demand seems to far outweigh potential supply. However, if the trading geography is expanded to the entire watershed, there would be more, and perhaps better, opportunities for trading that might prove economically beneficial. Because nutrient management by nature is so difficult and costly to begin with, there may also be some potential for thinking more holistically at the value added from environmental benefits for a wider suite of ecosystem services and environmental outcomes. In trading, this process, known as "credit stacking", more than one credit may be derived for a management action because of the value attributed to co-benefits of that action. For example, in addition to removing nitrogen, some practices may sequester carbon, protect endangered species habitat, remove phosphorus and sediments, provide for flood protection, and have recreational or aesthetic value, thus producing marketable benefits. Credit stacking is still a controversial concept that some call "double-dipping", and the premise of creating ecosystem service value when nitrogen reductions are not met, for example, may be subject to legal challenges. However, opportunities for injecting additional cash flow into a nitrogen trading program derived from these other benefits should not be ignored in the pricing and marginal cost assessments.

6.2 Climate Change, Adaptation Planning and Community Resiliency

Climate change has already and is expected to have significant impacts on infrastructure, natural resources, cultural resources, and social issues in our seacoast region over the next century. Sea level has been rising for decades and is expected to continue to rise well beyond the end of the 21st century. Rising seas pose significant risks to coastal communities, ecosystems, utilities, and roadways. The New Hampshire coast is subjected to both nor'easters and hurricanes. The winds from nor'easters and hurricanes drives ocean water to the land resulting in a short-term rise in water levels called storm surge. Storm surge adds to the impacts of SLR and can cause catastrophic impacts if they occur during a high tide. Over the last 100 years mean annual precipitation in the Northeast has increased by about 5 inches or more than 10%. During this period the region also experienced a greater than 50 % increase in the annual amount of precipitation from storms classified as extreme events. Projected increases in annual precipitation could be as high as 20 % in the period 2071-2099 compared to 1970-1999. In general, total annual precipitation is expected to increase as are extreme precipitation events. Climate-related increases in precipitation, as well as sea level rise and storm surge, are increasing stress on already overburdened stormwater and wastewater infrastructure. These climate stressors should be taken into consideration in integrated planning.

Climate resilience means building the ability of a community to "bounce back" after hazardous events such as hurricanes, coastal storms, and flooding – rather than simply reacting to impacts after they occur. A community that is prepared will have a greater ability to rebound quickly from weather and climate-related events. The ability to rebound can reduce negative human health, environmental, and economic impacts. Because all communities are going to face hazards, resilience is important. Resilience is our ability to prevent a short-term hazard event from turning into a long-term community-wide disaster. While most communities effectively prepare themselves to respond to emergency situations, many are not adequately prepared to recover in the aftermath.

There are many tools that municipalities can utilize to build resilience and deal with climate related stressors. The use of Green Infrastructure (GI) is one, and it provides multiple benefits. GI methods not only help resolve water quality issues but they also can build resilience by mimicking natural processes. Using GI to control stormwater will benefit communities in many ways. Existing stormwater management systems designed to control runoff and protect life and property are not always able to handle extreme precipitation events. Better water resource management will reduce infrastructure costs and help to alleviate flooding. Treating and reducing runoff will protect water quality, which for many communities is a required action under the new MS4 permit.

There are many resources that municipalities can use to help develop integrated plans that include resilience components. New Hampshire has state and federal agencies, as well as numerous other organizations and collaborations that offer outreach and education, or technical assistance on resilience building and climate adaptation. NHDES, the EPA through the regional office as well as the local National Estuary Program PREP, NOAA through Sea Grant and the GBNERR, the University of New Hampshire through multiple programs such as UNH Stormwater Center and Cooperative Extension, and the New Hampshire Coastal Adaptation Workgroup which is a local collaboration of over 20 agencies and organizations that help municipalities prepare for and adapt to climate change, all are available local resources.

7. REFERENCES

Arcieri, W., Henderson, Z., and Cedarholm, D. (2014). "Oyster River Integrated Watershed Management Plan." Vanasse Hangen Brustlin, Woodard and Curran, Town of Durham, Durham, NH.

Audubon Society of New Hampshire, UNH Cooperative Extension, NRCS, and NH Office of State Planning (1997). "Buffers for Wetlands and Surface waters. A Guidebook for New Hampshire Municipalities."

Bierman, V. J., Diaz, R. J., Kenworthy, W. J., and Reckhow, K. H. (2014). "Joint Report of Peer Review Panel-Great Bay Estuary."

Breaults, R.F., Sorenson, J.R., and Weiskel, P.K. (2002). "Streamflow, Water Quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999–2000." USGS Water Resources Investigations Report 02-4137, U.S. Department of Interior.

CRWA. (2014). Charles River Watershed Association http://www.crwa.org/project-resources.

Chesapeake Stormwater Network. (1997). http://chesapeakestormwater.net/bay-stormwater/baywide-stormwater-policy/urban-stormwater-workgroup/urban-street-sweeping/. Accessed on March 23, 2015.

Clar, M., (2003). "Case Study: Pembrook Woods LID Development Residential Subdivision." Ecosite, Inc.

CWP, and VA Department of Conservation. (2001). "The Economic Benefits of Protecting Virginia's Streams, Lakes and Wetlands and the Economic Benefits of Better Site Design in Virginia."

Elmer, H. (2007). "National Training Priority and Funding Needs Survey." National Estuarine Research and Reserve System (NERRS) Coastal Training Program External Funding Workgroup, Washington, DC.

EPA. (1996). EPA Watershed Approach Framework. U.S. Environmental Protection Agency, Washington, DC. http://water.epa.gov/type/watersheds/framework.cfm

EPA. (1999). Urban Storm Water Best Management Practices Study, Part D.

EPA. (1997). Monitoring Consortiums: A Cost-Effective Means to Enhancing Watershed Data Collection and Analysis (EPA 841-R-97-006). U.S. Environmental Protection Agency, Washington, DC. http://www.epa.gov/owow/watershed/wacademy/its03/mon_cons.pdf

EPA. (2004). Water quality trading assessment handbook. Can water quality trading advance your watershed's goals? EPA 841-B-04-001. EPA, Office of Water, Washington, DC. 120 p.

EPA. (2007). Watershed-based National Pollutant Discharge Elimination System (NPDES) Permitting Technical Guidance. (EPA 833-B-07-004). U.S. Environmental Protection Agency, Washington, DC. http://www.epa.gov/npdes/pubs/watershed_techguidance.pdf

EPA. (2008.) EPA water quality trading evaluation. Final report. EPA Office of Policy, Economics and Innovation. Industrial Economics Contract EP-W-04-023. US EPA, Washington, DC. 90 p.

EPA. (2009). Water quality trading toolkit for permit writers. EPA, Washington, DC. 55 p.

EPA SAB. (2011). Reactive nitrogen in the United States: An analysis of inputs, flows, consequences, and management options – A report of the EPA Science Advisory Board. Report EPA-SAB-11-013. EPA Science Advisory Board, Integrated Nitrogen Committee. Washington, DC. 172 p.

EPA. (2011). Memorandum entitled "Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans." Stoner, N., and Giles, C., October 2011, US EPA.

EPA. (2012). "Integrated Municipal Stormwater and Wastewater Planning Approach Framework", Stoner, N. and Giles, C., June 2012, USEPA.

EPA. (2012). "Authorization to Discharge Under the National Pollutant Discharge Elimination System, The Town of Exeter, New Hampshire, Squamscott River." NPDES Permit No. NH0100871, Office of Ecosystem Protection, U.S. Environmental Protection Agency, Region I, Boston, Massachusetts.

EPA. (2013). "2013 NH Small MS4 Draft General Permit, General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems."

EPA. (2014). "Estimating Change in Impervious Area (IA) and Directly Connected Impervious Area (DCIA) for New Hampshire Small MS4 Permit." Small MS4 Permit Technical Support Document, Revised April 2014 (Original Document, April 2011).

EPA. (2014). "Financial Capability Assessment Framework for Municipal Clean Water Act Requirements".

EPA (2015). Water: Best Management Practices. Landscaping and Lawn Care - Minimum Measure: Public Education and Outreach on Stormwater Impacts http://water.epa.gov/polwaste/npdes/swbmp/Landscaping-and-Lawn-Care.cfm. Accessed March 2015.

EPRI. (2013). Case studies of water quality trading being used for compliance with National Pollutant Discharge Elimination System permit limits. Electric Power Research Institute Technical Report 3002001454. EPRI, Palo Alto, CA. 80 p.

FB Environmental Associates, Inc. (2009) Long Creek Watershed Management Plan, July 2009, Appendix 7.

GBMC. (2010). Adaptive Management Plan. The Great Bay Municipal Coalition, Dover, Exeter, Newmarket, Portsmouth, and Rochester NH.

Geosyntec Consultants. (2014). Least Cost Mix of BMPs Analysis, Evaluation of Stormwater Standards Contract No. EP-C-08-002, Task Order 2010-12. Prepared for Jesse W. Pritts, Task Order Manager, U.S. Environmental Protection Agency.

Hayes, L., and Horn, M. A. (2009). "Methods for Estimating Withdrawal and Return Flow by Census Block for 2005 and 2020 for New Hampshire." Open-File Report 2009-1168, U.S. Geological Survey, Pembroke, NH.

Herrera Environmental. (2011). TAPE Literature Review for Manufactured Treatment Devices, Seattle, Wa.

Kim, H., Seagren, E.A., and Davis, A.P. (2003). "Engineering Bioretention for Removal of Nitrate from Stormwater Runoff." Water Environment Research. 75, 355 (2003).

Kleinfelder. (2012). “Exeter/Stratham Intermunicipal Water and Wastewater Systems Evaluation Study and Final Report.” Rockingham Planning Commission. December 2012.

MADEP. (2008). "Final Total Maximum Daily Load for Nutrients in the Lower Charles River Basin, Massachusetts." Massachusetts Department of Environmental Protection.

Narayanan, Arvind and Pitt, Robert. 2006. Costs of Urban Stormwater Control Practices (Preliminary Report).

NERRS. (2006). Research and Monitoring Plan (2006-2011).Washington, DC. http://www.NERRS.noaa.gov/pdf/Research_Monitoring.pdf Accessed August, 2008.

NHDES. (2008). “New Hampshire Stormwater Manual.” New Hampshire Department of Environmental Services. December 2008.

NHDES. (2009). “Draft Numeric Nutrient Criteria for the Great Bay”. New Hampshire Department of Environmental Services.

NHDES. (2010). “Analysis of Nitrogen Loading Reductions for Wastewater Treatment Facilities and Nonpoint Sources in the Great Bay Estuary Watershed”. Great Bay Nitrogen Loading Analysis Draft R-WD-10-22.

NHDES (2011) The Lower Exeter and Squamscott Rivers A Report to the General Court Prepared by State of New Hampshire Department of Environmental Services Water Division – Watershed Management Bureau

NHDES, Trowbridge, P., Wood, M. A., Underhill, J. T., and Healy, D. S. (2014). "Great Bay Nitrogen Nonpoint Source Study." *R-WD-13-10*, NH Department of Environmental Services, Concord, NH.

NJDEP. (2014). “New Jersey Stormwater Best Management Practices Manual.” New Jersey Department of Environmental Protection. Updated September 2014.

NH Sea Grant Fact Sheet ‘Green Grass – Clear Water’ https://seagrant.unh.edu/sites/seagrant.unh.edu/files/media/pdfs/extension/lawncare_information_sheet.pdf

PREP. (2010). Comprehensive Conservation and Management Plan. Piscataqua Regional Estuaries Program, Durham, NH.

PREP. (2012). "2012 State of Our Estuaries." Piscataqua Region Estuaries Program, Durham, NH.

PREP. (2015). Piscataqua Region Environmental Planning Assessment (PREPA), Durham, NH.

Smith, B. (2014). "Manure Calculator." NRCS, Durham, NH.

Stacey, P.E. In Press. Connecticut’s Long Island Sound Nitrogen Credit Exchange. Chapter 12 in Advances in water quality trading as a flexible compliance tool. A Special Publication of the Water Environment Federation. WEF, Alexandria, VA.

Stephenson, K. and L. Shabman. 2011. Rhetoric and reality of water quality trading an the potential for market-like reform. J. Amer. Water Works Assn. 47(1):15-28.

Stephenson, K., S. Aultman, T. Metcalfe, and A. Miller. 2010. An evaluation of nutrient nonpoint offset trading in Virginia: A role for agricultural nonpoint sources? Water Resources Res. 46:W04519-W04519.

Stratus. (2009). "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds." City of Philadelphia Water Department, Boulder, Colorado.

SWA. (2012). Southeast Watershed Alliance. http://www.southeastwatershedalliance.org/mission.html

SWA, UNHSC, and RPC. (2012). "Model Stormwater Standards for Coastal Watershed Communities." December 2012.

Tetra Tech. (2009). Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities, Final Report. Prepared for United States Environmental Protection Agency and Massachusetts Department of Environmental Protection.Underwood Engineers. (2014). "Towns of Exeter and Stratham, NH Regional Wastewater Disposal Options." November 21, 2014.

United States Department of Agriculture (USDA). (2013).

UNH Cooperative Extension. 2014. New Hampshire's Turf Fertilizer Law 'What You Should Know'. UNH Cooperative Extension Fact Sheet. http://extension.unh.edu/resources/files/Resource004116_Rep5835.pdf

UNHSC. (2007). "2007 Biennial Report." University of New Hampshire Stormwater Center.

UNHSC. (2009). "UNHSC Subsurface Gravel Wetland Design Specifications." June 2009.

UNHSC. (2012). "2012 Biennial Report." University of New Hampshire Stormwater Center.

USGS. (2002)."Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999–September 2000."

USGS. (2002). "Streamflow, Water Quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999–2000."

Valiela, I., Geist, M., McClelland, J., and Tomasky, G. (2000). "Nitrogen loading from watersheds to estuaries: verification of the Waquoit Bay nitrogen loading model." *Biogeochemistry*, 49(3), 277-293.

Willamette Partnership, The Freshwater Trust. 2014. Regional recommendations for the Pacific Northwest on water quality trading. USDA Conservation Innovation Grant Award to the Willamette Partnership, November 2012, for Multi-State Agency Guidance for Water Quality Trading: Joint Regional Water Quality Trading Agreement (69-3A75-12-255). Willamette Partnership, Portland, OR. 168 p.

Wright-Pierce. (2011). "Wasterwater Management Concept Plan for the Town of Stratham, NH."

Wright-Pierce. (2014). "Town of Exeter, NH, Wastewater Facilities Plan, Preliminary Draft." October 2014.

Zankel, M., C. Copeland, P. Ingraham, J. Robinson, C. Sinnott, D. Sundquist, T. Walker, and J. Alford. 2006. The Land Conservation Plan for New Hampshire's Coastal Watersheds. The Nature Conservancy, Society for the Protection of New Hampshire Forests, Rockingham Planning Commission, and Strafford Region Planning Commission. Prepared for the New Hampshire Coastal Program and the New Hampshire Estuaries Project, Concord, NH.

Zarriello, P.J. and Barlow, L.K. (2002). "Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999–September 2000." USGS Water Resources Investigations Report 02-4129, U.S. Department of Interior.

We are
engineers, scientists
and innovators.

Geosyntec
consultants

engineers | scientists | innovators

Offices in Principal Cities of the United States and Select International Locations

geosyntec.com

Appendix A:
Nutrient Control Measures

Appendix A: Nutrient Control Measures and Fact Sheets on Green Infrastructure

This appendix includes a summary description of the following nutrient control measures considered in the WISE Nitrogen Control Plan. This section is not intended to provide design guidance, but rather introduce the reader to the practices and design sources.

1. Structural Management Measures for Impervious Surfaces
2. Municipal/Commercial/Industrial/Institutional Strategies
3. Residential Strategies
4. Non-Structural Management Measures for Impervious Cover Areas
5. Agriculture Strategies
6. Septic System Strategies

A series of 2015 Green Infrastructure Factsheets and Case Studies (EPA 842-R-15-002) are provided on how to include GI in the municipal environment which include:

- Fact Sheet #1 Build in Green Features during Routine Right-of-Way Maintenance and Operations
- Fact Sheet #2 Build or Retrofit Parking Facilities to be Greener
- Fact Sheet #3 Build Green Infrastructure at Public Facilities
- Fact Sheet #4 Design Traffic Safety Features to Manage Stormwater and Improve Aesthetics
- Fact Sheet #5 Create Stormwater Microparks

Nutrient control measures, or BMPs, as part of the WISE project focused on both point and nonpoint sources. The management measures, both structural and non-structural, look to reduce pollutant load from wastewater treatment facilities, subsurface septic systems, and stormwater sources including: agriculture, managed turf (i.e., golf courses, lawn), impervious and pervious surfaces, residential, commercial/industrial/institutional, roads, and outdoor recreational spaces (i.e., parks).

Working with the three Towns, a series of nutrient control measures were selected that would be suitable for specific land uses that fit in with town character, town ability to review designs, ability to remove nitrogen and likelihood and feasibility for installation. The selected management measures and their associated removal efficiency of total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) are presented in Table 1. The nutrient management measures with the greatest removal potential for total nitrogen include gravel wetlands and enhanced biofiltration. These two management practices are designed with an anaerobic zone which allows for greater removal of total nitrogen from the system.

Table 1. Pollutant Removal Efficiencies for Nutrient Management Strategies

Nutrient Management Measures	TSS	TN	TP
Gravel Wetland	96%	75%	58%
High Efficiency Biofiltration	73%	60%	72%
Subsurface Infiltration/Drywell	89%	42%	65%
Wet Pond	71%	31%	34%
Biofiltration	77%	28%	34%
Tree Filter	88%	20%	5%
Sand Filter	74%	18%	44%
Porous Pavement	82%	3%	44%

Table 2. Structural Nutrient Management Measures

CATEGORY		COVER TYPE	STRUCTURAL NUTRIENT MANAGEMENT MEASURES									
			Wet Pond	Gravel Wetland	Subsurface Infiltration	Sand Filter	Biofiltration	High Efficiency Biofiltration	Tree Filter	Raingarden	Dry Well	Permeable Pavement
LAND USE	Residential	Pervious						●		●	●	
		Impervious						●		●	●	
		Roof						●		●	●	
	Residential Subdivision	Pervious					●	●				
		Impervious					●	●				●
		Roof					●	●			●	
	Commercial/ Industrial/ Institutional	Pervious	●	●	●	●	●	●	●			
		Impervious	●	●	●	●	●	●	●			●
		Roof			●		●	●			●	
	Road/ Freeway	Impervious	●	●			●					
	Outdoor/ Other Urban Land	Pervious		●	●	●	●	●	●			
		Impervious		●	●	●	●	●	●			●

The nutrient management strategies were evaluated using local design standards and water quality reductions were calculated using build up and washoff functions for total nitrogen and event mean concentrations (EMCs) for TSS and TP.

1.1.1 Structural Management Measures for Impervious Surfaces

Impervious surfaces are defined as areas covered by materials that impede the natural infiltration of water into the underlying soil. Examples of impervious surfaces are roofs, pavement, concrete, and severely compacted soils. In the State of the Estuaries Report (PREP, 2013), impervious surfaces were shown to be a major contributor to nutrient impairments in the Great Bay. Impervious surfaces alter the natural flow of water, especially in urban areas, where stormwater is directed from the surface along curbs and gutters and into storm drain systems, which typically provide little to no treatment of runoff prior to discharging to the receiving water. Therefore, structural management practices to manage and treat runoff from impervious surface prior to the receiving water is imperative to the improvement of receiving water quality. Table 2 presents a list of nutrient management measures for roofs and impervious surfaces for a variety of land uses.

Figure 1. Wet Pond

(Credit: Chesapeake Stormwater Network)

Typically used by regulatory agencies, effective impervious cover (EIC) is best described in relation to total impervious cover. The EIC of a site is the portion of the total impervious cover that is directly connected to the storm drain network. EIC usually includes roadways, driveways and other impervious surfaces, such as rooftops, that are hydraulically connected to the drainage network. However, if a roof drain transporting rooftop runoff is directed to a pervious, vegetated area to infiltrate into the ground, it may be considered disconnected and is not included as EIC. EIC is also typically expressed as a percentage of the total project area.

Structural nutrient management practices specified for impervious surfaces which could reduce the EIC include: wet ponds, gravel wetlands, subsurface infiltration, sand filters, bioretention, enhanced high efficiency biofiltration and tree box filters.

1.1.1.1 Wet Ponds

Wet ponds are designed to maintain a permanent pool of water throughout the year. The pool, located below the outlet invert, allows for pollutant removal through settling and biological uptake or decomposition. Wet ponds are among the most cost-effective and widely used stormwater treatment practices.

Wet ponds, if properly sized and maintained, can achieve high rates of removal for a number of urban pollutants, including sediment and its associated pollutants: trace metals, hydrocarbons, BOD, nutrients and pesticides. They also provide some treatment of dissolved nutrients through biological processes within the pond.

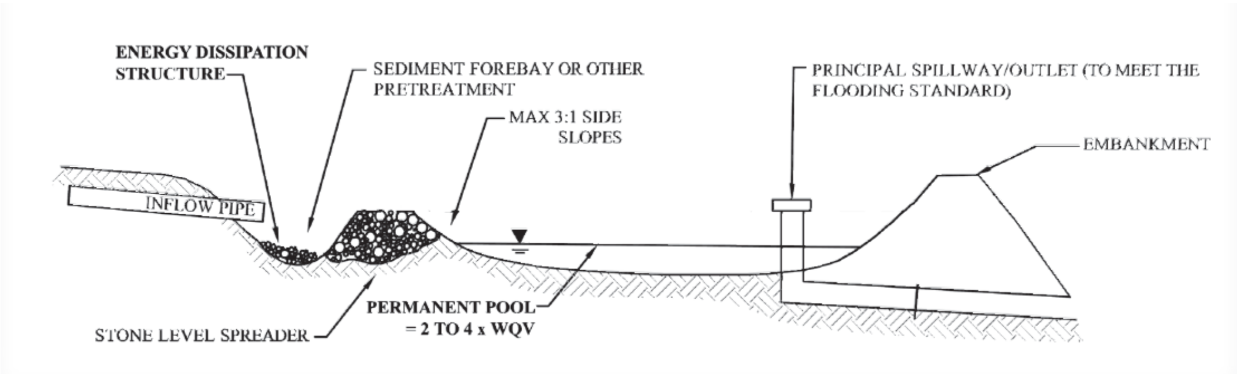


Figure 2. Wet Pond Profile (Credit: NH Stormwater Manual, 2008).

Due to the size footprint required for wet ponds, these practices aren't recommended for urban environments (i.e., urban centers and downtown areas). Furthermore, wet ponds need sufficient drainage area to maintain the permanent pool which lend them to be typically applied to commercial, industrial, institutional and roadway land uses.

1.1.1.2 Gravel Wetland

Gravel wetland systems consist of one or more flow-through constructed wetland cells, preceded by a forebay. The cells are filled with a gravel media, supporting an organic substrate that is planted with wetland vegetation. During low-flow storm events, the system is designed to promote subsurface horizontal flow through the gravel media, allowing contact with the root zone of the wetland vegetation. The gravel and planting media support a community of soil microorganisms. Water quality treatment occurs through microbial, chemical, and physical processes within this media. Treatment may also be enhanced by vegetative uptake (NH Stormwater Manual, 2008).

The outlet of the wetland system is designed to keep the media submerged, to provide the hydrology to support the wetland plant community. The gravel media consists of either crushed rock or processed gravel. An organic soil layer is placed on top of this material, and the wetland plants are rooted in the media where they can directly take up pollutants.

Figure 3. Gravel Wetland (Credit: UNH Stormwater Center)

The system can be designed to integrate some stormwater storage, and also to provide infiltration. With these features, the practice would not only remove pollutants, but also contribute to the attenuation of peak rates through temporary storage and reduction in runoff volume through infiltration and evapotranspiration.

The conversion and removal of nitrogen in gravel wetlands is dependent on two conditions: an aerobic sedimentation forebay followed by subsurface anaerobic treatment cells. Aerobic conditions exist in the forebay when it is designed *and maintained* as a dry area with temporary ponding conditions during storm events. The anaerobic condition in the treatment cells is created by maintaining the high water table within the system as well as the slow flow through the gravel layer. This saturated condition drives the dissolved oxygen level down and creates conditions in which nitrate conversion to nitrogen gas occurs (UNHSC, 2009).

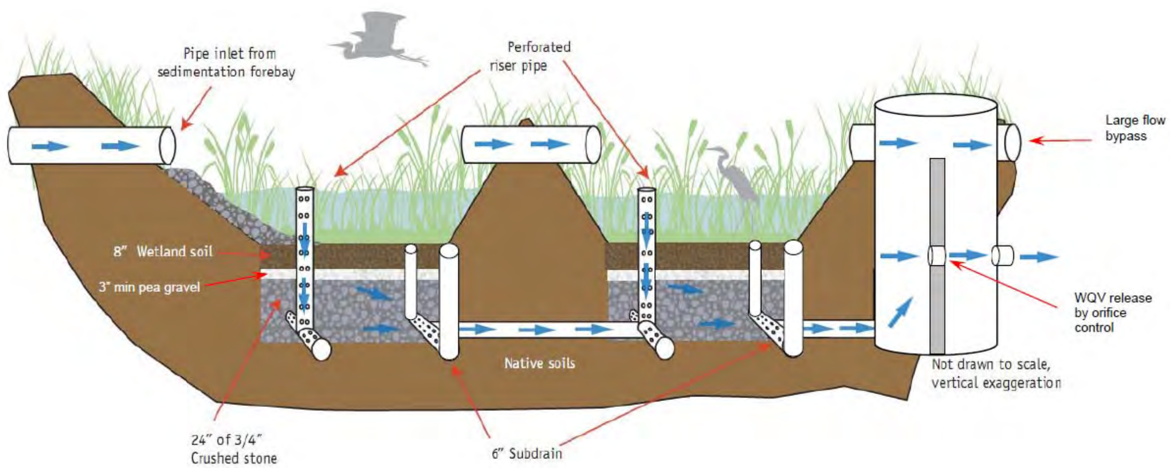


Figure 4. Gravel Wetland Cross-Section Concept Design (Credit: UNH Stormwater Center)

1.1.1.3 Sand Filter

A sand filter is a stormwater management facility that uses sand to filter particles and particle-bound constituents from runoff. The pollutant removal occurs solely in sand bed in both types of systems. Stormwater entering the sand filter is first conveyed through the pretreatment zone where trash, debris and coarse sediment are removed. It then passes through the treatment zone and out of the system through either an outlet pipe, in an underdrained system, or through the subsoil via infiltration. Pollutants in runoff are treated in sand filters through the processes of settling, filtration and adsorption.

Figure 5. Sand Filter (Credit: UNHSC)

Surface sand filters, like other infiltration/filtration systems, have a tremendous capacity to reduce peak flow. Sand filters are comprised of a sedimentation forebay and an adjacent filter basin. Sand filters are best suited for impervious drainage areas with high TSS, heavy metals and hydrocarbon loadings like roads, driveways, drive-up lanes, parking lots and urban areas. They are not recommended for use in pervious drainage areas where high sediment loads and organic material can clog the sand bed; where such loadings cannot be avoided, pretreatment is recommended (NJDEP, 2014).

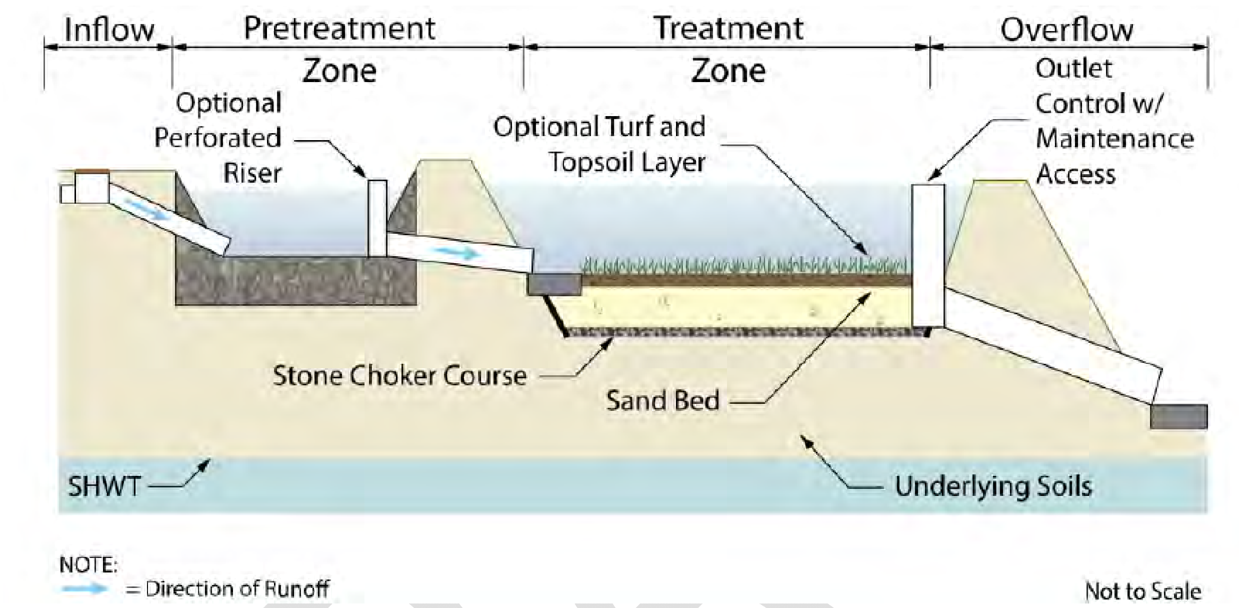


Figure 6. Sand Filter Profile (Credit: NJDEP, 2014)

Maintenance typically involves removing up to one inch of clogged sand from the surface of the filter bed, and fine particles from the pretreatment forebay. After repeated maintenance, sand may need to be added to the filter bed to maintain two feet of media. Depending on the size of the basin, sediment removal can be done by hand or with heavy machinery (UNHSC, 2012).

1.1.1.4 Subsurface Infiltration

Subsurface infiltration generally consists of underground stormwater storage through installation of manufactured reservoirs (i.e., pipes or chambers) and aggregate. Subsurface infiltration systems function in both permeable and non-permeable soils for subsurface retention or detention of storm water runoff and for a water quality treatment. It reduces nutrient and other

Figure 7. Subsurface infiltration at a commercial parking lot. (Credit: www.waterworld.com)

pollutant loadings by taking advantage of the natural biological and physical properties of the soil, directly comparable to the functions of a septic drain field. It also recharges ground water drinking supplies, while concurrently helping to maintain base flow to streams, wetlands, lakes, and ponds, and counter salt-water intrusion.

Applications would include connection of rooftop leaders, connection of existing pipes, inlets or pipes, under existing impervious surfaces or open space areas (i.e., recreational playing fields). These systems are typically used in areas with space constraints or urban environments. If properly installed and maintained, subsurface infiltration systems can significantly reduce or eliminate the discharge of runoff from impervious surfaces to receiving waters or drainage systems.

1.1.2 Municipal/Commercial/Industrial/Institutional Strategies

The following other management strategies are used for municipal, commercial, industrial and institutional land uses to manage both roof tops, impervious surfaces and pervious surfaces.

1.1.2.1 Porous Pavements

Stormwater runoff from impervious surfaces such as parking lots, roads and buildings, carries pollutants into storm drains and then to the streams, rivers and lakes that we use for drinking, swimming, and boating. Porous pavements can mitigate the impacts of impervious surfaces by allowing for infiltration through a porous surface, base, and sub-base materials which allow penetration of runoff through the surface into underlying soils. The surface materials for porous pavement can consist of paving blocks or grids, porous asphalt, or porous concrete. These materials are installed on a base which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground.

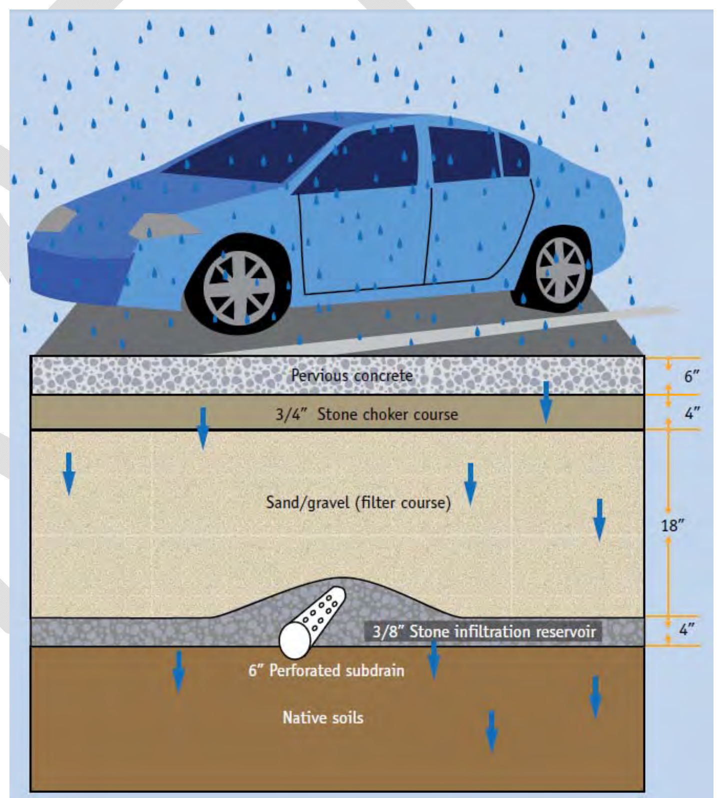


Figure 8. Porous pavement cross-section (Source: UNHSC, 2012).

The use of porous pavements to replace traditional asphalt pavement reduces the overall impervious cover of a site and can also act as a mechanism to disconnect existing impervious areas. Porous pavements can reduce the need for conventional stormwater management facilities (i.e., pipe networks, ponds) as more water is infiltrated and the volume of water to be treated through detention or retention is reduced. Research conducted by the University of New Hampshire's Stormwater Center has also found that porous pavement can reduce the amount of salt needed for deicing road and parking area surfaces, and reduces the formation of black ice due to less pooling of water on the pavement surface.

Porous pavements are recommended for implementation as new, redevelopment or retrofit opportunities at municipal, commercial, industrial or institutional land.   Porous pavements are suitable for locations such as parking lots, sidewalks, low-use roadways and develops with large areas of impervious surface.

1.1.2.2 Biofiltration

Biofiltration, otherwise known as bioretention, is a best management practice (BMP) developed in the early 1990's by the Prince George's County, MD, Department of Environmental Resources (PGDER) (EPA, 1999). Bioretention utilizes soils and both woody and herbaceous plants to remove pollutants from storm water runoff. As shown in Figure 1, runoff is conveyed as sheet flow to the treatment area, which consists of a grass buffer

1.1.2.3 High Efficiency Biofiltration

High efficiency biofiltration systems are biofiltration BMPs with an anaerobic zone for nitrate removal via microbial denitrification. Studies have suggested that biofiltration systems attenuate nitrate; therefore, engineering the system with an aerobic zone for denitrification provides additional water quality benefits (Kim, et. al, 2003).

1.1.2.4 Tree Filters

Tree box filters or tree filters are mini biofiltration systems that combine the versatility of manufactured devices with the water quality treatment of vegetated systems. They serve as attractive landscaping and drainage catchbasins. Unlike many other

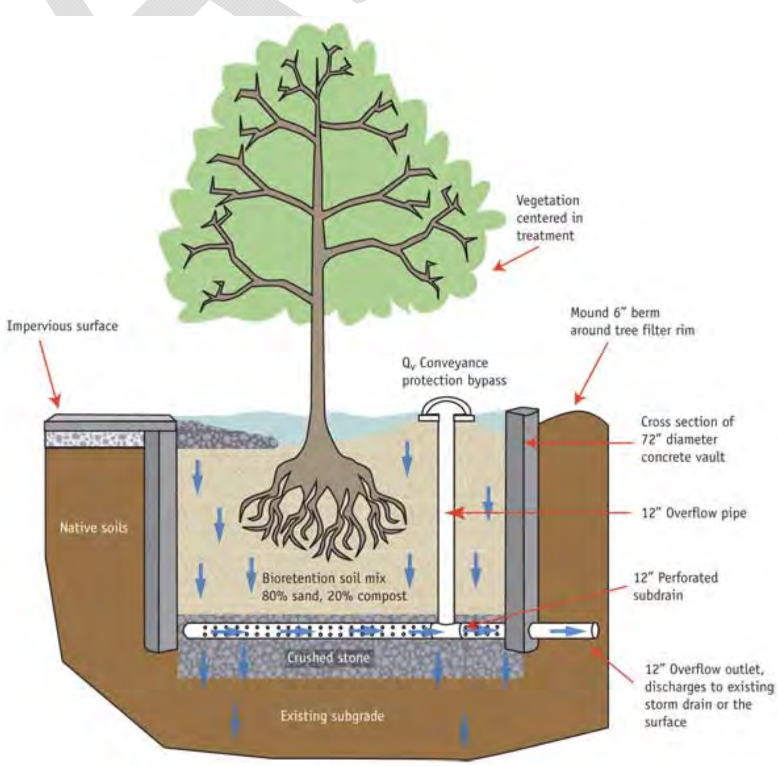


Figure 9. Tree Filter Cross-Section Detail. (Source: UNHSC, 2007)

forms of urban landscaping, they are not isolated behind curbs and deprived of water and nutrients in runoff. Their water quality treatment performance is high, often equivalent to other biofiltration systems, particularly when well distributed throughout a site (UNHSC, 2012).

Tree box filters are often installed along urban sidewalks, but they are highly adaptable and can be used in most development scenarios. In urban areas, tree filters can be used in the design of an integrated street landscape—a choice that transforms isolated street trees into stormwater filtration devices. They also can be used in designs that seek to convert entire non-functional streetscapes into large stormwater or combined sewer flow filtration systems.

1.1.3 Residential Strategies

In 2001, NHDES published the *New Hampshire Homeowner's Guide to Stormwater Management, Do-It-Yourself Stormwater Solutions for Your Home*, which provides information for homeowners on the common causes of stormwater problems and their effects. The Guide also provides fact sheets for structural controls that residential homeowners can install to mitigate the effects of stormwater. The structural controls include several of the management practices used in the WISE model, including raingardens, dry wells and porous pavements.

NHDES has also ran a success campaign called "Soak up the Rain".

1.1.3.1 Raingardens

Raingardens are filtration systems designed to collect and filter moderate amounts of stormwater runoff, typically from small drainage areas (i.e., roof tops, driveways) using conditioned planting soil beds, gravel beds and vegetation within shallow depressions. Raingardens are capable of reducing sediment, nutrients, oil and grease, and trace metals. Bioretention systems should be sited in close proximity to the origin of the stormwater runoff to be treated.

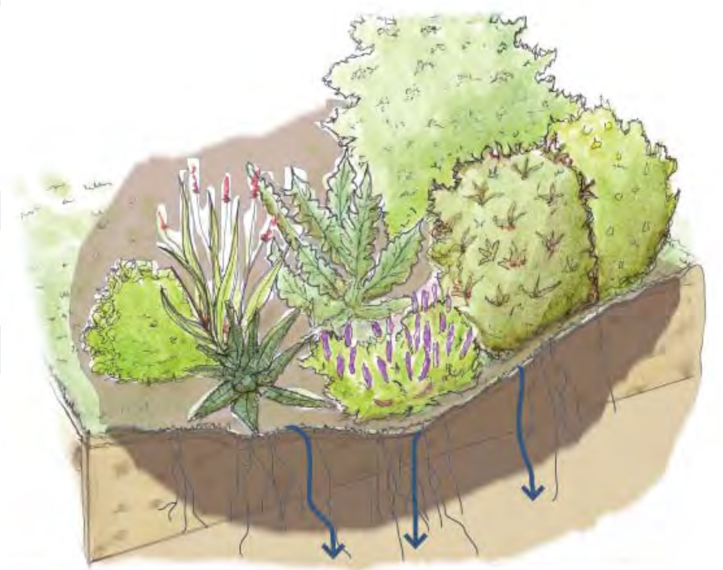


Figure 10. Raingarden Schematic (Source: NHDES)

1.1.3.2 Dry Well

Dry wells are essentially small subsurface leaching basins. The dry well consists of a small pit filled with stone, or a small structure surrounded by stone, used to temporarily store and infiltrate runoff from a very limited contributing area. Runoff enters the structure through an inflow pipe, inlet grate, or through surface infiltration. The runoff is stored in the structure and/or void spaces in the stone fill. Properly sited and designed dry wells provide treatment of runoff as pollutants become bound to the soils under and adjacent to the well, as the water percolates into the ground. The infiltrated stormwater contributes to recharge of the groundwater table.

Dry wells are well-suited to receive roof runoff via building gutter and downspout systems. With the small size and manageable cost of these BMPs, they are particularly suited for use in subdivisions and for single-family homes. When used for roof drainage, pretreatment of runoff is not typically required.

1.1.3.3 Porous Pavement

Permeable pavement consists of a porous surface, base, and sub-base materials which allow penetration of runoff through the surface into underlying soils. The surface materials for permeable pavement can consist of paving blocks or grids, pervious asphalt, or pervious concrete. These materials are installed on a base which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground.

Although traffic loading capacities vary, permeable pavement alternatives are generally appropriate for low traffic areas (e.g. sidewalks, parking lots, overflow parking, residential roads). Careful maintenance is essential for long term use and effectiveness.


YOUR LAND
YOUR WATER
YOUR SOLUTION

Soak up the Rain.

What is Stormwater?

Stormwater runoff is water from rain or melting snow that doesn't soak into the ground. In a forest, meadow, or other natural area, stormwater soaks into the ground and naturally filters through the soil.

When forests and meadows are developed, they are replaced with neighborhoods, shopping centers, and other areas that introduce impervious surfaces such as roofs, roads, parking lots, and driveways.

Impervious surfaces prevent rain or melting snow from soaking into the ground. This creates excess stormwater runoff and stormwater pollution.

Why is Stormwater a Problem?

Excess stormwater runoff and the pollutants that it carries can cause many different problems including flooding, erosion, and water pollution. This can make the water unhealthy for fish and other animals to live in and unsafe for us to swim and play in.

What is Soak up the rain NH ?

Soak up the Rain (SOAK) New Hampshire is a voluntary program with the goal of protecting and restoring clean water in our local lakes, ponds, streams, rivers, and estuaries.

Working with local organizations, SOAK assists home and property owners to:

- Determine if a property is creating stormwater runoff that may be impacting nearby surface waters.
- Make recommendations and a plan for simple improvements including low-cost, do-it-yourself stormwater practices like the ones described in the *New Hampshire Homeowner's Guide to Stormwater Management.*

Pollution in stormwater is the primary cause of water contamination in New Hampshire

All of our homes have the potential to create stormwater runoff. This is because roofs, driveways, and even lawns can prevent rain water from soaking into the ground. The New Hampshire Homeowner's Guide to Stormwater Management was created for homeowners to learn the simple things that can be done to reduce the impacts of stormwater from our homes, while improving our properties at the same time.

Simple activities such as picking up pet waste, minimizing fertilizer use, and maintaining septic systems can reduce water pollution. Do-it-yourself stormwater practices like rain barrels, dry wells, infiltration trenches, and rain gardens can be built to further protect clean and healthy water.

Find out more about how you can soak up the rain at www.soaknh.org.

Want to Learn More?
Find out more about how you can soak up the rain at:
www.soaknh.org
or email jillian.mccarthy@des.nh.gov

A Program of
New Hampshire Department of Environmental Services

Photo source: Think Blue Maine

Figure 11. Residential Educational Brochure

Frequently, permeable pavements filter only the runoff generated on the pavement surface itself. However, runoff from other areas can be directed to permeable pavement if properly designed. Runoff generated from adjacent areas of the site may require pretreatment prior to discharge to the pavement surface, to prevent clogging of the pavement structure and (where the pavement is used to infiltrate as well as filter the runoff) the underlying soils.

1.1.4 Non-Structural Management Measures for Impervious Cover Areas

The integration of site design and planning techniques that preserve natural systems and hydrologic functions on a site reduce impervious surfaces through the use of non-structural management measures. Non-structural measures deployment is a design standard that can result in a variety of environmental and financial benefits. Reliance on non-structural management measures encourages the treatment, infiltration, evaporation, and transpiration of precipitation close to where it falls while helping to maintain a more natural and functional landscape. The BMPs described in this chapter preserve open space and working lands, protect natural systems, and incorporate existing site features such as wetlands and stream corridors to manage stormwater at its source. Some BMPs also focus on clustering and concentrating development, minimizing disturbed areas, and reducing the size of impervious areas.

Perhaps one of the most defining distinction for non-structural management measures is to prevent the generation of stormwater and not just mitigate stormwater-related impacts once these problems have been generated. Prevention can be achieved by re-developing or developing land in ways other than through use of standard or conventional development practices. Prevention and non-structural management measures go hand in hand and can be contrasted with structural measures that provide mitigation of those stormwater impacts, which cannot be prevented and/or avoided.

FERTILIZE RESPONSIBLY

- **Nitrogen Content Reduced**
  Lawn fertilizers sold at retail shall not exceed 0.9 pound of total nitrogen applied per 1,000 square feet per application when applied according to the label. At least 20% of the nitrogen must be in slow release form.
- **Phosphorus-Free**
  Most NH soils provide all the phosphorus that a home lawn needs. Phosphorus sold at retail should be used only on newly established or repaired lawns, or on lawns testing deficient in phosphorus. Annual applications may not exceed a rate of 1 pound per 1,000 square feet of available phosphate.

Figure 12. New Hampshire's Turf Fertilizer Law (Source: UNH Cooperative Extension, 2014)

Several major areas of non-structural management measures include:

- Protection of sensitive areas and valuable resources;
- Reduce impervious cover;
- Disconnect, distribute and decentralize impervious cover; and
- Street sweeping.

1.1.4.1 Development of a "Bay Friendly" Lawn Fertilizer Program

Homeowners also contribute to the serious problem of nutrient enrichment. Americans apply millions of tons of fertilizers, which contain nitrogen and phosphorus to gardens and lawns each year. When improperly applied, water runoff from properties carry these pollutants into ponds, rivers and ultimately Great Bay. Nutrient inputs from residential lawns can be managed through a combination of voluntary and regulatory controls. Voluntary methods include education and outreach programs which identify water quality impacts associated with lawn care, and provide attainable solutions. EPA Guidance on Best Management Practices recommends targeting lawn care industry workers and actively supporting companies using fertilizer and pesticide-limiting techniques, for instance, by providing promotional opportunities. Training lawn and garden center employees in lawn care and pollution control is another important message-spreading tool, as is direct outreach to homeowners. The Town of Exeter Think Blue Campaign, which is hosted on the Town website *http://exeternh.gov/bcc/think-blue-exeter* contains recommendations, videos and other educational materials for residents. Additional resources are available through EPA, and UNH Sea Grant facts sheet, 'Green Grass – Clear Water'.

Regulatory controls include municipal setbacks for fertilizer, and the recently adopted NH State Statute RSA:431 which requires that nitrogen in turf fertilizer not exceed 0.9 pounds per 1,000 square feet of total nitrogen per application when applied according to the instructions on the label. Furthermore, no turf fertilizers sold at retail shall exceed 0.7 pounds per 1,000 square feet of soluble nitrogen per application when applied according to the label. Detailed information on this regulation, and recommendations for lawn care are available in a UNH Cooperative Extension Fact Sheet: New Hampshire's Turf Fertilizer Law 'What You Should Know'.

1.1.4.2 Protection of Sensitive Areas and Valuable Resources/LID Planning

Buffers and riparian corridors are vegetated ecosystems along a waterbody that serve to protect the waterbody from the effects of runoff by providing water quality filtering, bank stability, recharge, rate attenuation and volume reduction, and shading of the waterbody by vegetation (Audubon et.al, 1997). Riparian corridors also provide habitat and may include streambanks, wetlands, floodplains, and transitional areas.

To minimize stormwater impacts, new and re-development projects should avoid affecting or encroaching upon areas with important natural stormwater functional values (floodplains, wetlands, riparian areas, drainage ways and buffers) and with stormwater impact sensitivities (steep slopes, adjoining properties, others) wherever practicable. Development should not occur in areas where sensitive resources exist so that their valuable natural functions are not lost and increasing stormwater impacts.

1.1.4.3 Disconnect, Distribute and Decentralize Impervious Cover

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed impervious area is correlated with a number of negative impacts on our water resources such as increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater (Center for Watershed Protection, 2003).

The amount of runoff and associated pollutants from a project can be reduced by disconnecting impervious surfaces. Disconnection of rooftop down spouts and impervious cover are the typical practices. Disconnection of impervious surfaces increases the amount of EIC on a site, which allows for filtering and infiltration prior to discharging to the receiving water.

The draft NPDES Small MS4 permits for New Hampshire require regulated communities to estimate the number of acres of impervious area (IA) and directly connected impervious area (DCIA) that have been added or removed each year due to development, redevelopment, and or retrofitting activities.

Why Quantify Your IA & DCIA?

New construction, redevelopment, and restoration activities can change existing IA and DCIA – potentially exacerbating or reducing existing watershed impairments. Understanding watershed imperviousness is important for communities because it:

- Informs management of impaired waterbodies and prioritization of watershed restoration efforts;
- Facilitates investigation of existing chronic flooding and stormwater drainage problems, and avoidance of new problems;
- Indicates potential threats to drinking water reservoirs/aquifers; commercial fisheries, and recreational waters;
- Demonstrates progress toward achieving future **Total Maximum Daily Load (TMDL)** allocations based on impervious cover thresholds;
- Serves as an educational tool for encouraging environmentally sensitive land use planning and **Low Impact Development (LID);**
- Facilitates equitable derivation of possible stormwater utility fees based on parcel-specific impervious cover; and
- Provides guidance for stormwater retrofit efforts.

(Source: EPA, 2014)

1.1.4.4 Street Sweeping

Streets are a major component of urban impervious cover and are typically directly connected impervious cover and are often pollutant hotspots. Streets with the three watershed are owned and maintained by state and local governments.

Frequent street sweeping of the dirtiest roads and parking lots within a community can be an effective strategy to pick up nutrients and sediments from street surfaces before they can be washed off in stormwater runoff (Chesapeake Stormwater Network, 2015). Under the draft NH MS4 permit (EPA, 2013),

Figure 13. Trash from street sweeper being dumped. (Source: Chesapeake Stormwater Network)

increases in the frequency of street sweeping and catch basin cleaning were included and protocols for proper disposal of street sweeping and catch basin refuse. Street sweeping and catch basin cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with MS4 permits.

Research conducted in the Chesapeake Bay in 2008 (CWP, 2008), suggests that municipalities should:

- Develop street sweeping and storm drain maintenance program efforts to target areas and times during the year in communities that may receive the greatest impact from street sweeping or storm drain cleanouts.
- Implement a downspout disconnection program and/or an urban stormwater retrofit program that redirects and treats stormwater before it reaches the storm drainage system (via parking lots, roads, sidewalks, alleyways) in ultra-urban catchments, such as those in this study.
- Expand MS4 stormwater programs to include a curb-side leaf litter pick-up program that is able to maximize the reduction of leaf litter and prevent it from entering the storm drain. This is important for two reasons, 1) street sweepers avoid leaf piles and this reduces the effectiveness of this practice (sweepers may also emulsify leafy debris and make it more easily entrained by runoff, and 2) the decomposition of leaves and other organic debris in storm drain inlets or catch basins can create an environment suitable for the release of inorganic nitrogen and transport to receiving waters.

For the purposes of WISE, street sweeping and catch basin cleaning was assumed to be completed bi-weekly to maximize reduction of particulates along roadways.

1.1.5 Agriculture Strategies

Nitrogen is one of the most important crop inputs; yet, it is also one of the most complex. It is susceptible to environmental losses, and its effectiveness is impacted by soil types and weather. Many commercial applications of nitrogen fertilizer are excessive, incorrectly timed, and do not result in uptake by the plant. Crops have an optimum period during their growth stage for the most efficient uptake of nitrogen. In-depth knowledge of the growth characteristics of each specific crop is beneficial to efficient nitrogen fertilizer applications. Heavy rainstorms, poorly drained soils, volatilization, and denitrification are all environmental factors that result in the loss of nitrogen fertilizer.

(Department of Soil Science, College of Agriculture and Life Sciences – University of Wisconsin-Madison, 2010) http://www.soils.wisc.edu/extension/wcmc/2010/ppt/Ruark.pdf

1.1.5.1 Slow Release Fertilizer

Quick release commercial nitrogen fertilizers often result in nitrogen loss due to agricultural runoff during storm events or error in time of application. Slow release fertilizers are designed to slowly apply nitrogen into soil such that the period of nitrogen uptake by the crop can be lengthened. Slow release fertilizers are available in many different forms depending on the physical requirements of the crop. Many products are distributed in pellet form, where the available nitrogen is contained within a compostable or polymer coating that is slowly dissolved by water or nitrogen diffuses through the porous membrane of the polymer walls. Some nitrogen slow release products are uncoated and rely on the soil's natural chemical decomposition process to become available for plant uptake. The key benefit of using a slow release fertilizer is to increase and maintain a positive yield with the same fertilizer application rate as compared to conventional methods. (Best management Practices for Nitrogen Fertilizer in Missouri, College of Agriculture and Natural Resources, 2006)
http://plantsci.missouri.edu/nutrientmanagement/nitrogen/pdf/Missouri_Nitrogen_BMPs.pdf

1.1.5.2 Cover Crops

Cover crops are one of the most valuable management practices available for protecting water quality, especially groundwater quality, from non-point sources of soluble nutrients like nitrate nitrogen (USDA, XXXX). Cover crops reduce soil erosion in several ways. They protect the soil surface from raindrop impact, increase water infiltration, trap and secure crop residues, improve soil aggregate stability and provide a network of roots which protect soil from flowing water (USDA, 2013.

Cover crops help improve soil health by reducing erosion, increasing soil organic matter content, improving air and water movement through soil, reducing soil compaction, capturing and recycling nutrients in the soil profile and managing soil moisture to promote biological nitrogen fixation. Several farmers and ranchers using cover crops saw increases in yields during extreme drought (USDA website:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=STELPRDB1083051)

1.1.6 Innovative Septic System Designs

Advanced and innovative treatment systems differ from conventional septic systems because they incorporate an additional treatment step to further the removal of nitrogen. Septic systems that target nitrogen removal utilize biological degradation in conditions that are aerobic, anoxic, and a combination of both in series. Aerobic systems that target nitrogen removal aerate the septic tank to provide biological removal of BOD, organic nitrogen, and ammonium nitrogen through a process called nitrification. For additional removal of nitrogen, aerobic systems would be paired with an anoxic system to provide an environmental without oxygen and allow for denitrification, where the nitrogen components in the wastewater are broken down to nitrogen gas.

Resources:

- New England Onsite Wastewater Training Program http://web.uri.edu/owt/
- EPA Septic (Onsite / Decentralized) Systems http://water.epa.gov/infrastructure/septic/technical.cfm

1.1.7 Green Infrastructure Factsheets

Build in Green Features during Routine Right-of-Way Maintenance and Operations

FACT SHEET #1

A variety of green infrastructure practices can be used to manage stormwater and enhance the walkability and aesthetics of streets. Green infrastructure implemented in the street right-of-way can be used to

- Reduce impervious area
- Infiltrate/filter runoff from the street and adjacent property
- Provide shade using trees
- Improve air quality
- Reduce the urban heat island effect
- Create a sense of place
- Showcase public art
- Calm traffic
- Provide wildlife habitat
- Create a welcoming area
- Enhance aesthetics


This green street features low-maintenance vegetation and mature trees.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement Choose permeable pavement for lower volume traffic areas, such as parking spaces, bike lanes, sidewalks, medians, and alleys.

Bioretention Install bioretention in the right-of-way between the curb and sidewalk, in curb bump-outs, and in medians or roundabouts to filter stormwater and beautify the streetscape.

Trees Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts for enhanced stormwater infiltration, shade, and aesthetics.

Reduce impervious area Replace pavement in medians, centerline safety strips, and roundabouts with pervious surfaces, and create shallow depressions to capture more runoff.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$50,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs
- Performance goals

Financing Opportunities

- Capital improvement funds
- Property tax assessments
- Stormwater utility fees
- State or private grants
- State revolving loans
- Private funding
- Bonds
- Federal funds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement
- Soil replacement

THINGS TO CONSIDER BEFOREHAND

- Design for public safety and access
- Green streets and alleys are most cost-effective to complete in conjunction with necessary street or infrastructure improvements or rehabilitation projects.
- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Design practices with sufficient access and features that make maintenance easier, such as inlets that are easy to clean.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Use wheel stops or curb cuts to ensure that cars do not drive over bioretention areas.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.

Permeable pavement can be used for lower volume traffic areas such as parking and bicycle lanes.
Photo credit: Dan Christian, Tetra Tech, Inc.

POTENTIAL PROJECT PARTNERS

Downtown business associations, civic leagues, neighborhood associations, and **environmental groups** can provide input into the design and placement of the practices for maximum community benefit and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs on portions of the project. For example, an **arts council** might be willing to partner with a municipality to convert a pervious plaza into a park with an interpretive rain garden if the space incorporated public art.

Roadside bioretention can include trees and attractive, low maintenance vegetation to enhance streetscapes.

FOR MORE INFORMATION

- National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets
- Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm
- Portland Green Streets website: www.portlandoregon.gov/bes/44407
- Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

CASE STUDY: NORTH STREET GREEN RETROFIT—PITTSFIELD, MASSACHUSETTS

The City of Pittsfield, Massachusetts is working to retrofit existing roadways with green street technology for stormwater management. One portion of the city's larger project is a 1,200 foot section of North Street in urban Pittsfield, where an existing streetscape plan included plantings and bump-outs for traffic calming. The city updated the original plan to incorporate three rain gardens to help manage stormwater. To successfully execute the rain gardens, the city needed to consider both urban conditions and local weather conditions. For example, the rain gardens were adapted for bioinfiltration with a specified medium, mulch, and appropriate plants that could withstand harsh New England conditions while aiding in pollutant removal.

In total, the three rain gardens covered an area of 520 square feet. The addition of rain gardens to North Street's renovation plan added the benefit of reducing stormwater pollutants from entering the West Branch of the Housatonic River. The rain gardens also reduce the volume of stormwater that is captured in catch basins and pumped to the municipal stormwater system with no treatment (Ogden et al. 2010). In addition to stormwater benefits, the retrofit achieves street calming measures in a downtown area that is emerging as an artistic and cultural hub in Pittsfield. The project successfully contributes to the goal of linking the city's dense urban center with green infrastructure (Greene et al. 2005). The cost of constructing the rain gardens along North Street totaled $44,379 (Ogden et al. 2010).

North Street before (top) and after (bottom) rain garden retrofits.
Photo credits: VHB, Inc., 2104

References:

Greene, C., S.P. Barr, S. Ibendahl, W. Sedovic, R.G. Shibley, and A. Livingston. 2005. Pittsfield SDAT: Sustainable Urbanism in the Heart of the Berkshires. Sustainable Design Assessment Team. http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias078159.pdf.

Ogden, K.M., M.J. Seluga, and B.E. Eisenberg. 2010. Green street retrofits in the Northeast: Design and acceptance challenges for stormwater management retrofits. Low Impact Development 2010: pp. 628-641.

CASE STUDY: PLAINFIELD AVENUE—GRAND RAPIDS, MICHIGAN

In 2012, the City of Grand Rapids, Michigan updated the design of Plainfield Avenue to incorporate stormwater management features. The arterial roadway was redesigned to incorporate linear below-grade bioretention islands in the median that are designed to capture the first 0.5 inch of rainfall, eliminating the discharges to the storm sewer system from the most frequently occurring small storms. The islands effectively reduce 420,000 cubic feet of runoff, 60% of sediment, and 65% of phosphorus loading that would otherwise directly enter Grand River in flash flood events every year. In addition to runoff reduction and water quality benefits, the Plainfield Avenue island also serves the community by increasing pedestrian safety, calming traffic, and improving the area's aesthetics.

Design and construction costs of the Plainfield Avenue island totaled $264,000, which was funded by a collaboration of federal, local and private sources. Funding contribution sources included the Michigan Department of Transportation Enhancement Grant, Creston Neighborhood Association, Creston Business Association, Fishbeck, Thompson, Carr & Huber, Inc., and the West Michigan Environmental Action Council. In addition to capital costs, maintenance is expected to cost about $1,500 annually, $30,000 of which was endowed by the Cranston Business Association (SEMCOG 2013).

One of seven bioretention islands on Plainfield Avenue.
Photo credit: David Kidd, Governing Magazine.

Reference:

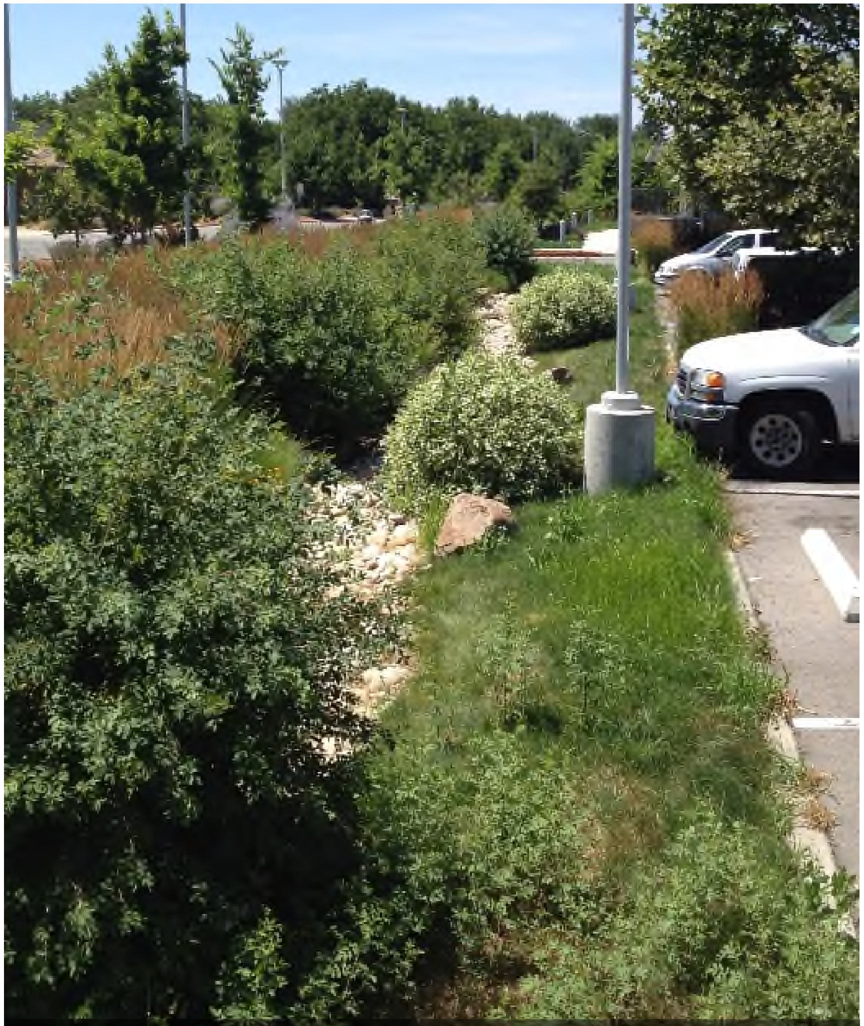
SEMCOG. 2013. Great Lakes Green Streets Guidebook: A Compilation of Road Projects Using Green Infrastructure. http://www.semcog.org/uploadedFiles/Programs_and_Projects/Water/Stormwater/GLGI%20Guidebook_web.pdf.

Build or Retrofit Parking Facilities to be Greener

FACT SHEET #2

Parking lot pavement at municipal facilities constitutes a substantial portion of urban and suburban impervious surface area. These lots, as well as medians, curbs, and bump-outs, present opportunities for municipalities to incorporate green infrastructure features into new parking lot designs or retrofit existing parking lots with green infrastructure to capture runoff from parking spaces, parking lanes, and buildings before it leaves the site. Greener parking can be used to:

- Reduce effective impervious area
- Infiltrate runoff from parking lanes and stalls
- Improve parking lot drainage
- Provide shade when trees are used
- Improve pedestrian safety with curb bump-outs to reduce crossing distances
- Improve aesthetics
- Provide wildlife habitat



This parking lot drains to a vegetated bioretention area along the perimeter.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement	Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, pedestrian walkways, and overflow parking.
Bioretention	Install or convert areas between parking rows to bioswales. Install bioretention along the parking lot perimeter and in corners where cars cannot park. Use curb bump-outs with bioretention at the end of stalls to calm traffic and reduce pedestrian crossing distances.
Trees	Plant trees between parking rows, in bump-outs, and along perimeters. Use stormwater tree boxes in wide sidewalks and entrance courts.
Reduce impervious area	Create shallow depressions in medians, centerline safety strips, and roundabouts and plant with low-profile vegetation. For retrofits, redirect stormwater flow from storm sewers to bioretention areas.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$10,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Capital improvement funds
- Property tax assessments
- Smart growth grants
- State or private grants
- State revolving loans
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Design practices with sufficient access and features that make maintenance easier, such as paved forebays for easy sediment removal.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use wheel stops or curbs with cuts to ensure that cars do not drive over bioretention.
- Grade drainage to slope toward bioretention areas or permeable pavement; avoid concentrated flows.
- Design curb cuts and inflow areas to manage adequate flow.

POTENTIAL PROJECT PARTNERS

Seek input from **business improvement districts** and **neighborhood associations** regarding desired features and amenities of green parking areas. Solicit funding from business associations to improve municipal parking areas serving a commercial district. Engage **civic leagues, environmental groups,** and **garden clubs** to provide support and volunteers to help build and maintain green infrastructure. Provide municipal incentives to **private property owners** to build new parking with green features. Consider provision of design assistance and expedited permit reviews.

FOR MORE INFORMATION

- EPA Office of Sustainable Development Green Parking Lot Fact Sheet: www.epa.gov/regionn2/ sustainability/parking/index.html
- Green Parking Council: www.greenparkingcouncil.org
- Parking Spaces/Community Places: Finding the Balance through Smart Growth Solutions: www.epa.gov/smartgrowth/pdf/EPAParkingSpaces06.pdf

Permeable pavers are used in compact parking stalls, which have lower traffic volume than the driving lanes.

A bioretention area treats runoff from the parking surface and is planted with low-maintenance vegetation.

CASE STUDY: LANCASTER PARKING LOT TRANSFORMATIONS—LANCASTER, PENNSYLVANIA

The City of Lancaster, Pennsylvania has taken on a series of four city-owned parking lot renovations in the city's southeast region. The renovated parking lot designs incorporate stormwater management features. Stormwater measures added to the parking lots on Plum Street, Dauphon Street, Pennsylvania Avenue, and Mifflin Street include repaving with permeable concrete, tree plantings, rain gardens, and reorganization of parking area placement to accommodate additional vehicles without expanding paved surface area (City of Lancaster 2014). The four renovated parking lots are each estimated to intercept between 600,000 and 700,000 gallons of stormwater that drains from surrounding blocks every year. Prior to the renovations, stormwater entered the sewer system and was overwhelming the treatment capacity of the facility, leading to raw sewage discharges into the Conestoga River, and ultimately the Chesapeake Bay (Harris 2011). Each of the parking lot renovations is estimated to cost about $160,000, with funding provided by a loan from the Pennsylvania Infrastructure Investment Authority and grant funding from the National Fish and Wildlife Foundation. The parking lot renovations are part of a series of green projects that the City of Lancaster implemented as an alternative to a $300 million grey infrastructure approach of building storage tanks to hold overflow until it could be treated (Harris 2011).

Plum Street parking lot retrofits.
Photo credit: CH2M Hill.

References:

City of Lancaster. 2014. *Parking Lots: Southeast Parking Lot Transformation*. http://www.saveitlancaster.com/local-projects/parking-lots/.

Harris, B. 2011, November 27. Lancaster city alley gets 'green' makeover. *Lancaster Online*. http://lancasteronline.com/news/lancaster-city-alley-gets-green-makeover/article_f05a7df8-8a75-5ab5-b799-c251c92905ec.html.

CASE STUDY: ST. LANDRY PARISH VISITOR'S CENTER—ST. LANDRY PARISH, LOUISIANA

The St. Landry Parish Visitor Center in Louisiana, was constructed to achieve LEED certification by incorporating sustainable materials with both aesthetic and functional purposes. For example, construction incorporated recycled building materials and stormwater control measures including permeable recycled asphalt in the conservatively sized parking lots. Stormwater runoff from the parking lot and roof is entirely retained on site by cisterns, rain gardens, and a series of bog ponds that collect and filter runoff. Native plants landscape the building's exterior, reducing maintenance and eliminating irrigation needs. In addition to stormwater control features, the visitor center incorporates energy saving measures, such as wind turbines, daylighting, low-energy insulated glazing, minimized east and west exposure to reduce solar heat gain, personal temperature controls, dual flush toilets, and energy star rated appliances. The resulting visitor center complements the existing landscape in a way that maximizes the natural meadow and landscape space and showcases sustainable strategies that are not only effective from ecological and monetary standpoints, but also serves as an educational example of the benefits of green infrastructure. The project was funded through public funding from federal and parish sources. Costs totaled approximately $330,000, with $130,000 allocated to parking sitework, walkways, and bioswales. The remaining $200,000 was split equally between landscaping, and utilities, drainage, gabion walls, and dirtwork. The stormwater measures incorporated in the visitor center are estimated to provide over 10% savings in construction costs compared to traditional site design and development and should result in long-term savings from landscaping that will not require potable water for irrigation.

Rain chains direct roof runoff to a cistern and infiltration area.
Photo credit: Jeffrey Carbo Landscape Architects.

Reference:

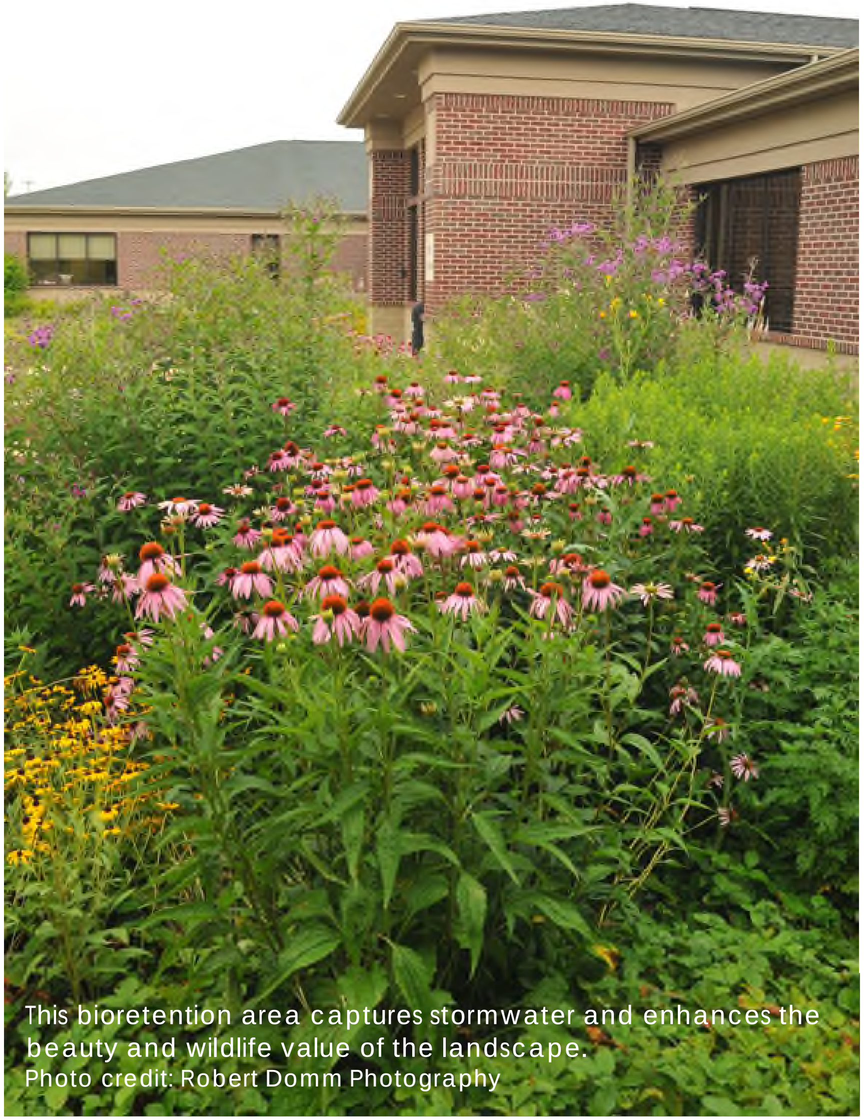
ASLA. No date. Green Infrastructure & Stormwater Management Case Study: St. Landry Parish Visitor's Center. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20128%20St%20Landry%20Parish%20Visitor's%20Center,%20LA.pdf.

Build Green Infrastructure at Public Facilities

FACT SHEET #3

Municipal buildings, libraries, public parking lots, schools, community centers and parks offer opportunities for highly visible green infrastructure retrofits. Projects can be undertaken as part of the capital improvement process, ideally in conjunction with other needed maintenance such as building additions and modifications, repaving, re-landscaping, or infrastructure repair or replacement. Green infrastructure offers the following benefits:

- Reductions in impervious area
- Infiltration of runoff from paved areas and rooftops
- Public education opportunities (signage)
- Shade when trees are used
- Wildlife habitat
- Welcoming area
- Creation of park-like areas



This bioretention area captures stormwater and enhances the beauty and wildlife value of the landscape.
Photo credit: Robert Domm Photography

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement	Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, sidewalks, medians, and alleys.
Flow-through planters	Install fully-lined flow-through planters at the foot of buildings to slow the flow of runoff from rooftops to the storm drain system.
Bioretention	Replace paved and gravel areas between the curb and sidewalk, in parking islands and medians, and parking aisles with shallow depressions planted with low-maintenance vegetation.
Trees	Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts, and in landscaped areas to provide shade and improve aesthetics.
Rainwater harvesting	Install cisterns and rain barrels to collect runoff from roof downspouts for nonpotable reuse (e.g., irrigation, wash water).
Reduce impervious area	Convert unused parking to open space or bioretention. Replace pavement in medians and traffic islands with vegetation.

Project Complexity

Medium

Timeframe

1–3 years

Installation Costs

$50,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Property tax assessments
- Stormwater utilities
- Smart growth grants
- State and private grants
- State revolving loans
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Retrofitting public property to include green infrastructure features is most efficient and cost-effective when it occurs in conjunction with other needed maintenance and upgrades.
- Incorporate signage to educate the public about how stormwater is managed by the facilities.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.
- Site and design practices with sufficient access and features that make maintenance easier, e.g., include paved forebays for easy sediment removal.

POTENTIAL PROJECT PARTNERS

School districts and students, parent/teacher associations, friends of the library, and downtown business associations can provide input into the design and placement of the practices for maximum utility and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs. Students can study, monitor, and maintain water quality facilities on school grounds as part of their science curriculum.

FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx

Educational signage can explain how stormwater practices work.


Tree boxes and other green infrastructure features enhance the aesthetics of a plaza space, create shade, and infiltrate stormwater.

CASE STUDY: NORTH AND SOUTH RIVERS WATERSHED ASSOCIATION RAIN GARDENS—SOUTH SHORE, MASSACHUSETTS

The South Shore Region of the Massachusetts Bays National Estuary Program (MassBays) and its host organization, the North and South Rivers Watershed Association (NSRWA), have worked to implement and encourage green infrastructure techniques throughout the region. Between 2006 and 2008, MassBays/NSRWA installed a rain garden in nearly every town on the South Shore. Partnering with local organizations to identify areas that receive high volumes of stormwater runoff, MassBays/NSRWA installed rain gardens in key public locations like schools and libraries in towns including Hull, Weymouth, Hingham, Norwell, Hanover, Pembroke, Scituate, Marshfield, Duxbury, Kingston, and Plymouth. Funding for the rain gardens was sourced by a 104b3 grant from EPA and MassDEP. MassBays/NSRWA also helped the Towns of Kingston and Pembroke obtain EPA 319 grants through MassDEP in 2006 to install green infrastructure practices like rain gardens, permeable pavement and pavers, and plastic grid at the Kingston Intermediate School and Pembroke's Town Hall and Oldham Pond boat ramp. In 2010, NSRWA/MBP worked with the Town of Marshfield to secure a 604b ARRA grant from the EPA and MassDEP for bacterial source tracking in the South River and subsequent design of stormwater BMPs to remediate bacterial pollution.

In 2011, MassBays provided funding to the town of Kingston received funding to evaluate the feasibility of installing green infrastructure at stormwater outfalls that discharge into the Jones River and Kingston Bay to address deteriorating water quality that resulted in restrictions on shellfish harvesting. Beginning with 35 known stormwater outfalls to the Jones River, the town identified a subset at which to perform water quality sampling during two storm events. Based upon the results of the sampling, local site conditions, and proximity of the site to the Bay, green infrastructure-based BMPs for 10 of the sites were brought to a conceptual design stage. Since 2012, detailed engineering designs have been developed for the most promising sites with funding from the state Office of Coastal Zone Management, and two BMPs are now in place. Based upon the conceptual designs, a materials quantity takeoff was performed and a construction cost estimate developed for each location. Construction costs were increased by 15% to cover contingencies and 25% to cover the cost of services for final design and construction inspection. The total construction cost, including final engineering design, construction, and construction inspection for all ten locations, was estimated to be $556,392. Based upon the matrix analysis results, two sites were selected for preliminary design. Two drawings were completed for the preliminary designs. Preliminary design at the paved swale on Delano Avenue was proposed to be comprised of a trench drain at the toe of the road, two 5’ drain manholes with 4’ sumps, and two 18’ diameter rain gardens. Based on the preliminary designs, a total construction cost estimate of $268,778 has been calculated for the two catchment areas. The total construction cost includes 10% for construction contingencies and 25% for services related to design and construction inspection. The total construction cost estimate to mitigate all twelve outfalls is $825,170.

Rain garden off of Delano Avenue in Kingston, MA.
Photo credits: Maureen Thomas, Town of Kingston.

CASE STUDY: BAMBOO BROOK HISTORIC WATER SYSTEM RESTORATION—MORRIS COUNTY, NEW JERSEY

The Bamboo Brook Outdoor Education Center, formerly Merchinston Farm, underwent a restoration effort in 2009 to restore the existing but deteriorated system of scenic pools, streams, and tanks constructed by the original owner, a pioneer of landscape architecture. The design included water conservation measures such as bioswales, native plants, and rainwater harvesting devices. The system can now capture the runoff generated by a 2-year storm event. The restoration of the stormwater project was estimated between $1M and $5M, with public funding from state, local, New Jersey grant and Morris County Park Commission funding. The state estimates that 7 employment years were created by this project. To complete the project, approximately 6,346 hours were needed for planning and design; 6,820 hours for construction, and approximately 4,000 hours needed for annual maintenance.

Bamboo Brook Outdoor Education Center restoration.
Photo credit: Patricia M. O'Donnell, Heritage Landscapes LLC.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bamboo Brook Historic Water System Restoration. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20055%20Bamboo%20Brook%20Historic%20Water%20System%20Restoration,%20Morris%20County,%20NJ.pdf.

Design Traffic Safety Features to Manage Stormwater and Improve Aesthetics

FACT SHEET #4

Municipalities are tasked with ensuring that vehicles, pedestrians, and cyclists are safe on roads and sidewalks. Traffic-calming features, such as chicanes, roundabouts, and curb bump-outs, slow vehicle traffic and enhance pedestrian safety by drawing attention to pedestrians and reducing the distance pedestrians must travel to cross the road. These safety features offer opportunities to integrate green infrastructure. By building new streets and retrofitting existing streets with green infrastructure traffic calming measures, a municipality can do the following:

- Reduce street and sidewalk impervious area
- Infiltrate runoff from streets, sidewalks, and adjacent properties
- Calm vehicle traffic
- Enhance pedestrian safety
- Encourage multimodal transportation
- Improve streetscape aesthetics
- Provide wildlife habitat
- Improve water quality

This curb bump-out integrates bioretention and art. Its location at a crosswalk shortens the crossing distance for pedestrians.

GREEN INFRASTRUCTURE OPPORTUNITIES

Bioretention	Use bioswale islands at skewed intersections to decrease impervious area and make traffic paths more obvious. Install bioretention chicanes and bumpouts to slow vehicle traffic. Install curb bump-outs with bioretention at pedestrian crossings for increased visibility, safety, and convenience. Use narrow strips of bioretention (i.e., green gutters) to provide a visual barrier and buffer between bicycle and vehicle lanes.
Trees	Incorporate street trees for shade and aesthetic benefits.
Permeable pavement	Use permeable pavement for bicycle lanes to distinguish them from automobile travel lanes and to reduce standing water and ice formation.
Reduce impervious area	Convert raised medians and traffic islands to swales with curb cuts. Replace the center of paved cul-de-sacs with vegetated, shallow roundabouts.

Project Complexity

Low to medium

Timeframe

Months to several years depending on complexity

Installation Costs

$10,000 and up, depending on site and scale

Factors Affecting Costs

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Property tax assessments
- Stormwater utilities
- Transportation planning grants
- State and private grants
- Issuing bonds

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Ensure that traffic-calming measures do not interfere with emergency response vehicles.
- Select vegetation that will not impede driver sight lines or block pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Select vegetation that will be less likely to be stolen.
- Design facilities to manage the appropriate flow volumes to avoid blow-outs.
- Design to allow easy maintenance and reduce the potential for clogging.
- Consider a pilot project to incorporate green infrastructure and traffic calming features at an intersection or along a residential or commercial corridor that has a history of conflicts between drivers, cyclists, and pedestrians.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to eliminate the need for regrading.

POTENTIAL PROJECT PARTNERS

Residents can help municipalities identify areas of known conflicts between vehicles, cyclists, and pedestrians. Business associations benefit from slower traffic in commercial corridors and measures that encourage foot traffic. Public health organizations support measures that encourage walking and biking and reduce injuries to pedestrians. State highway departments can partner with municipalities to undertake projects on state-managed roads.

FOR MORE INFORMATION

National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets

Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm

Portland Green Streets website: www.portlandoregon.gov/bes/44407

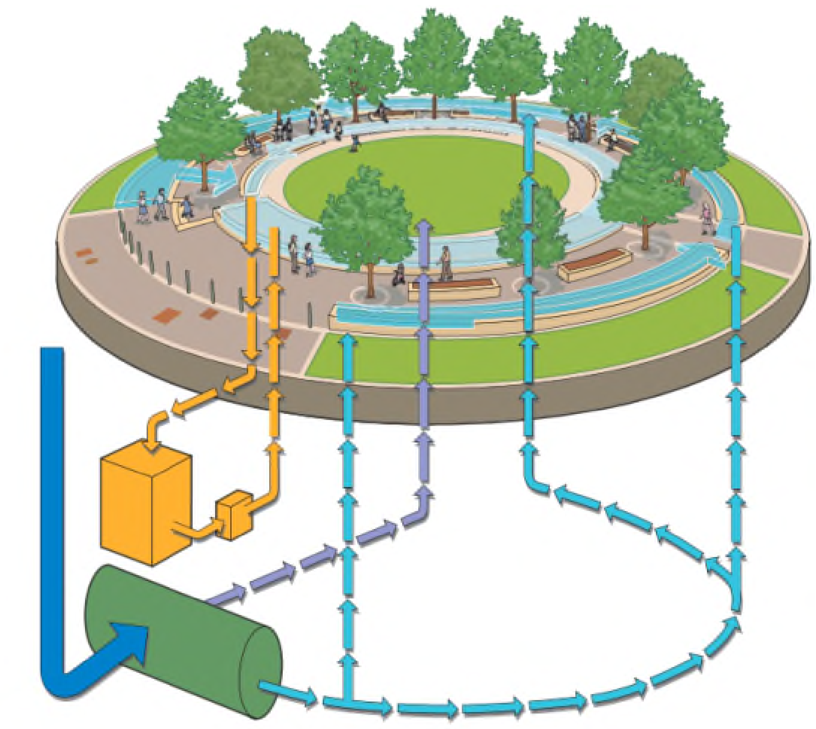
Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

This bioretention bump-out captures runoff and slows traffic on a road frequented by cyclists and pedestrians.

CASE STUDY: UPTOWN CIRCLE TRAFFIC CALMING AND BIORETENTION PROJECT—NORMAL, ILLINOIS

Uptown Circle unites four Central Business District streets in Normal, Illinois. Completed as part of a larger business district redevelopment plan, the completed traffic circle transforms a formerly awkward intersection into a shared environment for motorists, pedestrians, and bicyclists, while providing community benefits such as slowed traffic, improved air quality, and reduced and mitigated stormwater runoff (Context Sensitive Solutions.org 2005).

The center of the circle provides innovative stormwater management by collecting stormwater using an obsolete storm sewer converted into a cistern. Subsequently, the stormwater flows via a series of filters into two subsurface channels where the water is filtered by plants in the outer channel and is slowed by a textured surface in the inner channel. SilvaCell™ trees and a grassy area enhance aesthetics and create a park-like setting (Context Sensitive Solutions.org 2005). The cistern beneath the traffic circle holds as much as 75,000 gallons of stormwater collected from the nearly 3 acres of paved surfaces draining to the system (Context Sensitive Solutions.org, no date).



Uptown Circle design.
Photo credit: Hoerr Schaudt, Landscape Architects

The project cost $1.5 million for Uptown Circle (Landscape Architecture Foundation, no date). The Landscape Architecture Foundation (no date) estimates many cost savings and environmental benefits from the traffic circle construction that include:

- Capture and reuse of 1.4 million gallons of stormwater onsite resulting in an estimated $7,600 annual potable water savings from the 58,800 square foot area.
- 1.4 million gallon reduction in stormwater load entering the municipal storm sewer from stormwater reuse for irrigation, onsite water feature, groundwater recharge, and water uptake by onsite green features (e.g., tree wells, planter areas, or underground storage facilities).
- Improved onsite water quality resulting from the sand, UV and bog filter systems. Estimates suggest that 91% of total suspended solids, 79% of total phosphorous, and 64% of total nitrogen can be removed each pass through the various filtration systems.
- Expected cost savings of over $60,000, across a 50 year period, from increased street tree lifespan resulting from the use of underground structural cells; thus, reducing costs associated with new street tree purchase and installation.
- Expected average carbon sequestration of more than 103 pounds of carbon annually from each of the 104 newly planted trees.
- Increase in Uptown financing district property values. Property values in the financing district increased by $1.5 million (or 9%) from 2009 to 2010, which translates to a 31% increase from 2004.
- Increase in revenue of more than $680,000 from conference events held in the newly developed multi-phase, mixed use Uptown Redevelopment project.

References:

Context Sensitive Solutions.org. 2005. Uptown Circle. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/.

Context Sensitive Solutions.org. No date. The Uptown Normal Circle: A Living Plaza. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/resources/b4/.

Landscape Architecture Foundation. No date. Uptown Normal Circle and Streetscape. http://landscapeperformance.org/case-study-briefs/uptown-normal-circle.

CASE STUDY: 14TH AVENUE NEIGHBORHOOD STREET FUND PROJECT—SEATTLE, WASHINGTON

The City of Seattle, Washington is benefitting from improvements to 14th Avenue that address previous stormwater treatment challenges while enhancing the appearance of the avenue. The project location has historically been susceptible to stormwater impacts due to soil with naturally low permeability and close proximity to a non-combined sewer system. To control stormwater impacts, 14th Avenue was redesigned at a cost of $75,000 to divert runoff through vegetated swales that are lined with a layer of aggregate and bioretention soil to promote retention and slow water velocity by a series of check dams. Additional water that is not retained by the bioswales is diverted to an existing stormwater system via curb cuts. While the city did not record water treatment improvement specific to this project, they estimate an 80 to 85 percent improvement in non-point source pollutants, based on a similar local project (ASLA 2013).

In addition to stormwater management improvements, pedestrian safety was addressed with the addition of a planted pedestrian island and curb bulb extensions that reduce the distance to cross the avenue and increase visibility distance for both pedestrians and motorists. Aesthetic appeal was enhanced with the installation of trees and public art (ASLA 2013, City of Seattle 2009).

The project was a collaborative effort among the city of Seattle, the 14th Ave Visioning project group, and the East Ballard Community Association and was implemented by the Seattle Department of Transportation. The $75,000 budget covered both stormwater and pedestrian safety features. Funding was sourced from the Neighborhood Street Fund, a local levy. The green infrastructure approaches were a cost effective alternative that the city estimates to have saved over 10% compared to traditional design approaches (ASLA 2013).

Rain garden along Seattle's 14th Avenue.
Photo credit: Aaron and Jennifer Britton

References:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: 14th Avenue Neighborhood Street Fund Project. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20422%2014th%20Avenue%20Neighborhood%20Street%20Fund%20Project,%20Seattle,%20WA.pdf.

City of Seattle. 2009. 14th Avenue S Street Improvements. http://www.seattle.gov/transportation/14ave_south_improvements.htm.

Create Stormwater Microparks

FACT SHEET #5

Urban landscapes have many small-scale pockets of space that are underutilized and sometimes unsightly. These spaces often are located in triangles at junctions of diagonal streets, in spaces between buildings, in vacant lots, or in corners of parking lots. These underused areas are often paved or have high-maintenance turf that offers limited amenity value. They can be converted to a bioretention area or community garden with trees and attractive vegetation, and can accomplish the following:

- Reduce impervious surface
- Infiltrate runoff from the right-of-way and adjacent property
- Protect and restore water quality
- Improve aesthetics
- Create park-like areas
- Provide shade
- Showcase public art
- Provide wildlife habitat
- Promote urban agriculture

The low concrete walls of stormwater planters in a courtyard serve as seating. The project was designed with mixed textures and prominent structure to be safe for the visually impaired.

GREEN INFRASTRUCTURE OPPORTUNITIES

Permeable pavement Incorporate pavers into walkways and areas in deep shade where vegetation might not thrive.

Flow-through planters Use these practices, which are fully lined to prevent infiltration from undermining building foundations or other structures, alongside buildings to temporarily detain rooftop runoff from downspouts.

Bioswales Remove pavement or gravel and create a shallow depressed area with ornamental grasses, shrubs, and trees.

Trees Incorporate trees into microparks for shade, stormwater and climate change benefits, and to improve aesthetics.

Soil amendments Evaluate in-situ soils and amend them with organic matter or till them as necessary to improve infiltration and plant growth.

Reduce impervious area Remove pavement at underused sites to increase stormwater infiltration. Convert vacant lots and larger sites to community gardens for the benefit of neighborhood residents. Convert one or more street parking spaces to a micropark that serves as a seating area or gathering space.

Project Complexity

Easy

Timeframe

Less than 1 year to several years

Installation Costs

$5,000 and up, depending on site and scope

Factors Affecting Costs

- Scale of the project
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

Financing Opportunities

- Neighborhood revitalization funding
- Parks bonds
- Property tax assessments
- Stormwater utility
- Smart growth grants

Necessary Maintenance

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

THINGS TO CONSIDER BEFOREHAND

- Review local codes (setback requirements, sidewalk widths, parking requirements, etc.) to ensure there is space for green infrastructure practices.
- Identify possible conflicts with existing utilities.
- Ensure that there is adequate light for plant growth, or select shade-tolerant plants for microparks surrounded by buildings.
- For microparks adjacent to streets, consider enhanced pedestrian safety measures, such as wheelstops, railings, buffers, curb extensions, and painted crosswalks.
- Consider maintenance requirements and confer with public works staff who maintain such systems and landscapes.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.

POTENTIAL PROJECT PARTNERS

Business associations, neighborhood associations, garden clubs, and **private sponsors** can provide funding and volunteers to help build and maintain microparks. They can also offer input into the design and placement to maximize the benefit to the community.

FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx

The concrete walls of this drywell offer seating around the perimeter of a courtyard, and an artful downspout creates a focal point.

The low stone walls on either side of this sidewalk artfully funnel rainwater to a flow-through planter along the side of a building.

CASE STUDY: BAYSIDE PROMENADE TRAIL MICROPARK AND REDEVELOPMENT PROJECT—PORTLAND, MAINE

In association with the City of Portland, Portland Trails, the Trust for Public Lands, and the Bayside Neighborhood Association, the 1.2-mile shared-use Bayside Promenade was constructed as a "spine" throughout the City, allowing pedestrian and bicycle access to pocket parks, residential areas, schools, and local businesses. The trail utilizes an abandoned railroad right-of-way and was constructed in the heart of the revitalized commercial and residential neighborhoods in Bayside and East Bayside.

Bayside Promenade Trail permeable pavement.
Photo credit: Portland Trails

No stormwater reduction analyses were performed for the full scale project; however, the project is expected to reduce stormwater runoff by 10% to 20% through a combination of newly installed LID practices including bioretention, rain gardens, bioswale, porous pavers, and curb cuts. The project cost between $100,000 and $500,000 and used public funding from federal, state, and local sources. Planning, design, construction, and long-term maintenance of the project increased jobs and boosted the local economy.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bayside Promenade Trail. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20332%20Bayside%20Promenade%20Trail,%20Portland,%20ME.pdf.

CASE STUDY: RINCON HEIGHTS MICROPARKS PROJECT—TUCSON, ARIZONA

As part of a larger neighborhood-scale retrofit project, a previously abandoned lot in the Rincon Heights Neighborhood in Tucson, Arizona, was retrofitted into a pocket park with multiple green infrastructure practices to capture stormwater runoff, improve water quality, and reduce flooding. The project features a 5,000 square foot pocket park featuring curb cuts, bioretention facilities (e.g., swale, gravel-filled trenches, basins), curb extensions, and removal of unnecessary impervious pavement onsite.

Rincon Heights, Feld Davis pocket park.
Photo credit: Alisha Goldstein

The estimated project cost was approximately $500,000 and included grant funding from the Arizona Department of Environmental Quality; Rincon Heights Neighborhood Association, the City of Tucson Department of Transportation, and Tucson Clean and Beautiful/Trees for Tucson were project partners. The project now showcases an innovative sustainable design in a previously underutilized residential area in Tucson. The green infrastructure practices aim to slow traffic and increase onsite infiltration providing aesthetic, safety, and stormwater benefits.

Reference:

Watershed Management Group. 2014. Demonstration Sites. http://watershedmg.org/demo-sites/tucson.

Appendix B:

Pollutant Load Modeling Report

APPENDIX B: POLLUTANT LOAD MODELING REPORT

Water Integration for the Squamscott-Exeter (WISE) River Watershed

Prepared for

Town of Exeter, Town of Stratham and Town of Newfields

Prepared by

Geosyntec Consultants, Inc.
75 Congress Street, Suite 301
Portsmouth, New Hampshire 03801

Project Number: BW0246

April 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. PURPOSE

The purpose of this report is to present the modeling methodology, data analysis and results from the pollutant load model developed as part of the Water Integration for the Squamscott-Exeter (WISE) Preliminary Integrated Plan. The model was developed to guide and advise the Integrated Planning process and to quantify the pollutant load sources, total loads and nutrient management strategies to reduce loads from the subwatershed. The model evaluates both point source and non-point source loads from the subwatershed and quantifies them by both subwatershed and municipality.

1.1 Terms of Reference

This report was prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of the WISE Project Team. The WISE Project Team, New Hampshire Department of Environmental Services (NH DES) and Region 1 Environmental Protection Agency (EPA) provided review, comment and input during the development of the modeling methodology, data analysis and results.

1.2 Report Organization

The report is organized into seven (7) sections with accompanying tables, figures and attachments:

- Section 1 provides an introduction.
- Section 2 provides project approach.
- Section 3 discusses the methodology utilized to develop the models, including the model goals and a discussion of each of the models included in the report.
- Section 4 discusses the hydrologic and hydraulic assumptions and calculations performed as part of the stormwater/BMP model, including a discussion of inputs.
- Section 5 describes the pollutant load budget model scenarios, a linear optimization model for non-point source (NPS) management decision support, and a discussion of the analysis and results.
- Section 6 provides report references.

1.3 Limitations

There is an inherent level of uncertainty in the watershed characteristics, stormwater pollutant concentrations and other information that was used to help estimate the baseline pollutant load status from the subwatershed. Therefore, it is important to understand the sources of uncertainties so that they can be quantified and incorporated into the model to create a more robust analysis. The sources of uncertainty are described below and a brief discussion of the main approaches for characterizing the uncertainty of the model input parameters.

The sources of uncertainty relating to the model input parameters arise from, but are not limited to, the:

- representativeness of data from studies conducted in other areas that were used in the analysis (e.g. runoff concentrations)
- general uncertainty in any stormwater data due to measurements, field protocols, data quality, and data accuracy
- stormwater volume estimating methods that rely on empirical relationships between annual rainfall and runoff
- spatial uncertainty in watershed/site conditions (e.g., imperviousness, soils, runoff parameters), as they relate to the certainty that can be had regarding hydrologic conditions at a given location
- model output relates one land use to one nutrient management measure and therefore, cannot be applied to a variety of land uses or multiple consecutive nutrient management measures (i.e., treatment train)
- model output associated with runoff volume and pollutant load are scaled from 1-acre parcels to the entire watershed area
- model does not consider runoff hydraulics after runoff leaves a hydrologic response unit or nutrient management measure

It is important to note that the model does not seek to describe the temporal variability that is inherent in stormwater pollutant loading. The model is intended to estimate long-term average conditions for the location and project. At this scale, temporal variability (e.g., storm-to-storm, year-to-year) is not relevant. Additionally, the model is not intended to predict conditions for a given storm event or monitoring period.

2. PROJECT APPROACH

The Squamscott-Exeter River is a tributary to the Great Bay tidal estuary. Like many other coastal regions, the Great Bay has experienced rising population and an associated increase in impervious cover and wastewater effluent, resulting in declining estuarine health attributed in large part to the nitrogen impairment in the Great Bay estuary. In 2009, the New Hampshire Department of Environmental Services (NHDES) published a proposal for numeric nutrient criteria for the Great Bay Estuary. The report found that total nitrogen concentrations in most of the estuary needed to be less than 0.3 mg/L to prevent loss of eelgrass habitat and less than 0.45 mg/L to prevent occurrences of low dissolved oxygen. Based on these criteria and an analysis of a compilation of data from at least seven different sources, NHDES concluded that the Squamscott-Exeter River and ten other sub-estuaries in the Great Bay Estuary were impaired for nitrogen. EPA confirmed the impairment and placed Great Bay on the 303(d) list of impaired and threatened waters in September 2009.

In response to the 2009 nitrogen impairment listing, new and revised discharge permits in the Great Bay watershed are subject to additional constraints related to nitrogen. The primary municipal permits which are affected include: National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment facilities and Municipal Separate Storm Sewer Discharge (MS4) permits for stormwater.

In response to the additional permit constraints, outlined in the Integrated Plan, using the modeling approach discussed in this Report, the Towns of Exeter, Stratham, and Newfields are working together to evaluate their current pollutant load contributions to the Squamscott-Exeter Watershed and nutrient management measure that could be installed to mitigate the effects of their current pollutant load.

2.1 Model Approach Overview

To understand the pollutant load inputs from the Squamscott-Exeter River subwatershed to the estuary, a watershed-scale pollutant load model and budget were developed, which provides the average annual load to the estuary from nonpoint and point sources for the subwatershed and by Town.

The pollutant load model was developed building on a number of existing studies and methods to account for surface water and groundwater loads to the estuary (Breaults et al 2002, NHDES 2014, VHB et. al. 2014, Valiela et al 2000, Exeter 2014). The various components are summarized below:

- Stormwater Load Model (Unattenuated), (SWMM5);
- Aerial Deposition Load Model (GBNNPSS);
- Septic System Load Model (GBNNPSS);
- Agricultural Load Model (NRCS/WISE/GBNNPSS/ORIWMP);
- Attenuation in pathways in groundwater and surface water (GBNNPSS/NLM); and
- WWTF Load (Exeter/Wright Pierce).

The model was developed using a hydrologic response unit (HRU) approach, idealized 1-acre representative parcels, with varying combinations of land use, soil type, and impervious cover. Precipitation data from a local gauge is used to perform a continuous rainfall-runoff simulation of the HRUs to estimate the amount of stormwater volume generated by each HRU. A full description of the modeling methodology is discussed below.

2.2 Modeling Goals

The modeling goals are to:

- Quantify annual pollutant loads by source for the Towns of Exeter, Stratham and Newfields;
- Evaluate and examine a range of stormwater green infrastructure control strategies for the Towns of Exeter, Stratham and Newfields to achieve reduction of nitrogen and other pollutants of concern;
- Evaluate and examine a range of non-point source controls such as fertilizer reductions, septic system improvements, street sweeping efforts and good housekeeping measures to achieve reductions of nitrogen and other pollutants of concern;
- Evaluate and examine a range of point source controls at the wastewater treatment plant (WWTP) based on regulatory requirements to achieve reduction of nitrogen and other pollutants of concern; and
- Develop costs associated with a range of potential control strategies to achieve reduction of nitrogen and other pollutants of concern.

2.3 Model Area

The modeled area includes all portions of the towns of Newfields, Stratham, and Exeter that are located within the Squamscott-Exeter River subwatershed, as illustrated by the area in Figure 2-1. Project AreaThe model area consists of 19,124 acres, with 7,324 acres of developed (residential, commercial, industrial, etc.) land. The overall percent impervious cover within the model area is 9.6%. Soils within the model area are predominantly within the B and C soil hydrologic groups. In each of the three towns within the model area, “forest” is the predominant land use, with “residential” being the second most common land use.

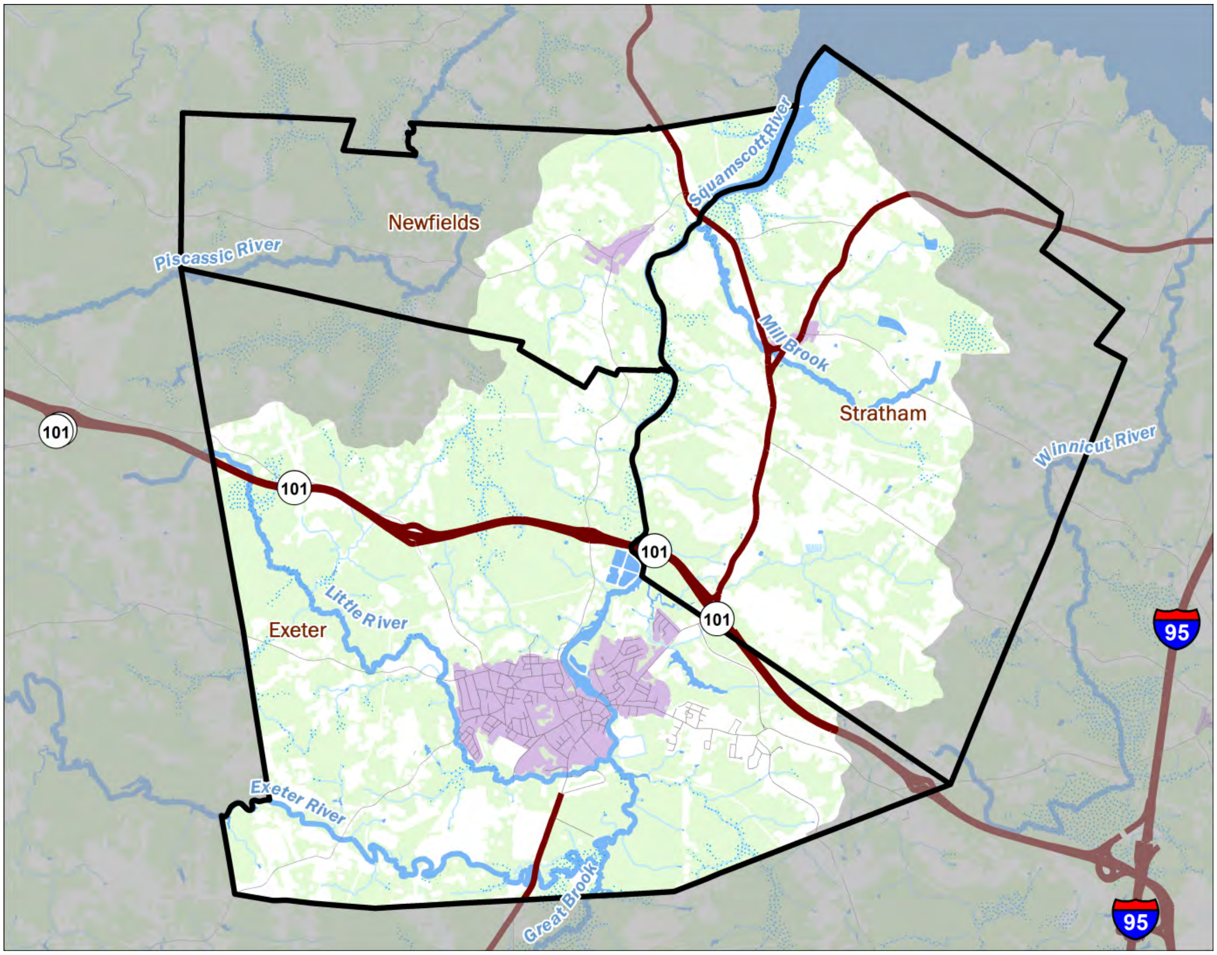


Figure 2-1. Project Area

3. MODEL METHODOLOGY

3.1 Stormwater Model

The purpose of the stormwater model is to estimate annual pollutant load export rates (PLERs) and annual pollutant load from the land uses within the subwatershed. Using the EPA Stormwater Management Model, Version 5.1 (SWMM5), a dynamic rainfall-runoff model, idealized 1-acre watersheds were created to quantify the volume of stormwater runoff and pollutant load from the land uses represented in the subwatershed. SWMM5 was also used to simulate treatment from various nutrient management measures consisting of non-structural controls and structural green infrastructure (GI) controls of varying sizes.

3.1.1 Climatological Inputs

3.1.1.1 Precipitation and Temperature

Precipitation and temperature data were gathered from a regional gauge to accurately represent historic climatological conditions. Twenty years of historic 1-hour precipitation data (1985-2005) for the project area was obtained from the National Climate Data Center at the following station:

(i) Station ID: COOP272174 in Durham, New Hampshire approximately 9 miles north of the Project area at latitude 43°09', longitude 71°57'W (NAD27).

Temperature data were used to simulate evaporation and precipitation which would fall as snow, instead of rain.

3.1.1.2 Evaporation

Under natural conditions, a fraction of surface water and moisture in the upper soil (vadose) zone may circulate back to the atmosphere via evapotranspiration processes (Thornwaite, 1948). It is assumed that vegetative uptake (and subsequent loss via transpiration) is significant within existing surface water sources (i.e., wetlands, ponds, river).

Monthly average evaporation rates were obtained from the Northeast Regional Climate Center (NRCC) for Concord, NH (Table 3-1).

Table 3-1. Monthly Average Evaporation Rates, Concord, NH (NRCCC)

Month	Evaporation (in/day)
Jan	0.010
Feb	0.017
Mar	0.037
Apr	0.070
May	0.113
Jun	0.130
Jul	0.142
Aug	0.122
Sep	0.080
Oct	0.046
Nov	0.021
Dec	0.011

3.1.1.3 Snow Pack

A snow pack routine was used in the SWMM model to account for the buildup of snow on the land surface and its subsequent melting, runoff, and infiltration. The following parameters summarize the snow pack model.

a) Dividing temperature between snow and rain: the temperature below which precipitation falls as snow instead of rain. This parameter was set to 28 degrees F.

b) Base temperature: the temperature at which snow begins to melt. This parameter was set to 20 degrees F.

c) Melt coefficient: the rate at which snow melts beyond the base temperature. This was set to a standard value of 0.001 in/hr-deg F.

d) Areal depletion curves: these curves describe the percentage of area covered by snow as a function of the average snow depth. Impervious HRUs were represented with uniform snow cover, while pervious HRUs were assigned the standard ‘natural area’ areal depletion curve provided by SWMM (Table 3-2).

Table 3-2. Aerial depletion curve for pervious areas.

Snow Depth (in)	Fraction of Area Covered by Snow
0.0	0.1
0.5	0.35
1.0	0.53
1.5	0.66
2.0	0.75
2.5	0.82
3.0	0.87
3.5	0.92
4.0	0.95
4.5	0.98
5.0	1

3.1.2 Land Use Analysis

Using land use data layers provide by NH GRANIT, the state of New Hampshire's GIS clearing house, 58 land use classifications were analyzed in the subwatershed (NH GRANIT, 2008). The 58 land use classifications were reduced to a smaller subset, to represent both pervious and impervious cover within the subwatershed (Table 3-3). The land use data is used in the stormwater model for each land use, impervious/pervious cover combination as an HRU.

Table 3-3. Land Use Categories

Land Use Category	Cover Type		
	Pervious	Roof	Other Impervious
Residential	X	X	X
Commercial, Services	X	X	X
Institutional, Government	X	X	X
Industrial	X	X	X
Transportation, Communications, and Utilities			X
Industrial and Commercial Complexes	X	X	X
Mixed Developed Uses	X	X	X
Outdoor and Other Urban and Built-up Land		X	X
Agriculture	X		
Transitional	X		
Forest	X		
Wetlands	X		
Barren	X		

3.1.3 Hydrologic Response Units

To characterize and estimate the volume and quality of stormwater runoff generated from each of the land uses, identified in the subwatershed (Table 3-3), through the use of hydrologic response units (HRUs). HRUs are idealized catchments, 1-acre in size, which represent a land use cover, one of four hydrologic soil groups (HSG) and an imperviousness condition, either 100% impervious or 100% pervious.

3.1.3.1 Hydrologic Response Unit Characterization

Each hydrologic response unit was modeled in EPA SWMM 5.1, as a subcatchment. Subcatchments are defined as hydrologic units of land whose topography and drainage system elements direct surface runoff to a single discharge point. Subcatchments have user-defined properties which include the following parameters:

a) Area: area of each subcatchment (or HRU). All HRUs were modeled as 1-acre parcels

b) Width: width of the subcatchment is the physical width of overland flow. In ideal subcatchments or watersheds, this width is approximately twice the length of the main drainage channel. In more realistic, irregular watersheds, the width can be approximated by dividing the area of the subcatchment by the maximum length of overland flow. Since the HRUs were represented as square 1 acre parcels, the width was defined as the square root of the area of the parcel.

c) Percent Slope: percent slope should reflect the average along the pathway of overland flow to the inlet location (EPA, 2009). The slope of each of the HRUs was based on average slope of the landscape obtained by GIS analysis.

d) Percent impervious area: values are 100% or 0% for impervious and pervious HRUs, respectively.

e) Manning's n-values: describes the overland flow over impervious and pervious portions of the subcatchment. Default Manning's n values obtained from the SWMM 5 Applications Manual (EPA, 2009) were used.

f) Depth of depression storage: describes the ability of a particular land area to retain water in pits or depressions, thus preventing it from running off, on impervious and pervious portions of the subcatchment. The values were obtained from the SWMM 5 User's Manual (EPA, 2009) and based on cover type.

g) Percent zero-impervious: describes the impervious area in the subcatchment with no depression storage. The default value of 25% was used for all HRUs.

h) Sub-area routing: describes the internal routing of runoff between pervious and impervious areas. All HRUs use the "outlet" routing, which represents runoff from both areas flows directly to the outlet.

Error! Reference source not found.summarizes the SWMM input parameters and assumptions related to HRU characterization.

Table 3-4. SWMM input parameters for HRU characterization.

Input Parameter	HRU Type				
	Impervious	Pervious Soil Type			
		A	B	C	D
Area (ac)	1.0				
Width (ft)	208.7				
% Slope	0.50				
% Impervious	100	0	0	0	0
n-Impervious	0.012	-	-	-	-
n-Pervious	-	0.15	0.15	0.15	0.15
Depression Storage - Impervious (in)	0.10	-	-	-	-
Depression Storage - Pervious (in)	-	0.19	0.17	0.16	0.16
% Zero-Impervious	0.25	-	-	-	-
Routing	Outlet				
Curve Number	98	39	61	74	80

3.1.3.2 Hydrologic Response Unit Infiltration

SWMM estimates the rate at which rainfall infiltrates into the upper soil zone of a subcatchment's pervious area. Infiltration is estimated for each HRU using the Curve Number (CN) Method. The CN Method is adopted from the NRCS (SCS) and assumes that the total infiltration capacity of a soil can be found from the soil's tabulated Curve Number. During a rain event this capacity is depleted as a function of the cumulative rainfall and remaining capacity. The input parameters for this method are the Curve Number and the time it takes a fully saturated soil to complete dry (used to compute the recovery of infiltration capacity during dry periods). Curve numbers were assigned to HRUs based on the soil type and impervious cover (Table 3-4). For pervious subcatchments, the land use condition was assumed to be open space in good condition: grass cover on 75% or more of the area.

3.1.3.3 Hydrologic Response Unit Water Quality

In addition to generating stormwater runoff volumes, the HRUs were also used to generate pollutant loads. This was accomplished by using event mean concentrations (EMCs) and buildup/washoff functions.

An EMC is representative of the total pollutant mass during a runoff event divided by the total runoff volume of that event for a given land use. Literature values of EMC data are readily available with the most notable sources being the USEPA National Urban Runoff Program (NURP) and the National Stormwater Quality Database (NSQD).

Table 3-5 lists the various land use types from the model and the average EMC value from a variety of literature sources.

For pollutants, such as dissolved nitrogen, concentrations in runoff are typically higher during the beginning of a washoff event. Readily available pollutant mass that has built up on the land surface is washed off quickly, causing high pollutant concentrations early in the runoff event, and is gradually depleted, leading to lower concentrations at the end of the event. This phenomenon is known as 'first flush.' As EMCs are average concentrations over the course of a storm event, they are unable to represent first flush processes. For pollutants where first flush is a concern, such as nitrogen, the model uses buildup and washoff functions instead of EMCs.

Table 3-5. Event Mean Concentration (EMC) values for water quality modeling

Land Use Category	Cover Type	Event Mean Concentration (EMC)			
		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Total Suspended Solids (mg/L)	FC Bacteria (col/100mL)
Residential	Pervious (Lawn)	0.414 [1,6,7,12,13]	Buildup/ Washoff functions used for these land uses	171 [1,13]	4700 [1]
	Roof	0.1 [1,6,7,12,13]		28 [1,12]	2400 [1,12]
	Other Impervious	0.81 [1,6,12,13]		178 [1]	1900 [1]
Commercial, Services	Pervious	0.414 [1,6,7,12,13]		171 [1,13]	4700 [1]
	Roof	0.152 [1,6,7,12,13]		14 [1,12,13]	1100 [12]
	Other Impervious	0.26 [1,6,7,12,13]		64 [1,12,13]	3350 [1,12]
Institutional, Government	Pervious	0.24 [8,11]		29.5 [8,11]	
	Roof	0.24 [8,11]		29.5 [8,11]	
	Other Impervious	0.24 [8,11]		29.5 [8,11]	
Industrial	Pervious	0.414 [1,6,7,12,13]		171 [1,13]	4700 [1]
	Roof	0.08 [12]		17 [12]	5800 [12]
	Other Impervious	0.65 [12]		228 [12]	2500 [12]
Transportation, Communications, and Utilities	Road	0.54 [1,6,7,12,13]	1.51 [1,13]	248 [1,12]	2400 [1]
	Freeway	0.36 [4,8,11,13]	2.58 [4,8,11,13]	87 [4,8,11,13]	
	Right-of-Way	0.54 [1,6,7,12,13]	1.51 [1,13]	248 [1,12]	2400 [1]
	Utilities	0.2 [8]	1.2 [8]	20.7 [8]	
	Rail	0.13 [3]	1.63 [3]	97 [3]	
Industrial and Commercial Complexes	Pervious	0.414 [1,6,7,12,13]	Buildup/ Washoff functions used for these land uses	171 [1,13]	4700 [1]
	Roof	0.116		16	3450
	Parking	0.46		146	2925
Mixed Developed Uses		0.29 [5,8,10,11,13]	2.48 [5,8,10,11,13]	103 [5,8,10,11,13]	4600 [11]
Outdoor and Other Urban and Built-up Land		0.12 [8,9,13]	1.36 [8,9,13]	27.3 [8,9,13]	
Agriculture		0.53 [2,4,8,9,13]	2.85 [2,4,8,9,13]	80 [2,4,8,9,13]	
Transitional		0.31 [11]	1.33 [11]	48.5 [11]	7200 [11]
Forest		0.15 [2,4,8,10,13]	1.4 [2,4,8,10,11,13]	52 [2,4,8,10,11,13]	7200 [11]
Wetlands		0.16 [4,8,13]	1.36 [4,8,13]	9.6 [4,8,13]	
Barren		0.13 [3]	1.63 [3]	97 [3]	
References					

Steuer et al (1996). Sources of Contamination in an Urban Basin in Marquette, Michigan and an
1 Analysis of Concentrations, Loads, and Data Quality.

2 Line, D.E. et al (2002). Pollutant Export from Various Land Uses in the Upper Neuse River Basin.

3 Los Angeles County Stormwater Monitoring Report: 1998-1999

4 Harper, H.H. (1998). Stormwater Chemistry and Water Quality

5 Guerard, P., and Weiss, W.B. (1995). Water quality of Storm Runoff and Comparison of Procedures for Estimating Storm-Runoff Loads, Volume, Event-Mean Concentrations, and the Mean Load for a Storm for Selected Properties and Constituents for Colorado Springs, Southeastern Colorado.

6 Bannerman et al (1992). Sources of Pollutants in Wisconsin Stormwater

Waschbusch et al (2000). Sources of Phosphorus in Stormwater and Street Dirt from Two Urban
7 Residential Basins in Madison, WI.

8 CH2MHill Technical Memo. Urban Stormwater Pollutant Assessment, NC DENR 2001.

Adamus and Bergman (1995). Estimating Nonpoint Source Pollution Loads with a GIS Screening
9 Model

10 Results of the Nationwide Urban Runoff Program (NURP). Volume 1 – Final Report

11 Pitt, R. National Stormwater Quality Database v1.1. Summary Table.

12 Claytor & Shueler (1996). Design of Stormwater Filtering Systems

13 New Hampshire Stormwater Manual, Appendix D.

Buildup and washoff functions represent a two-stage process. During dry periods, pollutant mass builds up on the surface according to the following power relationship:

$$B = Min(C_1, C_2 t^{C_3})$$

where B is the total built-up mass, C_1 is the maximum possible built-up mass, C_2 and C_3 are constants that describe the rate of pollutant buildup, and t is the time.

When runoff begins to be generated during a precipitation event, the previously built up pollutant mass begins to wash off according to the following exponential process:

$$W = C_4 q^{C_5} B$$

where W is the rate of washoff in mass per hour, q is the rate of runoff in inches per hour, B is the amount of built up pollutant mass, and C_4 and C_5 are constants.

Literature data relating to buildup and washoff functions is scarce, and most reported parameters are site-specific and/or related only to broad land use classifications. For this reason, buildup and washoff parameters have been estimated by first using EMC data to calculate an annual pollutant load and subsequently calibrating buildup and washoff parameters so that the same annual load is reported from a 20-year continuous model simulation.

Table 3-6 presents the buildup and washoff coefficients (C1 – C5) used to describe nitrogen washoff from residential, commercial, and industrial land uses, where first flush is expected to be an important process. Figure 3-1 presents a comparison of nitrogen concentrations over the course of a storm event modeled with both EMC data and buildup/washoff functions. Figure 3-1 illustrates how EMC data is an average concentration over the entire period of the storm; whereas, the buildup and washoff functions have varying pulses of pollutants throughout the storm, which greater concentrations at the start of the storm.

Table 3-6. Buildup and washoff function parameters for total nitrogen from residential, industrial, and commercial land uses.

		Buildup Parameters			Washoff Parameters	
Land Use Category	Impervious Cover Type	C1	C2	C3	C4	C5
Residential	Pervious (Lawn)	28	0.05	0.88	0.085	1.55
	Roof	28	0.089	0.88	0.122	1.65
	Other Impervious	30	0.089	0.88	0.225	1.22
Commercial, Services	Pervious	28	0.05	0.88	0.085	1.55
	Roof	30	0.093	0.88	0.225	1.22
	Other Impervious	30	0.089	0.88	0.225	1.65
Institutional, Government	Pervious	28	0.05	0.88	0.105	1.8
	Roof	30	0.093	0.88	0.225	1.22
	Other Impervious	30	0.093	0.88	0.225	1.22
Industrial	Pervious	28	0.05	0.88	0.085	1.55
	Roof	30	0.093	0.88	0.225	1.22
	Other Impervious	30	0.089	0.88	0.124	1.65
Industrial and Commercial Complexes	Pervious	28	0.05	0.88	0.085	1.55
	Roof	30	0.093	0.88	0.225	1.22
	Parking	30	0.089	0.88	0.124	1.65

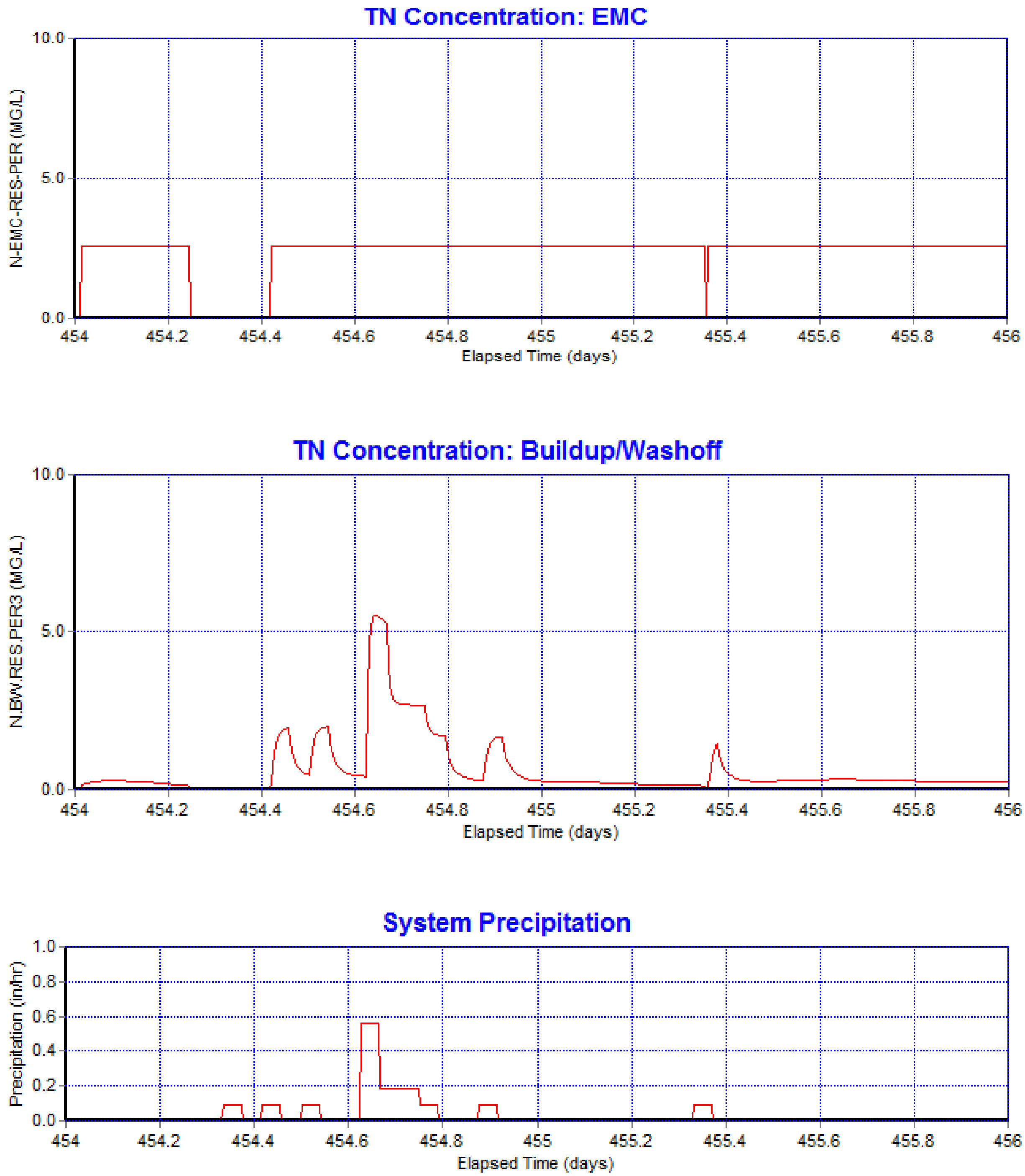


Figure 3-1. Total Nitrogen concentrations in runoff during a modeled storm event using EMC data (top) and using calibrated buildup/washoff functions (middle). Precipitation for the event is shown at bottom.

3.1.3.4 Hydrologic Response Unit Quantification

To estimate the area of each HRU type within the project area, several geospatial data layers were used to define the extent of each HRU type which include:

a) 2010 Land Use Data, provided by Rockingham Planning Commission (RCP);
b) USDA/NRCS SSURGO-Certified Soils;
c) 2010 Impervious Cover, provided by New Hampshire GRANIT; and
d) Building footprints (provided by Town of Exeter, Town of Stratham, and digitized from 2010 aerial photography by Geosyntec for Town of Newfields).

Table 3-7 through Table 3-9 show the results of this GIS analysis by listing the area of each HRU classification within the portion of each town in the Exeter-Squamscott watershed.

Table 3-7. Land Use/HRU areas for the portion of the Town of Exeter within the Exeter-Squamscott watershed.

	Town of Exeter: HRU Area within E-S Watershed (acres)					
Land Use Category	Roof	Other Impervious	A Soil	B Soil	C Soil	D Soil
Residential	153.80	205.47	175.63	695.34	481.56	418.60
Commercial, Services	23.70	93.90	1.15	18.41	27.00	24.39
Institutional, Government	33.75	97.52	6.40	29.85	25.09	43.81
Industrial	13.85	33.72	7.23	22.05	7.23	16.15
Road	-	391.33	-	-	-	-
Freeway	-	56.24	-	-	-	-
Utilities	-	-	8.15	48.24	43.77	46.96
Rail	-	-	0.81	0.68	7.46	6.84
Industrial and Commercial Complexes	0.92	17.53	0.03	2.22	4.88	2.37
Mixed Developed Uses	-	0.19	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	24.30	6.28	6.64	46.74	48.83
Agriculture	-	-	37.56	66.39	203.20	16.40
Transitional	-	-	33.49	64.11	177.19	37.68
Forest	-	-	266.73	2280.84	2114.76	180.01
Wetlands	-	-	10.44	236.43	893.56	473.60
Barren	-	-	4.48	18.45	17.24	8.56
Managed Turf	-	-	6.06	19.77	47.09	33.93

Table 3-8. Land Use/HRU areas for the portion of the Town of Stratham within the Exeter-Squamscott watershed.

	Town of Stratham: HRU Area within E-S Watershed (acres)					
Land Use Category	Roof	Other Impervious	A Soil	B Soil	C Soil	D Soil
Residential	77.72	129.23	443.13	237.57	531.00	84.54
Commercial, Services	9.44	42.82	5.30	15.70	17.99	7.11
Institutional, Government	4.14	10.64	3.75	1.38	12.11	3.68
Industrial	0.83	1.81	1.26	0.00	0.83	4.63
Road	-	191.84	-	-	-	-
Freeway	-	19.91	-	-	-	-
Utilities	-	-	9.55	7.27	63.20	4.12
Rail	-	-	0.25	0.22	0.00	0.44
Industrial and Commercial Complexes	8.06	21.70	0.00	1.26	3.27	7.89
Mixed Developed Uses	-	1.53	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	3.92	12.22	2.34	16.30	1.77
Agriculture	-	-	232.07	129.80	474.22	22.56
Transitional	-	-	110.45	53.93	207.02	29.95
Forest	-	-	267.72	362.29	1432.79	79.29
Wetlands	-	-	43.38	66.46	602.68	320.23
Barren	-	-	1.87	2.51	5.00	5.74
Managed Turf	-	-	3.64	0.31	3.56	9.57

Table 3-9. Land Use/HRU areas for the portion of the Town of Newfields within the Exeter-Squamscott watershed.

	Town of Newfields: HRU Area within E-S Watershed (acres)					
Land Use Category	Roof	Other Impervious	A Soil	B Soil	C Soil	D Soil
Residential	20.41	34.03	31.59	211.81	78.92	30.94
Commercial, Services	2.75	7.13	4.05	2.03	5.13	0.66
Institutional, Government	1.54	5.19	2.99	1.38	1.11	1.62
Industrial	10.35	11.69	1.06	3.85	2.80	3.93
Road	-	74.60	-	-	-	-
Freeway	-	-	-	-	-	-
Utilities	-	-	0.30	4.66	6.01	3.33
Rail	-	-	0.22	1.84	5.41	1.80
Industrial and Commercial Complexes	-	-	-	-	-	-
Mixed Developed Uses	-	-	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	1.53	7.27	9.37	10.20	1.78
Agriculture	-	-	3.98	37.96	42.42	1.82
Transitional	-	-	6.66	22.58	24.79	5.20
Forest	-	-	24.12	526.13	390.96	103.07
Wetlands	-	-	0.00	12.67	35.35	105.59
Barren	-	-	0.56	5.25	0.42	1.35
Managed Turf	-	-	-	-	-	2.5

3.2 Attenuated Groundwater Load

Attenuated groundwater load refers to nitrogen which originates from deposition on the ground surface and which is transported to the aquifer via infiltration. This quantity was not directly calculated, and relied on calculations performed as part of the GBNNPSS (NHDES, 2014).

Annual loads were calculated using the following process:

1. Deposition rates are used to determine the total initial load of nitrogen available in the watershed;

2. Nitrogen is partitioned into surface water (stormwater) and groundwater pathways according to the ratio of runoff to infiltration for a given land surface;

3. Delivery factors are applied to the two pathways to represent the effects of natural attenuation.

In order to estimate an attenuated groundwater load for the WISE model, two options were available. The first option was to directly use the estimated groundwater loads presented by GBNNPSS. This option was not preferable, because if stormwater loads calculated using the WISE model were larger than those calculated by GBNNPSS, the total initial load deposited on the land surface would have to increase. The second option was to assume that initial loads deposited on the land surface, as presented in GBNNPSS, are correct.

Therefore, new estimates of groundwater load are obtained by subtracting the calculated WISE stormwater load from the GBNNPSS initial deposited load. By pursuing this option, we do not need to make the assumption that the partitioning of nitrogen into surface and groundwater pathways is equivalent to the partitioning of precipitation into runoff and infiltration, as was assumed for GBNNPSS. Instead of making this assumption, we calculate stormwater nitrogen loads directly and assume that the remainder of the deposited load is delivered to the groundwater.

3.3 Aerial Deposition Model

Aerial deposition of nitrogen occurs through two pathways, dry deposition (the accumulation of particulate matter containing nitrogen) and wet depositions (nitrogen compounds within precipitation being deposited during rain events). Aerial deposition of nitrogen onto the land surface is modeled using methods and observational data provided by GBNNPSS (NHDES, 2014). The regional aerial deposition rate calculated by NHDES is 5.2 lb N/ac/yr. The nitrogen load deposited on the surface becomes partitioned during precipitation events, with a portion being washed from the land surface via stormwater runoff, and the remainder entering the groundwater pathway through infiltration. The concept of aerial deposition is used in this model to determine groundwater nitrogen loads; a stormwater model predicts the annual nitrogen load in the stormwater pathway, and the remainder of the deposited load is assumed to enter the groundwater pathway.

3.4 Septic System Model

The annual load derived from the use of septic systems in the watershed was derived based on estimates from the Great Bay Nitrogen Non-point Source Study (GBNNPSS) (NHDES, 2014). As part of this study, NHDES delineated regions serviced by municipal separate storm sewer systems (MS4) based on direct information from regional municipalities and information in the USGS Water Demand Model for New Hampshire Towns (Hayes and Horn, 2009). The population outside of these service areas, as determined by the 2010 US Census block data, was assumed to use septic systems for waste disposal. From the study, a per-capita excretion rate of 10.6 pounds of Nitrogen per year was multiplied by the population using septic systems to calculate a nitrogen load to groundwater from septic systems.

3.5 Agricultural Model

Load generated from agricultural areas tends to be different than typical land uses modeled in the stormwater model, as the loading is heavily dependent on the deposition of nitrogen on agricultural surfaces through chemical fertilizer and manure application.

Using the USDA National Agricultural Statistics Service (NASS) Crop Type geospatial data layer, the area of various crop types within the watershed were estimated. Major crops in the Squamscott-Exeter River watershed consisted of corn, alfalfa, hay, and pasture land.

3.5.1 Chemical Fertilizer Application

To estimate the load deposited on the land due to chemical fertilizer application, crop fact sheets prepared by Cornell University Cooperative Extension and values reported in the GBNNPSS were used and are presented in Table 3-10.

By working with the local farmers, the proportions of each crop type that actually receive chemical fertilizer as opposed to manure. Application rates were multiplied by the area of each crop type to determine an annual deposited chemical fertilizer load on each type of agricultural land, as presented in Table 3-10.

Table 3-10. Crop type and chemical fertilizer application for agricultural land.

	Area (acres)			Fertilizer Application Rates, Percentage of fields that receive application (lb/ac/yr, %)	Chemical Fertilizer Deposited Load (lb/yr)		
Cover Type	Exeter	Newfields	Stratham	Chemical Fertilizer	Exeter	Newfields	Stratham
Alfalfa	5.6	0.3	64.0	0, 0%	0	0	0
Corn	0.4	0.0	93.0	150, 10%	7	0	1,394
Fallow	0.0	0.0	3.3	0, 0%	0	0	0
Hay	175.0	69.6	369.4	140, 50%	12,250	4,869	25,858
Pasture	28.6	9.2	70.2	0, 0%	0	0	0
TOTAL	209.6	79.2	599.9	-	12,257	4,869	27,252

3.5.2 Manure Application

Manure application was calculated by estimating the number of animals in the watershed and multiplying by a species-specific nitrogen production rate. To quantify the number of animals within the watershed, for all animals except for horses, the 2012 New Hampshire State and County Data Agriculture Census (USDA, 2014) was used to estimate the number of animals in the watershed and within each of the three towns. The estimates were revised and verified through conversations with local farmers. To quantify the number of horses within the watershed, guidelines from the American Veterinary Medical Association (AVMA, 2014) were used. The AVMA recommends that the number of houses can be estimated by multiplying the number or housing units by 0.015. The count of animals are presented in "Animal Units" (AUs) which quantifies the animals per 1,000 lbs, as shown in Table 3-11.

To estimate the amount of manure generated by each animal type, the NRCS "Manure Spreading Calculator for Animal Feeding Operations" spreadsheet was used to assist in these calculations, as presented in Table 3-11. Using these values, an estimated manure nitrogen load is estimated for the watershed. Further, the nitrogen content in the manure nutrients is partitioned out and presented in Table 3-11.

Fertilizer applied to the surface, from either manure or chemical fertilizer is made available for plant uptake and therefore, not completely available for surface runoff or infiltration to groundwater. Therefore, crop uptake values for nitrogen were estimated from the NRCS "Manure Spreading Calculator for Animal Feeding Operations" spreadsheet. Average crop yields and typical nitrogen removal from each crop type is presented in Table 3-12.

Table 3-11. Animal count and manure loading calculation

Livestock Type	# of Animals in Watershed	Average Weight (lbs)	# of Animal Units	Manure Production (tons/yr)	Manure Nitrogen Content (lb/yr)
Dairy, Lactating Cow (75 lbs/day)	250	1,375	344	6,775	**89,083**
Beef, Mature	15	1,000	15	285	**1,916**
Poultry, Broiler	321	2	1	11	**247**
Swine, Growing Pig	10	110	1	13	**217**
Sheep, Mature	54	170	9	67	**1,541**
Horses, Mature	148	1,250	185	1,688	**16,544**
		TOTAL	**555**	**8,840**	**109,548**

Table 3-12. Crop nitrogen uptake.

Crop Type	# Acres	Avg Yield (tons/ac)	Total Yield (tons/yr)	N Crop Removal (lb/yr)
Corn Silage	93	20	1,860	14,880
Hay, 3-5 Cuts	614	4	2,456	98,240
Pasture, Rotation, Basic	108	4	378	15,120
Vegetables, Mixed	70	11	770	5,073
			TOTAL CROP UPTAKE OF N:	133,313

Working towards obtaining a single event mean concentration value for agricultural land, the total crop uptake (Table 3-12) was subtracted from the other sources of deposited nitrogen loads from chemical fertilizer application, manure application and aerial deposition. Table 3-13 shows the various sources and sinks of nitrogen and the remaining available deposited nitrogen load. The resulting estimate indicates that on average, 16.3 lb N/ac/yr are deposited on agricultural land in the watershed.

Table 3-13. Sources of agricultural nitrogen and surplus applied nitrogen.

Total Agricultural Land (acres)	1268
Aerial Deposition Rate (lb/ac/yr)	5.2
Total Aerial Deposition (lb/yr)	6,596
Total Chemical Fertilizer (lb/yr)	44,378
Total Manure (lb/yr)	109,548
Total Agricultural Deposition (lb/yr)	**160,522**
Total Plant Uptake (lb/yr)	133,313
Adjusted Agricultural Deposition (lb/yr)	**20,613**
Weighted Average Agricultural Deposition Rate (lb/yr/ac)	**16.3**

Typically, deposited load is partitioned into stormwater and groundwater pathways by subtracting the modeled stormwater load from the deposited load and then assuming that the remainder enters the groundwater pathway. Because the agricultural stormwater loads were not modeled in SWMM, an assumption was made that the proportion of TN load entering stormwater/groundwater pathways is proportional to the volume of water entering those pathways (this is similar to the assumption used by NHDES in the GBNNPSS). The SWMM model provided estimates of the annual runoff volume from pervious surfaces of varying hydrologic soil types. This data was used to calculate a watershed-specific EMC for agricultural lands (Table 3-14), which will be used to estimate the total load from agricultural land for the pollutant load budget.

Table 3-14. Estimated EMC for agricultural land use.

Soil Type	A	B	C	D
% of Rainfall that becomes Runoff	3.2%	7.7%	13.0%	16.7%
Estimated Stormwater Load (lbs/ac/yr)	0.52	1.25	2.12	2.71
Annual Runoff Depth (in)	1.42	3.39	5.72	7.33
Annual Runoff Volume per acre (ft^3/ac)	5,151	12,309	20,760	26,604
Revised EMC (mg/L)	**1.63**	**1.63**	**1.63**	**1.63**

3.6 Wastewater Treatment Load

The point-source loads and costs associated with the Exeter Wastewater Treatment Facility (WWTF) are based on data provided by Wright-Pierce in a memorandum entitled “Exeter – Wastewater Facilities Planning Cost Estimates for WWTF Upgrades and for Use by WISE”, dated 10 October 2014. The point-source loads for the Newfields WWTF were taken from the preliminary draft Exeter Wastewater Facilities Plan (Wright-Pierce, 2014b).

3.7 Impervious Surface Disconnection

Impervious surface disconnection allows for some runoff volume and pollutant load generated on impervious surfaces to infiltrate as it passes overland on downgradient pervious surfaces. Impervious cover that is not directly connected to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) contributes a reduced stormwater pollutant load due to attenuation and infiltration as runoff moves across downstream pervious surfaces. To account for this decrease in pollutant load, a model of a disconnected impervious surface was created, and the level of directly connected impervious area (DCIA) was quantified for each land use type.

Quantification of the level of disconnected and directly connected impervious area was based on the use of the Sutherland equations. These equations were developed to predict the likely level of connection based on a description of the level of connection and the total impervious area (TIA) of the region in question. EPA provides guidance on the use of the Sutherland equations (EPA, 2014) for prediction of the level of DCIA specific to each type of developed land use. The Sutherland equations used in this project are summarized in Table 3-15.

Table 3-15. DCIA calculation and pollutant load reduction results of DCIA SWMM Model.

Land Use Category	DCIA FORMULA
Residential	0.04(TIA)^1.7
Residential High Density	0.4(TIA)^1.2
Commercial, Services	0.4(TIA)^1.2
Institutional, Government	0.1(TIA)^1.5
Industrial	0.1(TIA)^1.5
Industrial and Commercial Complexes	0.4(TIA)^1.2
Outdoor and Other Urban and Built-up Land	0.1(TIA)^1.5

Land use data for the study area only includes one type of residential land and does not further delineate high, medium, and low density residential land uses. Therefore, the UNH GRANIT residential land use classifications were refined according to zoning, to provide better estimates of impervious disconnection. In Newfields, Stratham, and rural portions of Exeter, residential land was considered "Low Density" (greater than 1 acre lots) for the purposes of assigning a Sutherland equation to that land use. In the Exeter downtown area (zoning code R2, R3, R5) which is known to be storm sewered and have smaller lot sizes (1/4 acre), residential land was classified as "High Density." **Error! Reference source not found.** illustrates the location of Exeter's residential land within the "Low Density" and "High Density" classifications.

A simple SWMM model was created using two-watersheds to investigate the pollutant load reduction due to impervious surface disconnection. The first watershed was a typical fully impervious HRU similar to those discussed in Section 3.1.3.1. Runoff from this watershed was routed to a second pervious watershed where infiltration could occur. The ratio of the areas of the two watersheds is equal to the ratio of total impervious and pervious cover in the study area. For example, if total impervious cover percentage of a land use is equal to 10%, the model impervious catchment would be 1 acre and the pervious catchment would be 9 acres.

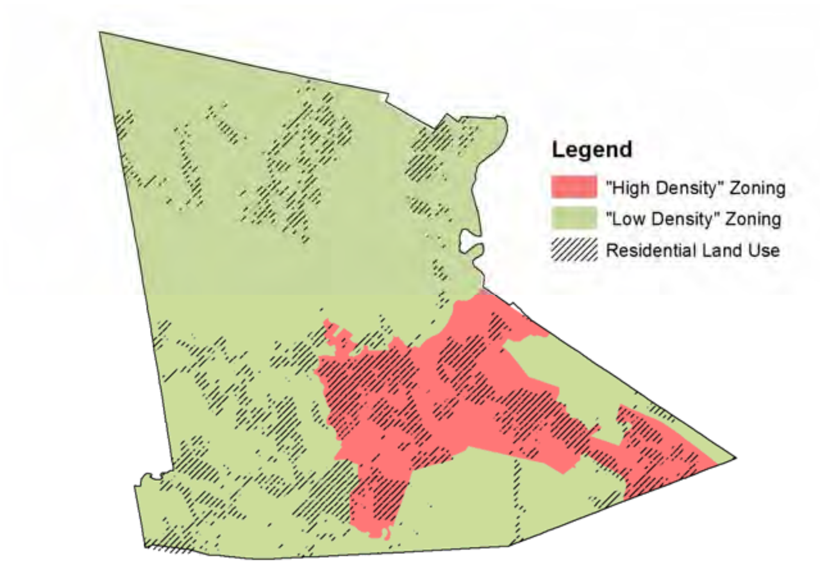


Figure 3-2. "High Density" and "Low Density" classification of residential land for the Town of Exeter.

The model was run in a continuous simulation for a 20 year period. The resulting pollutant load from the pervious catchment was compared to the load washed off from the impervious catchment to determine the load reduction due to impervious surface disconnection.

The model did not include site-specific routing, so it was not possible to know in every case the exact characterization of the pervious surface over which the runoff from the impervious catchment flowed. Therefore, the pervious catchment was assumed to be either a B or C soil, which are the most prevalent soil types within the study area.

3.8 Linear Optimization

In order to determine the load reduction and associated cost of non-point source management for the WISE project, the nutrient management measure performance results were entered into a Linear Optimization model. The linear optimization model was used to predict the most cost effective combination of non-point source management strategies to achieve a given target load reduction for a management scenario.

A linear optimization (LO) model utilizes a series of linear equations to minimize or maximize a given function. The model consists of the objective function (the mathematical relationship being optimized) and a set of constraints (equations describing the physical limits and/or minimum required performances of the system being modeled).

The objective function of the WISE BMP LO model is a function that describes the total cost of a given NPS management strategy. The goal is to minimize this cost for a given target nutrient load reduction. If C_{BMP1} is the total cost associated with the implementation of BMP1, then the objective function for the LO model is:

The objective function of the optimization model was:

$$Min.\ Z = \sum_{j=1}^{n} C_{BMP_j} A_{BMP_j} = C_{BMP_1} A_{BMP_1} + C_{BMP_2} A_{BMP_2} + \cdots + C_{BMP_n} A_{BMP_n}$$

where: Z =total cost (\$); BMP_j = BMP type; A_{BMP_j}= Acres treated by BMP_j; and C_{BMP_j}= capital cost of A_{BMP_j}(\$/acre treated by BMP_j).

The decision variables of the model were $A_{BMP_j} = A_{BMP_1}, A_{BMP_1}, \ldots, A_{BMP_n}$ (i.e. the goals was to find the optimal number of each of these variables).

The constraints of the model included:

$$A_{BMP_j} \geq 0$$

$$\sum_{j=1}^{n} A_{BMP_j} T_{BMP_j} = A_{BMP_1} T_{BMP_1} + A_{BMP_2} T_{BMP_2} + \cdots + A_{BMP_n} T_{BMP_n} = P$$

$$\sum_{j=1}^{n} A_{BMP_j LUC_x} \leq A_{Max_{LUC_x}}$$

where: A_{BMP_j}= Acres treated by BMP_j; T_{BMP_j}=treatment with BMP_j (lb/acre/year); P=total target treatment for watershed (lb/year); LUC_x =Landuse/Cover type; $A_{BMP_jLUC_x}$=Area of BMP_j with LUC_x (acres); and $A_{Max_{LUC_x}}$=Total area of Landuse/Cover type in watershed.

Constraint functions used in the LO model will fall into 6 categories:

1. Total cost associated with implementation of a given BMP of known capture depth;
2. Total load reduction associated with implementation of a given BMP of known capture depth;
3. Summation of costs associated with implementation of a given BMP type across all sizes
4. Summation of load reductions associated with implementation of a given BMP type across all sizes;
5. Total area available for treatment
6. Total target load reduction

Constraint type 1 describes the cost of implementing a given BMP type of a single size. Costs have been summarized in $/acre treated for each BMP type and size. Therefore, to describe the total implementation cost for a given BMP of a single size, type 1 constraints will follow the format:

$$(Cost/area)(Area\ Treated) - (Total\ Cost) = 0$$

As an example, a wet pond with capture depth of 0.25" costs $1425 per acre treated. The constraint to describe this BMP type of this size would be written as:

$$(1425)WPA_{0.25} - WPC_{0.25} = 0$$

Where $WPA_{0.25}$ is the area treated using wet ponds of capture depth 0.25", and $WPC_{0.25}$ is the total cost associated with implementing wet ponds of capture depth 0.25".

Constraint type 2 is similar to constraint type 1, except it describes load reduction associated with the given practice, rather than cost. To continue the example above, a wet pond with capture depth 0.25" will reduce nitrogen loads by 0.2234 lb N per acre treated. This constraint would be written as:

$$(0.2234)WPA_{0.25} - WPL_{0.25} = 0$$

Where $WPA_{0.25}$ is the area treated using wet ponds of capture depth 0.25", and $WPL_{0.25}$ is the total load reduction associated with implementing wet ponds of capture depth 0.25".

Constraint type 3 and 4 will summarize the costs and load reductions modeled by constraint types 1 and 2, respectively. If $WPC_{0.25}$ is the total cost associated with implementing wet ponds of capture depth 0.25", the total cost for wet ponds of all sizes is:

$$WPC_{0.25} + WPC_{0.50} + \cdots + WPC_{1.50} - WPC_{tot} = 0$$

where WPC_{tot} is the total cost associated with implementation of wet ponds of all sizes.

A similar method is used to determine the sum of load reduction associated with wet ponds of all sizes (constraint type 4):

$$WPL_{0.25} + WPL_{0.50} + \cdots + WPL_{1.50} - WPL_{tot} = 0$$

Where WPL_{tot} is the total load reduction associated with implementation of wet ponds of all sizes.

Constraints 1-4 are applied to each BMP type of each capture depth for each land use/cover type. The model is limited to only using BMP/land use combinations that have been agreed upon in cooperation with the towns of Exeter, Stratham, and Newfields (refer to **Error! Reference source not found.**).

Constraint type 5 describes the available area of a given land use type within the watershed. Until now, notation described in this methodology has not indicated land use; now we will consider land use in the notation. Let $WPA_{0.25\text{-com-i}}$ be the area of commercial impervious treated with wet ponds of 0.25" capture depth, and $GWA_{0.25\text{-com-I}}$ be the area of commercial impervious treated with gravel wetlands of 0.25" capture depth, and so on. Since we cannot possibly treat more acres of land with a suite of BMPs than what is available in the watershed, the total area of a given land use type is described by:

$$WPA_{0.25-com-i} + WPA_{0.50-com-i} + \cdots + WPA_{1.50-com-i} + GWA_{0.25-com-i} + \cdots < 143.9$$

In this constraint example, there are a total of 143.9 acres of commercial impervious surface within the watershed. The constraint states that the total area of this land use treated by each bmp type of each size cannot exceed 143.9 acres. This type of constraint is added for each land use which is suitable for NPS treatment (e.g. commercial impervious, commercial roof, commercial pervious with soil type A, commercial pervious with soil type B, etc.).

Constraint type 6 allows for a target load reduction to be specified. For this given target load reduction, the model will determine the mixture of BMP types, sizes, and acreages of each land use treated which will result in a minimum cost. The constraint is written as:

$$WPL_{tot-com-i} + WPL_{tot-com-r} + \cdots + BMP_{tot-LU} = X$$

Where each item in the summation refers to the total load reduction associated with a given BMP type treating a given land use/cover type (as determined in constraint type 4) and X represents the target load reduction.

4. BASELINE MODEL RESULTS

The purpose of the pollutant budget model was to account for pollutant loads not calculated by the stormwater/BMP model, such as septic systems and groundwater loads. The pollutant budget model converts the pollutant load generated at the source (unattenuated load) into a load to the receiving waters (attenuated load). This conversion was achieved using methods developed as part of the GBNNPSS.

The pollutant loads from various sources (stormwater, groundwater, septic systems, wastewater treatment, etc.) are summarized in this pollutant load budget, resulting in annual pollutant loads to the Squamscott-Exeter River watershed. The budget model was used to investigate the range of existing and achievable pollutant budgets that will result as a product of NPS management strategies.

A pollutant load budget for the portion of each town within the Squamscott-Exeter River watershed is composed of the following components:

- Attenuated stormwater load (resulting from pollutant deposition on the land surface);
- Attenuated groundwater load (resulting from pollutant deposition on the land surface);
- Attenuated load from septic systems;
- Wastewater treatment facility point-source load.

When added together, these four quantities represent the annual pollutant load delivered to Great Bay. This section presents a baseline annual pollutant load budget for the study area based on the current best estimates for the four pollutant load components listed above.

4.1 Stormwater Results

4.1.1 Runoff Volume

The first step in quantifying the pollutant load from the subwatershed from stormwater is to determine the runoff volume. The SWMM stormwater load model was run for a period of 20 years (1985-2005), which resulted in an average annual stormwater runoff volume from the combined HRU types as shown in Figure 4-1. The results generated from the stormwater model (Figure 4-1) were compared to runoff yields from an HRU model developed by EPA for the Charles River Basin in Massachusetts. Based on this comparison, the runoff yield results predicted by the WISE SWMM stormwater model are consistent with those developed by EPA.

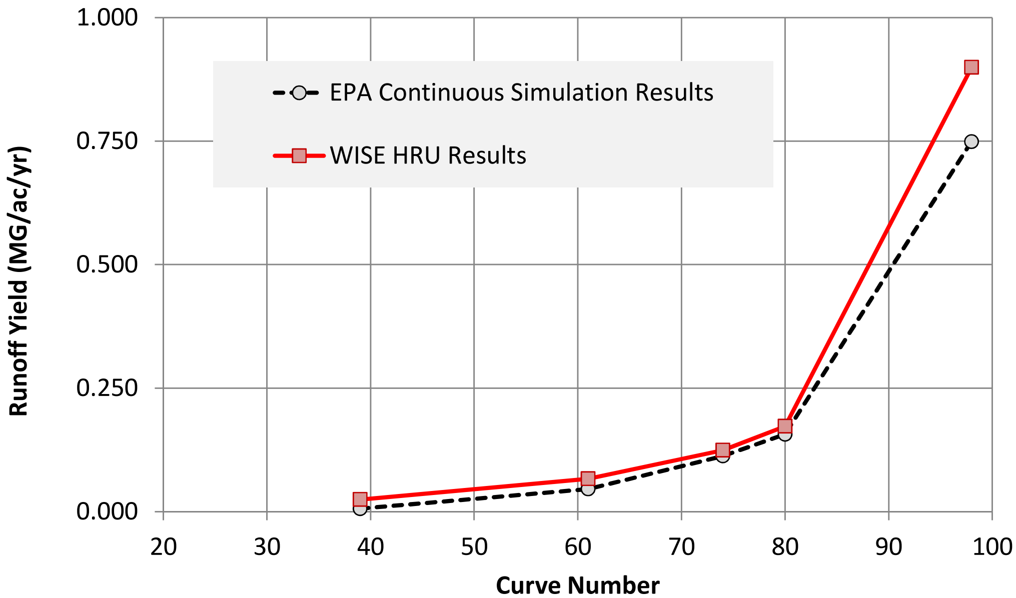


Figure 4-1. Runoff yield predicted by WISE SWMM model compared to runoff yield developed by USEPA.

Using the model output, a simplified water budget for each HRU type was developed (Table 4-1). The volume of infiltration for each HRU type is calculated as the difference between precipitation and the sum of runoff and evaporation. Based on the results, partitioning coefficients were estimated (presented in parenthesis in Table 4-1). The results indicate that for pervious surfaces with soil groups ranging from A (sandy soils) to D (clay soils) have 93% to 75% infiltration, respectively. Of the precipitation that falls on impervious surfaces, approximately 80% runs off and 20% is captured in depression storage areas for evaporation.

Table 4-1. Water budget results and partitioning coefficients

HRU	Precipitation (in)	Runoff (in, %)		Evaporation (in, %)		Infiltration (in, %)	
Pervious A	41.6	0.9	(2%)	2.1	(5%)	38.7	(93%)
Pervious B	41.6	2.4	(6%)	2.9	(7%)	36.3	(87%)
Previous C	41.6	4.6	(11%)	3.6	(9%)	33.5	(80%)
Pervious D	41.6	6.4	(15%)	4.0	(10%)	31.2	(75%)
Impervious	41.6	33.1	(80%)	8.5	(20%)	0.0	(0%)

4.1.2 Unattenuated Stormwater Loads

After determining the volume of stormwater runoff, the quantity of pollutant load that is washed from the land surface is estimated. Stormwater loads predicted by the WISE SWMM stormwater model represent the pollutant load washed from the land surface prior to any natural attenuation that occurs as the stormwater migrates from the source to the receiving waters. The total load from each land use for the 20 year simulation period was used to generate an average annual pollutant load export rate (PLER) (Table 4-2). Calculation of unattenuated loads is critical because structural stormwater BMPs are designed to treat runoff directly from a source prior to natural attenuation.

The total annual unattenuated load from any area of interest (such as a town boundary or watershed boundary) is calculated by multiplying the PLER of each land use by the area of that land use within the area of interest. Total annual unattenuated loads were calculated for the portions of the three towns within the Exeter-Squamscott Watershed which are presented in Table 4-3 through Table 4-5.

The PLERs listed in Table 4-2 are separated by impervious cover and soil type; however, most comparable literature values do not make such a distinction, and are instead related to land use only. In order to compare the model results to similar literature values, a set of 'bulk' PLERs were calculated for select land uses. These PLERs are specific to each town and are calculated by dividing the total annual load from a land use (including all impervious and pervious cover types, presented in Table 4-3 throughTable 4-5) by the total area of a land use (including all impervious and pervious cover types, presented in Table 3-7 through Table 3-9). The resulting land-use-specific PLERs were compared to a range of literature values which are presented in Table 4-6. Based on the results, the WISE calculated land-use specific PLERs are within the range of the literature values.

Table 4-2. Stormwater PLERs

Land Use Category	Annual Total Nitrogen Pollutant Load Export Rate (lb/ac/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	12.51	15.73	0.53	1.43	2.68	3.73
Commercial, Services	16.33	13.86	0.53	1.43	2.68	3.73
Institutional, Government	16.33	16.33	0.44	1.20	2.25	3.13
Industrial	16.33	13.86	0.53	1.43	2.68	3.73
Road	-	11.31	-	-	-	-
Freeway	-	8.99	-	-	-	-
Utilities	-	-	0.24	0.66	1.24	1.72
Rail	-	-	0.33	0.89	1.68	2.34
Industrial and Commercial Complexes	16.33	13.86	0.53	1.43	2.68	3.73
Mixed Developed Uses	-	18.58	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	13.86	1.09	2.95	5.54	7.71
Agriculture	-	-	0.62	1.69	3.17	4.41
Transitional	-	-	0.27	0.73	1.37	1.91
Forest	-	-	0.28	0.77	1.44	2.01
Wetlands	-	-	0.28	0.75	1.40	1.95
Barren	-	-	0.33	0.89	1.68	2.34
Managed Turf-Exeter	-	-	0.78	2.13	4.00	5.56
Managed Turf-Stratham	-	-	2.25	6.10	11.46	15.94
Managed Turf-Newfields	-	-	1.45	3.95	7.41	10.31

Table 4-3. Annual unattenuated stormwater loads for the portion of the Town of Exeter within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Imper-vious	A	B	C	D
Residential	1923.76	3231.81	92.36	992.08	1289.81	1560.33
Commercial, Services	386.97	1301.11	0.60	26.27	72.32	90.91
Institutional, Government	551.07	1592.31	2.82	35.71	56.35	136.92
Industrial	226.14	467.24	3.80	31.46	19.36	60.20
Road	-	4425.86	-	-	-	-
Freeway	-	505.48	-	-	-	-
Utilities	-	-	1.98	31.77	54.11	80.79
Rail	-	-	0.27	0.61	12.53	15.98
Industrial and Commercial Complexes	15.02	242.90	0.02	3.17	13.07	8.83
Mixed Developed Uses	-	3.53	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	336.71	6.83	19.60	259.04	376.63
Agriculture	-	-	12.14	58.23	334.58	37.58
Transitional	-	-	9.01	46.79	242.77	71.85
Forest	-	-	75.53	1752.25	3049.91	361.30
Wetlands	-	-	2.87	176.45	1251.88	923.40
Barren	-	-	1.48	16.50	28.95	20.00
Managed Turf	-	-	4.75	42.09	188.22	188.74
				TOTAL:	**29,464**	

Table 4-4. Annual unattenuated stormwater loads for the portion of the Town of Stratham within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	972.14	2032.64	233.04	338.95	1422.23	315.12
Commercial, Services	154.14	593.33	2.79	22.40	48.18	26.50
Institutional, Government	67.60	173.73	1.65	1.65	27.20	11.50
Industrial	13.55	25.08	0.66	0.00	2.22	17.26
Road	-	2169.67	-	-	-	-
Freeway	-	178.95	-	-	-	-
Utilities	-	-	2.32	4.79	78.13	7.09
Rail	-	-	0.08	0.20	0.00	1.03
Industrial and Commercial Complexes	131.60	300.68	0.00	1.80	8.76	29.41
Mixed Developed Uses	-	28.42	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	54.37	13.30	6.91	90.34	13.65
Agriculture	-	-	71.34	108.26	742.50	49.16
Transitional	-	-	29.71	39.36	283.64	57.11
Forest	-	-	75.80	278.33	2066.37	159.14
Wetlands	-	-	11.93	49.60	844.35	624.37
Barren	-	-	0.62	2.25	8.40	13.41
Managed Turf	-	-	8.19	1.89	40.78	152.57
				TOTAL:	**15,344**	

Table 4-5. Annual unattenuated stormwater loads for the portion of the Town of Newfields within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	255.29	535.25	16.61	302.20	211.38	115.33
Commercial, Services	44.90	98.80	2.13	2.90	13.74	2.46
Institutional, Government	25.15	84.74	1.32	1.65	2.49	5.06
Industrial	169.00	161.98	0.56	5.49	7.50	14.65
Road	-	843.71	-	-	-	-
Freeway	-	-	-	-	-	-
Utilities	-	-	0.07	3.07	7.43	5.73
Rail	-	-	0.07	1.65	9.08	4.21
Industrial and Commercial Complexes	-	-	-	-	-	-
Mixed Developed Uses	-	-	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	21.20	7.91	27.66	56.53	13.73
Agriculture	-	-	1.28	33.13	69.49	4.15
Transitional	-	-	1.79	16.48	33.96	9.92
Forest	-	-	6.83	404.20	563.84	206.87
Wetlands	-	-	0.00	9.46	49.53	205.87
Barren	-	-	0.18	4.70	0.71	3.15
Managed Turf	-	-	-	-	-	25.77
				TOTAL:		**4,734**

Table 4-6. PLERs for specific land uses predicted by WISE SWMM Model compared to those reported in literature.

Source	TN (lb/ac/yr)					
	Forested	Urban	Residential	Commercial	Industrial	Impervious Surface
Reckhow (1980)	2.6	8.9				
Rast & Lee (1978)	2.7	4.5				
McFarland & Hauck (2001)	0.5	8.9				
Clesceri, Curran, & Sedlak (1986)	3.3					
Dodd, McMahon, & Stichter (1992)	2.1	8.7				
Evaluation of Potential Nitrogen Load Reductions… from the Connecticut River Basin (2008)		8.8				
Shaver (2007) (Referenced in Region 1 BMP-PET Documentation)			3.9	9.8	4.7	
Loehr, Ryding, & Sonzogni (1989)	3.3		5.5	5.8	7.1	
EPA Preliminary Data Summary of Urban Stormwater BMPs (1999)	1.8		4.4	11.7	5.3	
Oyster River Watershed Integrated Planning (Preliminary Results)	0.9		10.2*			9.4
NHDES GBNNPSS						7
Chesapeake Bay Watershed Model (CSN Tech. Bulletin No. 9)						14.1
Voorhees (EPA Reg. 1)						13.1 - 17.5
Range of Reported Values	0.5 - 3.3	4.5 - 8.9	3.9 - 10.2	5.8 - 11.7	4.7 - 7.1	7.0 - 17.5
WISE PLER - Exeter	1.1	6.2	4.3	10.0	8.1	13.3
WISE PLER - Stratham	1.2	4.9	3.5	8.6	6.3	13.2
WISE PLER - Newfields	1.1	5.2	3.5	7.6	10.7	13.2

*Estimated export rate for "Lawn"

4.1.3 Attenuated Stormwater Loads

Once stormwater migrates from the surface on which it was initially generated, natural attenuation occurs as the water travels across pervious surfaces and vegetated buffers and through streams and natural waterways. Attenuation is caused by particulate settling, filtering, and biological uptake. By accounting for natural attenuation, the pollutant load which ultimately arrives at the receiving water (Great Bay) can be estimated.

NHDES estimates in the GBNNPSS (NHDES, 2014) that approximately 87% of nitrogen traveling in stormwater and surface water pathways will be transported from its origin to the receiving waters. Therefore, attenuation or delivery factors need to be applied to the unattenuated loads. Additionally, the disconnection of impervious surfaces allows for stormwater from those surfaces to travel across pervious and vegetated surfaces, providing additional attenuation, as presented in Table 4-7. The amount of attenuation caused by impervious surface disconnection ranges from 22% on industrial complexes to 81% on low density residential and outdoor and other urban land. The quantity of disconnected impervious surfaces and the load reduction associated with disconnection were used to calculate a weighted average annual load from impervious surfaces.

Table 4-7. Pollutant Load Reduction from Impervious Surface Disconnection

	%TIA			%DCIA			% Pollutant Load Reduction (B/C Soils)
Land Use Category	Exeter	Stratham	Newfields	Exeter	Stratham	Newfields	
Residential	13.6%	13.8%	13.4%	3.4%	3.5%	3.3%	81%
Residential High Density	21.1%	-	-	15.5%	-	-	77%
Commercial, Services	62.4%	53.1%	45.4%	57.0%	47.0%	39.0%	46%
Institutional, Government	55.5%	41.4%	48.7%	41.4%	26.6%	33.9%	53%
Industrial	47.5%	28.2%	65.4%	32.7%	15.0%	52.9%	49%
Industrial and Commercial Complexes	66.0%	70.6%	-	61.0%	66.1%	-	22%
Outdoor and Other Urban and Built-up Land	18.3%	10.7%	5.1%	7.8%	3.5%	1.1%	81%

Table 4-8 through Table 4-10 present the annual attenuated pollutant loads from the portions of the towns of Exeter, Stratham, and Newfields within the Exeter-Squamscott watershed which are expected to be delivered to Great Bay after natural attenuation has occurred.

Table 4-8. Annual attenuated stormwater loads for the portion of the Town of Exeter within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	1023.75	1719.85	80.36	863.11	1122.13	1357.49
Commercial, Services	323.49	1087.66	0.53	22.85	62.92	79.09
Institutional, Government	415.24	1199.82	2.46	31.07	49.02	119.12
Industrial	166.83	344.68	3.31	27.37	16.85	52.37
Road	-	3850.50	-	-	-	-
Freeway	-	439.77	-	-	-	-
Utilities	-	-	1.72	27.64	47.07	70.29
Rail	-	-	0.23	0.53	10.90	13.91
Industrial and Commercial Complexes	12.85	207.75	0.01	2.76	11.37	7.69
Mixed Developed Uses	-	3.07	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	156.59	5.95	17.05	225.37	327.67
Agriculture	-	-	10.56	50.66	291.08	32.69
Transitional	-	-	7.84	40.71	211.21	62.51
Forest	-	-	65.71	1524.46	2653.42	314.33
Wetlands	-	-	2.50	153.51	1089.13	803.36
Barren	-	-	1.29	14.36	25.19	17.40
Managed Turf	-	-	4.14	36.62	163.75	164.20
				TOTAL:	**23,353**	

Table 4-9. Annual attenuated stormwater loads for the portion of the Town of Stratham within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	149.58	312.76	202.75	294.89	1237.34	274.16
Commercial, Services	127.08	489.19	2.42	19.49	41.92	23.06
Institutional, Government	47.79	122.83	1.44	1.44	23.66	10.01
Industrial	9.09	16.82	0.58	0.00	1.93	15.01
Road	-	1887.61	-	-	-	-
Freeway	-	155.69	-	-	-	-
Utilities	-	-	2.02	4.16	67.97	6.17
Rail	-	-	0.07	0.17	0.00	0.89
Industrial and Commercial Complexes	112.88	257.90	0.00	1.56	7.62	25.59
Mixed Developed Uses	-	24.75	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	21.43	11.57	6.01	78.59	11.88
Agriculture	-	-	62.07	94.19	645.98	42.77
Transitional	-	-	25.85	34.24	246.77	49.68
Forest	-	-	65.95	242.15	1797.74	138.45
Wetlands	-	-	10.38	43.15	734.59	543.20
Barren	-	-	0.54	1.95	7.30	11.67
Managed Turf	-	-	7.12	1.65	35.48	132.74
				TOTAL:	**11,085**	

Table 4-10. Annual unattenuated stormwater loads for the portion of the Town of Newfields within the Exeter-Squamscott watershed.

Land Use Category	Exeter-Squamscott Watershed Annual Load (lb N/yr)					
	Roof	Other Impervious	A	B	C	D
Residential	38.85	81.45	14.45	262.91	183.90	100.34
Commercial, Services	36.53	80.38	1.85	2.52	11.95	2.14
Institutional, Government	18.40	62.01	1.15	1.44	2.17	4.40
Industrial	133.29	127.76	0.48	4.78	6.52	12.74
Road	-	734.03	-	-	-	-
Freeway	-	-	-	-	-	-
Utilities	-	-	0.06	2.67	6.46	4.98
Rail	-	-	0.06	1.43	7.90	3.66
Industrial and Commercial Complexes	-	-	-	-	-	-
Mixed Developed Uses	-	-	-	-	-	-
Outdoor and Other Urban and Built-up Land	-	6.82	6.88	24.07	49.18	11.94
Agriculture	-	-	1.11	28.82	60.46	3.61
Transitional	-	-	1.56	14.34	29.55	8.63
Forest	-	-	5.94	351.65	490.54	179.98
Wetlands	-	-	0.00	8.23	43.09	179.11
Barren	-	-	0.16	4.09	0.61	2.74
Managed Turf	-	-	-	-	-	22.42
				TOTAL:	**3,489**	

4.2 Attenuated Groundwater Load

The annual attenuated load from groundwater is presented in Table 4-11. Table 4-11 also presents the initial deposited loads for the portion of each town within the Exeter-Squamscott watershed. Initial loads from non-agricultural land uses were obtained from GBNNPSS. Because agricultural loading was calculated separately, and agricultural initial loading was dependent on factors such as fertilizer and manure application, initial nitrogen load from agriculture is broken out as a separate deposition load. The unattenuated groundwater load is calculated by subtracting the unattenuated stormwater load from the initial load and a generalized groundwater delivery factor, equivalent to 0.10 based on delivery factors presented in GBNNPSS, is applied in order to estimate the attenuated groundwater load that is eventually delivered to Great Bay.

Table 4-11. Calculation of attenuated groundwater nitrogen load based on GBNNPSS results.

Town	Initial Load[1] (GBNNPSS, non-agricultural)	Agricultural Deposition	SW Load (unattenuated)[2]	GW Load (unattenuated)	Groundwater Delivery Factor[3]	GW Load (attenuated)
Exeter	95,007	5,258	26,842	73,423	0.10	7,073
Stratham	39,405	13,955	12,742	40,618		3,913
Newfields	12,747	1,401	4,011	10,137		977
					TOTAL:	11,962

1. Initial loads obtained from GBNNPSS raw data files filtered to provide the results for Exeter, Stratham, Newfields, and the Exeter-Squamscott watershed.
2. Unattenuated stormwater loads are stormwater loads after impervious surface disconnection has been accounted for, but before surface water delivery factors have been applied. Because impervious surface disconnection is assumed to transfer a portion of the stormwater load into groundwater via added infiltration, it was necessary to account for disconnection in this calculation. For this reason, unattenuated stormwater loads in this table do not match.
3. Groundwater delivery factor based on values for atmospheric deposition-derived nitrogen, Appendix H of GBNNPSS. Factor includes 0.35 surface to vadose zone, 0.39 vadose zone to aquifer, and 0.65 aquifer to receiving water.

4.3 Septic System Load

The annual load derived from the use of septic systems is based on estimates from GBNNPSS (NHDES, 2014). As with other delivery pathways, the direct load from septic systems was multiplied by a delivery factor to account for natural attenuation within the groundwater pathway. For septic systems within 200 m of a receiving water, a delivery factor of 60% was applied. For septic systems farther than 200 m of a receiving water, a delivery factor of 26%

was applied, reflecting the assumption increased travel times will result in higher rates of natural attenuation.

Table 4-12 summarizes the relevant data from GBNNPSS with respect to the portions of Exeter, Stratham, and Newfields within the Exeter-Squamscott watershed.

Table 4-12. Summary of annual loading from septic systems, GBNNPSS.

Town	Population within 200 m buffer of receiving waters (persons)	Population beyond 200 m buffer of receiving waters (persons)	Attenuated Septic System Load within 200m buffer (lb N/yr)	Attenuated Septic System Load beyond 200m buffer (lb N/yr)	Total Estimated Load from Septic Systems (lb N/yr)
Exeter	45	2,489	294	6,843	7,137
Newfields	29	623	189	1,706	1,895
Stratham	269	4,105	1,724	11,295	13,019
Total	343	7,217	2,207	19,844	22,051

4.4 Wastewater Treatment Load

An estimate of current and future loading conditions, provided by Wright-Pierce (2014b) are presented in Table 4-13. The estimates include the current loads for both the Exeter and Newfields WWTFs and future loads based on planned upgrades to the WWTF which would reduce the effluent concentration of total nitrogen to 8, 5, or 3 mg/L. An additional future WWTF upgrade scenario relates to a portion of the Stratham commercial sector becoming sewered and delivering its wastewater to the Exeter WWTF, and is referred to as the Stratham Wastewater District.

Table 4-13. Estimated annual total nitrogen loads from wastewater treatment facility, under current conditions and planned treatment upgrades.

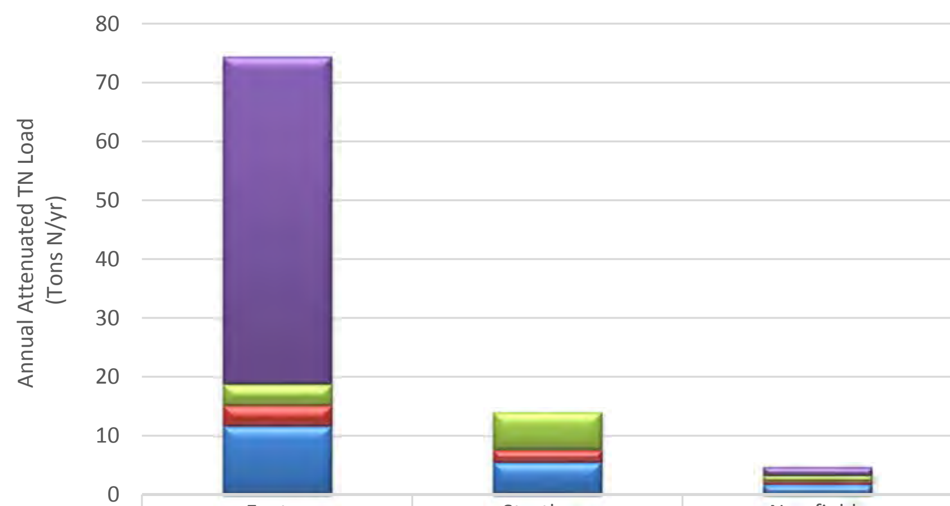
	Annual Total Nitrogen Load (lb/yr)			
Planned Condition	Exeter	Newfields	Stratham	Total
Historic (2003-2008)	92,600	-	0	92,600
Current Baseline	111,300	3,100	0	114,400
2017 Upgrades: 8 mg/L	41,400	1,000	0	42,400
2017 Upgrades: 5 mg/L	25,900	700	0	26,600
2017 Upgrades: 3 mg/L	15,500	400	0	15,900
Stratham Interconnection (3mg/L)	15,500	400	5,025	20,925

4.5 Baseline Total Nitrogen Load

For the baseline assessment, the total nitrogen load to the Squamscott-Exeter River subwatershed from the three WISE towns was estimated at 93 tons per year, from both point and non-point sources. Wastewater treatment facilities from Exeter and Newfields, discharging to the Squamscott-Exeter River subwatershed, account for 57.2 tons of nitrogen per year or 61 percent of the total nitrogen load from subwatershed (Wright-Pierce, 2014; GBNNPSS, 2014).

Nitrogen loading to the subwatershed from non-point sources accounted for 39 percent or 36 tons. The non-point sources include stormwater load, groundwater load and septic system load. The total stormwater load from the three towns represents 19 tons per year. Of that 19 tons, 6.1 tons is from natural land uses (i.e., forest, wetlands, ponds) and the remaining 12.9 tons is from other land uses including urban runoff from impervious surfaces, lawns, agriculture and managed turf.

The 93 tons is distributed between the three towns as presented in **Error! Reference source not found.**. Exeter contributed the largest load, 74.5 tons per year or 80% of the total annual load, with the WWTF contributing the largest load (57 tons) followed by stormwater runoff (12 tons). The Town of Stratham contributes 14 tons per year (15% of the total annual load), with septic systems contributing the largest load followed by stormwater runoff. The Town of Newfields contributes 4.6 tons per year (5% of the total annual load), with stormwater runoff and wastewater contributing nearly equal loads.



	Exeter	Stratham	Newfields
Wastewater Treatment Facility	55.7	0	1.6
Groundwater (Septic)	3.6	6.5	0.9
Groundwater (non-septic)	3.5	2.0	0.5
Stormwater	11.7	5.5	1.7

Figure 4-2. Annual Attenuated Load by Town; Total subwatershed load = 93 Tons per year

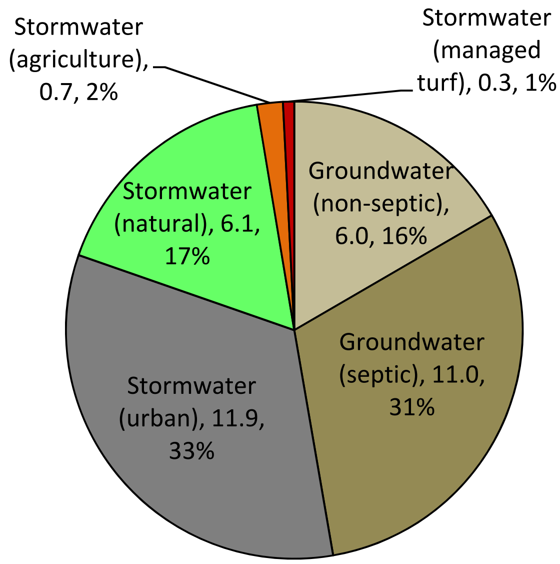


Figure 4-3. Baseline Attenuated Load (tons/year) from Point and Non-point Sources from Squamscott-Exeter Watershed

5. FUTURE MANAGEMENT OF POLLUTANT LOAD

The model was used to predict future water quality benefits by analyzing the effect of both structural and non-structural nutrient management measures on baseline stormwater runoff volume and quality. Structural measures reduce runoff through storage and/or physical/chemical/biological treatment of stormwater pollution. Examples include biofiltration, constructed treatment wetlands, permeable pavement and sand filters. Non-structural measures focus on reducing runoff volume and pollutant concentration through management approaches, such as impervious surface disconnection, street sweeping, watershed ordinances and open space protection.

5.1 NUTRIENT MANAGEMENT MEASURES

5.1.1 Structural Measures

Structural nutrient management measures were modeled in SWMM as storage units, which provide storage volume. Storage units can represent facilities as small as a catch basin or as large as a lake. Storage units have the ability to lose water from surface evaporation, infiltration into underlying soils, and from designed outlet structures. The storage unit properties are described by a surface area versus height relationship, a series of outflow rates (via infiltration, evaporation and outflow), and a pollutant treatment rate. Table 5-1 presents the structural BMPs that are incorporated into the model, design recommendations from the New Hampshire Stormwater Manual, and a list of land use types to which the management measure could be applied.

Table 5-1. Structural Measures, Design Constraints and Applicable Land Uses

				APPLICABLE LAND USES													
CATEGORY	**BMP**	**DESCRIPTION**	**DESIGN CONSTRAINTS**	Residential Pervious	Residential Impervious	Residential Roof	Commercial Pervious	Commercial Impervious	Commercial Roof	Industrial Pervious	Industrial Impervious	Industrial Roof	Institutional Pervious	Institutional Impervious	Insitutional Roof	Outdoor and Other Urban Built-up Land	Road
Structural (capture/infiltrate/treatment) Practices	Wet Pond	Pond with a permanent pool and sediment forebay	:Average Depth: 3' - 6' :Side Slopes 3:1 :10 acre minimum drainage area				x	x		x	x		x	x			x
	Gravel Wetland	Consists of several flow-through cells filled with gravel median and organic substrate. Promotes subsurface flow through root zone.	:45% WQV in each cell				x	x		x	x		x	x		x	x
	Dry Well	A gravel-filled trench that allows runoff to infiltrate into native soil.	:Minimum Depth = 4' :Media porosity = 0.4			x			x			x			x		
	Subsurface Infiltration	Vaults or chambers installed below ground surface that store and infiltrate runoff.	:Storage Volume > WQV				x	x	x	x	x	x	x	x	x	x	
	Sand Filter		:Storage = 75% WQV (including filter void space and temporary storage) :Depth > 2' :Drainage Area < 10ac				x	x		x	x		x	x		x	
	Biofiltration	A vegetated BMP designed to treat moderate amounts of runoff using soil, plantings, and filter media.	:Storage Volume > 75% WQV (including filter void space and temporary storage) :Media Depth = 2'	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	High Efficiency Biofiltration	A vegetated BMP designed to treat moderate amounts of runoff using soil, plantings, and filter media.	:Storage Volume > 75% WQV (including filter void space and temporary storage) :Media Depth = 2'	x	x	x	x	x	x	x	x	x	x	x	x	x	
	Rain Garden	A vegetated BMP designed to treat moderate amounts of runoff using soil, plantings, and filter media. Does not include an underdrain	:Storage Volume > 75% WQV (including filter void space and temporary storage) :Media Depth = 2'	x	x	x											
	Tree Pit	A small bioretention system typically used to treat road and sidewalk drainage.	:Storage Volume > 75% WQV (including filter void space and temporary storage) :Media Depth = 3'				x	x					x	x		x	
	Permeable Pavement	A pourous pavement surface that allows runoff to drain to subsurface storage.	:Filter media depth: (12" x drainage area)/(surface area) :Thickness = 32" :Storage Volume > WQV		x			x			x			x		x	

5.1.1.1 Sizing

Sizing of the structural management measures was accomplished by setting the storage volume of the measure equal to a capture depth which is similar to the water quality volume (WQV). The New Hampshire Stormwater Manual (NHSM) defines the WQV as the runoff volume from a catchment generated by a 1-inch precipitation event and base sizing of management measures on this volume. For this model, a range of capture depth sizes from 0.25-inches to 1.5-inches at 0.25-inch increments, were used for the management measures. The management measure were then statically sized to capture and hold the capture depth without overflowing or overtopping. For example, a measure with a sized for a capture depth of 0.25-inches would capture, store, and treat a runoff volume equal to 0.25-inch times the area of the catchment.

Other physical parameters of the BMP were determined using guidance from the NHSM. These parameters include ponding depth, media depth, media porosity and side slopes. An example sizing calculation is presented as Figure 5-1 for a biofiltration practice with a high-flow riser outlet structure with no underdrain.

SWMM input parameters related to structural management measure sizing are presented in Table 5-2.

EXAMPLE STRUCTURAL MEASURE SIZING CALCULATION

Objective: Size a biofiltration cell to capture 0.5" of runoff from a 1-acre impervious catchment

1. *Calculate the required storage volume.*
   Catchment area = 1 acre
   Runoff Volume = 0.5"
   $$V_{cap} = (1\ ac)(0.5\ in)\left(\frac{43560\ ft^2}{ac}\right)\left(\frac{1\ ft}{12\ in}\right) = 1815\ ft^3$$
2. *Determine typical sizing guidelines from NH Stormwater Manual.*
   From Vol. 2 Ch. 4.:
   a. Total estimated depth = 45"
   b. Ponding depth = 6"
   c. Mulch layer = 3"
   d. Biofiltration soil layer = 24"
   e. Gravel layer = 12"
3. *Convert media depth to equivalent depth runoff storage depth.*

   Total media depth = 36". Assuming a media porosity of 0.4, equivalent storage depth is:

   $$D_{media} = 36 \cdot 0.4 = 14.4 = 1.2'$$
4. *Total storage depth is the media equivalent storage depth plus the ponding depth.*

   $$D_{store} = D_{pond} + D_{media} = 6 + 14.4'' = 20.4'' = 1.7'$$
5. *Calculate surface area of BMP.*

   $$A = {V_{cap}}/{D} = {1815\ ft^3}/{1.7\ ft} = 1067.6\ ft^2$$

The BMP is sized as a rectangular prism with area equal to 1067.6 ft2 and a depth of 1.7'. The high-flow riser outlet is set at depth = 1.2 ft to allow for ponding depth over the riser.

Figure 5-1. New Hampshire Stormwater Manual Sizing Calculation

5.1.1.2 Infiltration

Infiltration of the structural measures was calculated by multiplying an assumed infiltration rate by the surface area where infiltration would occur. The infiltration rate was selected according to the underlying soil type of the HRU with which the BMP was paired. In this model, it was assumed that the BMP will have the same subsurface soil type as its contributing watershed. Infiltration rates were assumed to be equal to half of the soil saturated hydraulic conductivity

(NHSM, Vol. 1 Ch. 2). Hydraulic conductivity values were obtained from typical values presented in the SWMM model documentation. These hydraulic conductivity values were divided by two to generate the infiltration rates shown in Table 5-3.

The infiltration flow rate was modeled in SWMM as an outlet with a constant flow rate. Infiltrated water was routed to a distinct SWMM outfall which allowed volume and water quality load entering groundwater to be tabulated separately from other surface effluents.

Table 5-2. SWMM Input parameters for structural BMPs.

	Storage Area Parameters				Primary Outlet Parameters			Overflow Outlet Parameters			
BMP	Capture Depth (in)	Maximum Depth (ft)	Ponded Area (ft^2)	Evap. Factor	Outlet Invert (ft)	Outlet Diameter (ft)	Discharge Coefficient	Overflow Invert (ft)	Height (ft)	Length (ft)	Discharge Coefficient
Raingarden/ Tree Pit		1.7	534 - 3202		-	-	-	1.2			
Biofiltration		1.7	534 - 3202		0	0.083	0.65	1.2			
Gravel Wetland		2.5	430 - 2550		1.5	0.083	0.65	2.6			
Drywell		2.1	573 - 3407		-	-	-	1.6			
Wet Pond	0.25 - 1.5	5.0 - 7.7	841 - 2814	0.75	3 - 4	0.083	0.65	4.0 - 6.7	3	4	3.33
High Efficiency Biofiltration		1.7	534 - 3202		0	0.083	0.65	1.2			
Sand Filter		2.0	908 - 4538		0	0.083	0.65	1.2			
Subsurface Infiltration		3.0	367 - 2176		-	-	-	2.5			
Permeable Pavement		1.6-1.8	-		0	0.083	0.65				

Table 5-3. Infiltration rates for A-D soils.

Hydrologic Soil Group	Infiltration Rate (in/hr)
A	2.84
B	0.71
C	0.07
D	0.03

5.1.1.3 Outlet Structure

Outlet structures for the structural management measures consist of a low flow outlet (e.g. an underdrain) and an overflow outlet. The low-flow outlet is represented as a vertical orifice at the bottom of the structural measure. The overflow outlet, which allows for untreated runoff to leave the BMP once it has exceeded its storage capacity, is represented as a broad-crested weir. SWMM input parameters related to BMP outlet hydraulics are presented in Table 5-2.

5.1.1.4 Water Quality Treatment

The model provides water quality treatment of pollutants through settling, filtration, and biological activity, represented in the storage unit. Using a mathematical treatment expression which describes the changes in pollutant concentration at the storage unit, the treatment is modeled as a first-order decay processes. This process estimates the concentration of pollutant which will be removed by the structural management measure.

Due to limited site specific data, management measure treatment effluent concentration performance data from the International Stormwater BMP Database (Leisenring, et. al., 2014), University of New Hampshire Stormwater Center (Roseen, et.al., 2013) and Center for Watershed Protection. Using this data, the average reduction of pollutant concentration for total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) for the structural management measures was estimated (Table 5-4).

Table 5-4. Effluent concentration reduction percentages for select BMPs.

BMP	TSS	TN	TP
Biofiltration	77%	28%	34%
High Efficiency Biofiltration	73%	60%	72%
Tree Pit	88%	20%	5%
Wet Pond	71%	31%	34%
Sand Filter	74%	18%	44%
Subsurface Infiltration/Drywell	89%	42%	65%
Permeable Pavement	82%	3%	44%
Gravel Wetland	96%	75%	58%

5.1.2 Non-structural Nutrient Management Measures

Non-structural nutrient management measures selected for use, as treatment practices, in the Exeter-Squamscott watershed are presented in
Table 5-5

Table 5-5. Non-structural management measures are difficult to model and therefore, performance literature values, as presented in Table 5-5, were used to estimate the treatment performance benefits of these measures.

5.1.2.1 Street Sweeping

The National Urban Runoff Program (NURP) studies from the 1980's reported generally very poor results from street sweeping (PA DEP, 2006). However, in many cases, these studies were based on conventional mechanical street sweeping programs which removes a "crust" of large, coarser debris on many surfaces and exposes the finer particles to upcoming storm events. However, new street sweeping technology has dramatically improved street sweeping performance. While these new street sweeping technologies are considerably more costly, their pollutant reduction performance compares quite favorably to other pollutant reduction strategies. Street sweeping can actually be quite cost effective in terms of water quality performance (PA DEP, 2006).

Street sweeping performance data was obtained from the Chesapeake Bay Program (2011), where vacuum and mechanical sweepers were evaluated and compared. For our analysis, streets were assumed to be swept every other week and were assumed to be 12 foot wide with curb along both sides.

5.1.2.2 Septic System Measures

Conventional septic systems include a septic tank that collects the effluent from a home or business and a drainfield that disperses the effluent to the subsurface. The system receives effluent from a variety of sources including from toilet flushing, sink and shower drains, and washing machines.

Two septic system upgrades were evaluated and include: advanced treatment and advanced treatment with denitrification. Advanced treatment systems (Figure 5-2) have different requirements for flow composition and volume that allow the technology to react optimally to achieve the desired nitrogen reduction. In some cases, chemical additives might be used to adjust the level of available carbon or pH to facilitate the treatment process. The potential need for additives should be identified early in the design process and taken into consideration when choosing a technology, as some technologies might be more appropriate than others, depending on the composition of the wastewater.

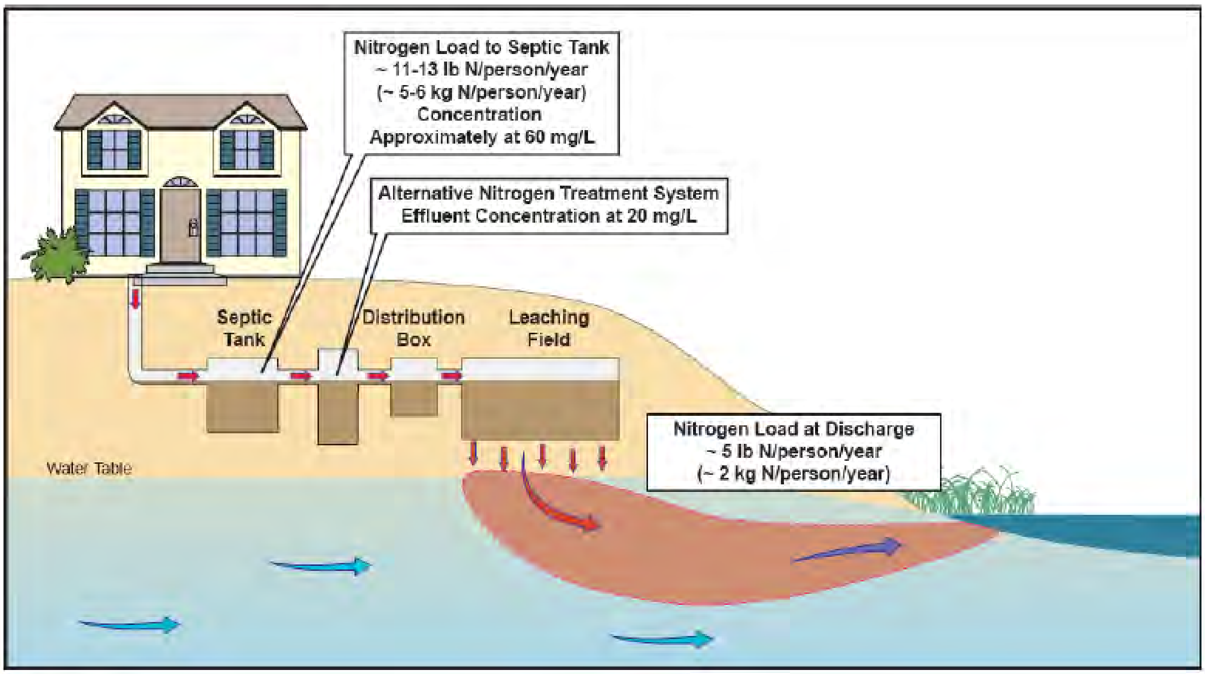


Figure 5-2. Alternative Nitrogen Septic System Upgrades

5.1.2.3 Lawn Fertilizer Program

Homeowners also contribute to the serious problem of nutrient enrichment. Americans apply millions of tons of fertilizers, which contain nitrogen and phosphorus to gardens and lawns each year. When improperly applied, water runoff from properties carry these pollutants into ponds, rivers and ultimately Great Bay. Nutrient inputs from residential lawns can be managed through a combination of voluntary and regulatory controls. Voluntary methods include education and outreach programs which identify water quality impacts associated with lawn care, and provide attainable solutions. EPA Guidance on Best Management Practices recommends targeting lawn care industry workers and actively supporting companies using fertilizer and pesticide-limiting techniques, for instance, by providing promotional opportunities. Training lawn and garden center employees in lawn care and pollution control is another important message-spreading tool, as is direct outreach to homeowners. The Town of Exeter Think Blue Campaign, which is hosted on the Town website http://exeternh.gov/bcc/think-blue-exeter contains recommendations, videos and other educational materials for residents. Additional resources are available through EPA, and UNH Sea Grant facts sheet, ‘Green Grass – Clear Water’.

Regulatory controls include municipal setbacks for fertilizer, and the recently adopted NH State Statute RSA:431 which requires that nitrogen in turf fertilizer not exceed 0.9 pounds per 1,000 square feet of total nitrogen per application when applied according to the instructions on the label. Furthermore, no turf fertilizers sold at retail shall exceed 0.7 pounds per 1,000 square feet of soluble nitrogen per application when applied according to the label. Detailed information on this regulation, and recommendations for lawn care are available in a UNH Cooperative Extension Fact Sheet: New Hampshire's Turf Fertilizer Law 'What You Should Know' (**Error! Reference source not found.**).

The WISE Lawn Fertilizer Program reduces total nitrogen load from fertilized on lawns by 9% on approximately 922 acres of residential lawn and assumes that 45% of lawns are fertilized.

5.1.2.4 Agricultural Measures

Two agricultural management measures were evaluated and include: cover crops and slow release fertilizer. Cover crops are one of the most valuable management practices available for protecting water quality, especially groundwater quality, from non-point sources of soluble nutrients like nitrate nitrogen. Cover crops reduce soil erosion in several ways. They protect the soil surface from raindrop impact, increase water infiltration, trap and secure crop residues, improve soil aggregate stability and provide a network of roots which protect soil from flowing water (USDA, 2013).

Cover crops help improve soil health by reducing erosion, increasing soil organic matter content, improving air and water movement through soil, reducing soil compaction, capturing and recycling nutrients in the soil profile and managing soil moisture to promote biological nitrogen fixation. From discussion with local farmers, using cover crops has also shown to be highly effective at reducing local erosion and reduces the amount of chemical or manure that needs to be applied. In the WISE watershed, cover crops were assumed to provide 66% reduction in total nitrogen runoff and has a total nitrogen export rate of 1.19 lbs/acre/year.

Slow release fertilizer is assumed to have a 15% total nitrogen reduction as it would replace conventional chemical fertilizer. Slow release fertilizer has an export rate of 0.27 lbs/acre/year.

Table 5-5. Non-structural BMPs.

Non-Structural BMP	**Assumptions**	**Performance Estimate**	**Source**
Street Sweeping	Streets are swept every other week. For the purposes of estimating cost/acre, a road lane is assumed to be 12 ft wide with curb along one side.	0.58 lbs/ac/yr	Chesapeake Bay Program Expert Panel Memorandum, "Street Sweeping/BMP Era Recommendations," 2011.
Advanced Septic System Upgrades	Assume load reduction of 4 lb/person/yr. Assume the average system serves 3 persons.	12 lbs/system/yr	USEPA. *A Model Program for Onsite Management in the Chesapeake Bay Watershed*. June 2013.
Septic System Upgrades with Denitrification	Assume load reduction of 4 lb/person/yr. Assume the average system serves 3 persons.	21 lbs/system/yr	USEPA. *A Model Program for Onsite Management in the Chesapeake Bay Watershed*. June 2013.
Lawn Fertilizer Education Program	Program reduces TN load from fertilized lawns by 9% (CSN). WISE project area contains approximately 922 acres of residential lawn (GBNNPSS) Assume 45% of lawns are fertilized.	935 lb/yr (combined Exeter, Newfields, and Stratham).	NHDES. *Great Bay Nitrogen Non-Point Source Study*. 2014. Chesapeake Stormwater Network. *Urban Nutrient Management Expert Panel: Approved Final Report*. 2013. VHB, Inc. *Oyster River Integrated Watershed Plan*. 2014
Slow Release Fertilizer for Agricultural Land	Assume 15% reduction in TN load due to replacement of conventional fertilizer with slow release fertilizer.	0.27 lb/ac/yr	Ruark, M. University of Wisconsin Dept. of Soil Science. *Understanding the Value of Slow Release Nitrogen Fertilizers*. 2013.
Cover Crops for Agricultural Land	Assume 66% reduction in TN runoff due to cover crop application.	1.19 lb/ac/yr	Chesapeake Bay Program. *Addition of New Cover Crop Species with Nitrogen Reduction Efficiencies*. 2013.

5.2 Cost of Nutrient Management Measures

The nutrient management measure cost to implement and maintain was characterized according to their estimated capital cost. In order to determine the most cost-effective suite of management measures to implement within the WISE study area, nutrient management measure capitol cost was determined through a detailed literature review and professional judgment.

The primary sources for nutrient management measure capitol cost information included:

1. Geosyntec Consultants. 2014. Least Cost Mix of BMPs Analysis, Evaluation of Stormwater Standards Contract No. EP-C-08-002, Task Order 2010-12. Prepared for Jesse W. Pritts, Task Order Manager, U.S. Environmental Protection Agency.
2. Tetra Tech. 2009. Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities, Final Report. Prepared for United States Environmental Protection Agency and Massachusetts Department of Environmental Protection.
3. USEPA. 1999. Urban Stormwater Best Management Practices Study, Part D.
4. University of New Hampshire Stormwater Center. 2012. University of New Hampshire Stormwater Center 2012 Biennial Report
5. FB Environmental Associates, Inc. 2009. Long Creek Watershed Management Plan, Appendix 7.
6. Charles River Watershed Association. 2014. http://www.crwa.org/project-resources. BMP Fact Sheets.
7. Narayanan, Arvind and Pitt, Robert. 2006. Costs of Urban Stormwater Control Practices (Preliminary Report).

Capitol cost data from these studies were normalized to represent the cost of treating the runoff from one acre of land (the standard size of an HRU) from a given capture depth (ranging from 0.25 – 1.5 inches). By normalizing the costs in this manner, the cost data was directly related to pollutant load reduction data provided by the SWMM model, which was also modeled on a per-acre basis. Relating the two aspects of the modeled practice (cost and performance) in this manner was a critical component to development of an optimization model (discussed in Section 0).

Table 5-6 and Table 5-7 list the range of per-acre capital costs for structural BMPs and non-structural BMPs that were found from the various sources as well as the final estimated capital cost.

Table 5-6. Capital Cost of Structural BMPs

BMP	Capture Depth (inches)	Capitol Cost per Treated Acre		
		LOW	HIGH	FINAL
Raingarden	0.25	-	-	**$4,500**
	0.5	-	-	**$7,000**
	0.75	-	-	**$10,000**
	1	-	-	**$13,000**
	1.25	-	-	**$16,000**
	1.5	-	-	**$18,000**
Biofiltration with underdrain	0.25	$2,759	$40,000	**$11,400**
	0.5	$5,518	$60,000	**$18,300**
	0.75	$8,276	$80,000	**$25,400**
	1	$11,035	$100,000	**$32,400**
	1.25	$13,794	$120,000	**$39,500**
	1.5	$16,553	$150,000	**$48,300**
High efficiency Biofiltration	0.25	$2,897	$42,000	**$11,970**
	0.5	$5,793	$63,000	**$19,215**
	0.75	$8,690	$84,000	**$26,670**
	1	$11,587	$105,000	**$34,020**
	1.25	$14,484	$126,000	**$41,475**
	1.5	$17,380	$157,500	**$50,715**
Tree Pit	0.25	$12,171	$18,661	**$11,800**
	0.5	$24,342	$25,950	**$21,700**
	0.75	$36,514	$34,453	**$31,600**
	1	$48,685	$50,000	**$41,100**
Wet Pond	0.25	$1,354	$70,000	**$5,500**
	0.5	$2,707	$80,000	**$8,000**
	0.75	$4,061	$80,000	**$11,200**
	1	$5,414	$85,000	**$15,000**
	1.25	$6,768	$90,000	**$18,700**
	1.5	$8,121	$100,000	**$22,400**
Sand Filter	0.25	$30,000	$100,000	**$30,000**
	0.5	$60,000	$200,000	**$60,000**
	0.75	$80,000	$300,000	**$80,000**
	1	$120,000	$400,000	**$120,000**
	1.25	$150,000	$500,000	**$150,000**
	1.5	$180,000	$600,000	**$180,000**

Table 5-6. Capital Cost of Structural BMPs (continued)

		Capitol Cost per Treated Acre		
BMP	Capture Depth (inches)	LOW	HIGH	FINAL
Subsurface Infiltration	0.25	$18,000	$35,000	**$18,500**
	0.5	$25,000	$45,000	**$28,000**
	0.75	$30,000	$38,300	**$38,300**
	1	$51,000	$80,000	**$51,000**
	1.25	$50,000	$90,000	**$61,300**
	1.5	$60,000	$125,000	**$77,800**
Drywell	0.25	$4,000	$11,500	**$4,000**
	0.5	$7,000	$40,000	**$7,000**
	0.75	$10,000	$70,000	**$10,000**
	1	$15,000	$80,000	**$15,000**
	1.25	$18,000	$100,000	**$18,000**
	1.5	$20,000	$100,000	**$20,000**
Gravel Wetland	0.25	$1,526	$6,564	**$5,900**
	0.5	$3,052	$13,127	**$11,800**
	0.75	$4,578	$19,691	**$17,700**
	1	$6,104	$26,254	**$23,600**
	1.25	$7,630	$32,818	**$29,400**
	1.5	$9,156	$39,381	**$35,300**
Porous Pavement New, Residential, 1:1 Ratio of catchment to PP surface	-	$2,178	$98,010	**$29,700**
Porous Pavement Redevelopment, Residential, 1:1 Ratio of catchment to PP surface	-	$187,308	$261,360	**$186,300**
Porous Pavement New, Commercial, 1:1 Ratio of catchment to PP surface	-	$23,958	$141,570	**$29,700**
Porous Pavement Redevelopment, Commercial, 1:1 Ratio of catchment to PP surface	-	$46,283	$68,063	**$186,300**
Porous Pavement New, Commercial, 4:1 Ratio of catchment to PP surface	-	$5,990	$35,393	**$29,700**
Porous Pavement Redevelopment, Commercial, 4:1 Ratio of catchment to PP surface	-	$185,130	$272,250	**$186,300**

Table 5-7. Cost Estimate for Non-structural BMPs.

Non-Structural BMP	Notes	Cost Estimate	Source
Street Sweeping	Assume $473/curb mile. A road lane is assumed to be 12 ft wide with curb along one lane.	$325/ac	Chesapeake Bay Program Expert Panel Memorandum, "Street Sweeping/BMP Era Recommendations," 2011.
Advanced Septic System Upgrades	-	$7,000/system	USEPA. *A Model Program for Onsite Management in the Chesapeake Bay Watershed*. June 2013.
Septic System Upgrades with Denitrification	-	$12,500/system	USEPA. *A Model Program for Onsite Management in the Chesapeake Bay Watershed*. June 2013.
Lawn Fertilizer Education Program	Costs reported in Oyster River Integrated Watershed Management Plan are scaled according to population ($3.80/person).	$89,100 (combined implementation between Exeter, Newfields, and Stratham)	VHB, Inc. *Oyster River Integrated Watershed Plan*. 2014
Slow Release Fertilizer for Agricultural Land	-	$7/ac	Ruark, M. University of Wisconsin Dept. of Soil Science. *Understanding the Value of Slow Release Nitrogen Fertilizers*. 2013.
Cover Crops for Agricultural Land	-	$52/ac	Chesapeake Bay Program. *Addition of New Cover Crop Species with Nitrogen Reduction Efficiencies*. 2013.

Figure 5-3 presents the cost per pound removed range for the nutrient management strategies evaluated as part of the optimization model. Figure 5-3 presents a single cost for non-structural measures and a cost range, defined by the length of the bar, for structural management measures. The structural practice cost range is defined by the management measure capture depth and the potential for pollutant removal is defined by structural practice type, underlying soil type (i.e., infiltration rate) and land use.

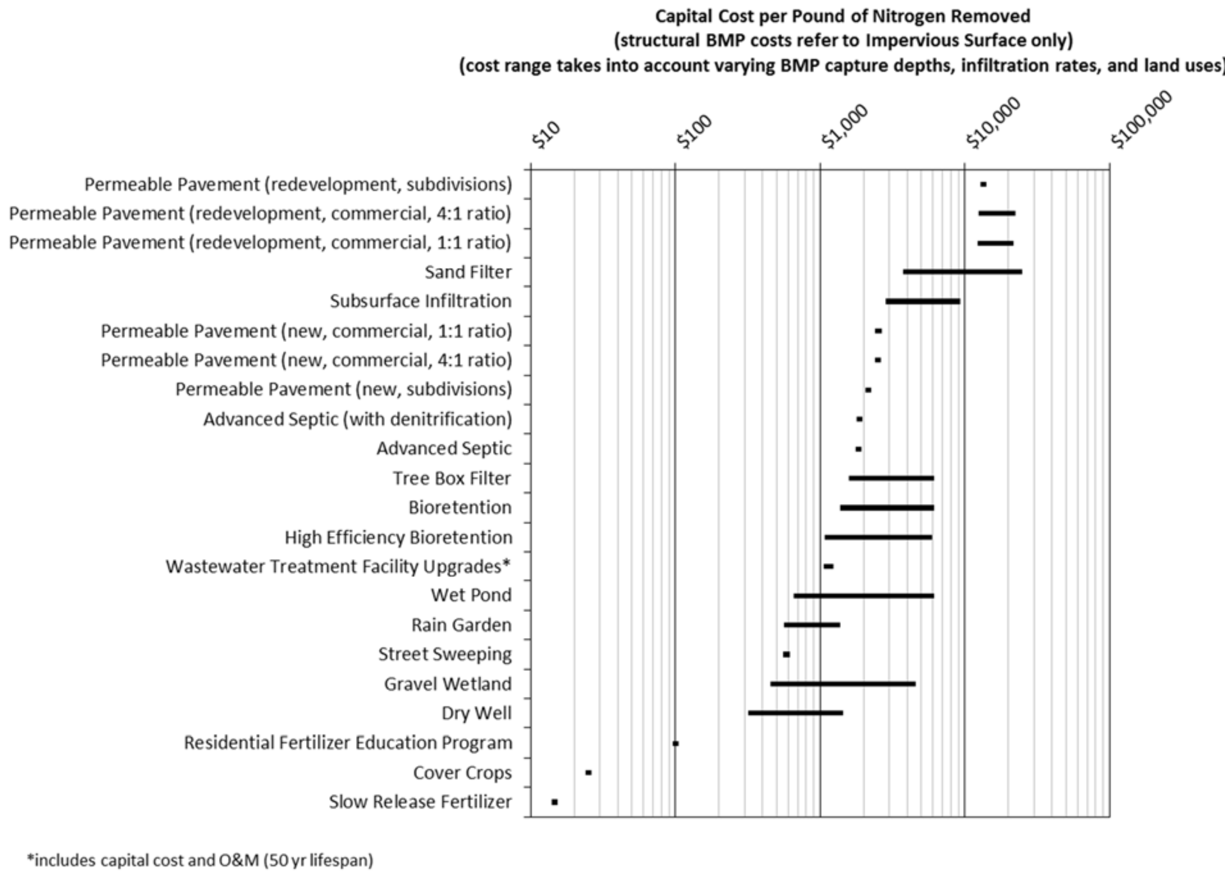


Figure 5-3. Nutrient Management Strategy Capital Cost for Nitrogen Removal

5.3 Management Scenarios

A range of management scenarios were evaluated for both wastewater and non-point source strategies over three different permitting and planning scenarios. The scenarios include:

(1) Subwatershed Integrated Planning (IP) – evaluates the three towns working together to develop an integrated plan to manage their four permits. The pollutant loads and costs are compiled by subwatershed.

(2) Traditional Permitting (T) – evaluates the three towns working independently to manage their permits (i.e., silo approach). The permits (i.e., wastewater and MS4) within the towns are managed separately and credit across permits is not considered.

(3) Town Integrated Planning for Exeter (EX) – evaluates the Town of Exeter using an integrated plan to manage their two permits (i.e., wastewater and MS4).

The permitting scenarios were evaluated for a range of management scenarios (Table 5-8) which consider varying WWTF load targets, receiving water load targets and non-point source sizing criteria. The management scenarios assume that the WWTFs are in the process of meeting the regulatory milestones outlined in the AOC, by designing a WWTF Plan to operate at 8 mg/L by 2019. The WWTF targets in all scenarios with the exception of IP-3/5/8 are to be implemented during a single permit cycle. Scenario IP-3/5/8 has an implementation schedule across multiple permit cycles and begins with 8 mg/l at 2019, transitions to 5 mg/l at 2029, and ends at 3 mg/L by 2042. The extended implementation schedule allows for ecosystem monitoring and adaptive management at each critical stage and for participation by upper watershed communities. The receiving water load targets will be met by a combination of point source reductions due to the upgrades made to the WWTF and through implementation of non-point source controls which are required under by the WWTF AOC and the MS4 permit.

Under the management scenarios a receiving water load target of 88 tons per year was used, which is the target for protection of eelgrass. This load target is for the entire Squamscott-Exeter River watershed, not just the subwatershed comprised of the three towns (Exeter, Stratham and Newfields).

Table 5-8. Management scenarios listed by wastewater limits and stormwater criteria

Scenario ID	Planning Level	WWTF Concentration Target (mg/L)	Non-point Source Sizing Criteria
IP-3/5/8	Integrated Planning	Phased from 8mg/L @2019, to 5 mg/L @ 2029 and 3mg/L @ 2042	Optimized sizing of BMPs
IP-3	Integrated Planning	3 mg/L @2019 (w/ Stratham WW District)	Optimized sizing of BMPs
IP-5	Integrated Planning	5 mg/L @2019	Optimized sizing of BMPs
IP-RO	Integrated Planning	<1 (Regional Outfall)	Optimized sizing of BMPs
EX-3	Town of Exeter Integrated Planning	3 mg/L @2019	Optimized sizing of BMPs
EX-5	Town of Exeter Integrated Planning	5 mg/L @2019	Optimized sizing of BMPs
T-5	Traditional Permit	5 mg/L @2019	MS4 1" WQV for all developed areas
T-3	Traditional Permit	3 mg/L @2019	MS4 1" WQV for all developed areas
T-RO	Traditional Permit	<1 (Regional Outfall)	MS4 1" WQV for all developed areas

The non-point source sizing criteria varies by the permitting scenario. Under the two Integrated Planning scenarios (IP and EX), the integrated planning framework allows the permittee the ability to credit across permits and for flexibility on the sizing requirements of stormwater best management practices for non-point source control. Therefore, the level of non-point source controls necessary to meet the receiving water quality load target was evaluated for varying water quality volume sizes, as described in Section **Error! Reference source not found.**, and level of implementation based on the highest unit performance and least cost mix of management strategies, described in Section **Error! Reference source not found.**.

Under the Traditional Permitting (T) scenarios with a receiving water load target of 88 tons per year are evaluated through implementation of non-point source management strategies to meet the requirements under the MS4 permit and by standards in the New Hampshire Stormwater Manual (NHDES, 2008), which requires sizing stormwater BMPs to capture and treat the volume from a 1 inch storm. The Traditional Permitting scenario does not allow include an MEP analysis or cross permit load reduction crediting.

The management scenarios were evaluated for the pollutant load reduction capability to the estuary and the economic impact of the scenario on the Towns. The management scenarios were then compared to determine the most viable path forward for the Towns, whether it be an integrated planning scenario or a traditional permitting path and the pros and cons of each of the scenarios.

An analysis was conducted to determine the cost of installation and implementation of non-point source strategies for achieving a full range of reductions including management of all impervious areas and significant sources. To evaluate this, a linear optimization (LO) model was developed which analyzes a range of pollutant load reduction targets with a range of land use types, soil types, non-point management measures and capture depth sizes.

5.3.1 Linear Optimization

In order to determine the load reduction and associated cost of non-point source management for these management scenarios, the BMP performance results were entered into a Linear Optimization model. The linear optimization model was used to predict the most cost effective combination of non-point source management strategies to achieve a given target load reduction for a management scenario.

The LO model was run repeatedly, changing the target load reduction with each iteration. Each model run results in a total minimum cost (as determined by the objective function). By plotting the model results of load reduction vs. minimum cost, a Pareto curve (Figure 5-4) was generated. The Pareto curve illustrates the concept of diminishing returns, i.e. the most cost-effective options are pursued first, and each additional pound of nitrogen reduction will have a higher differential cost. Higher target load reduction amounts result in BMP combinations that have a higher average cost per acre treated.

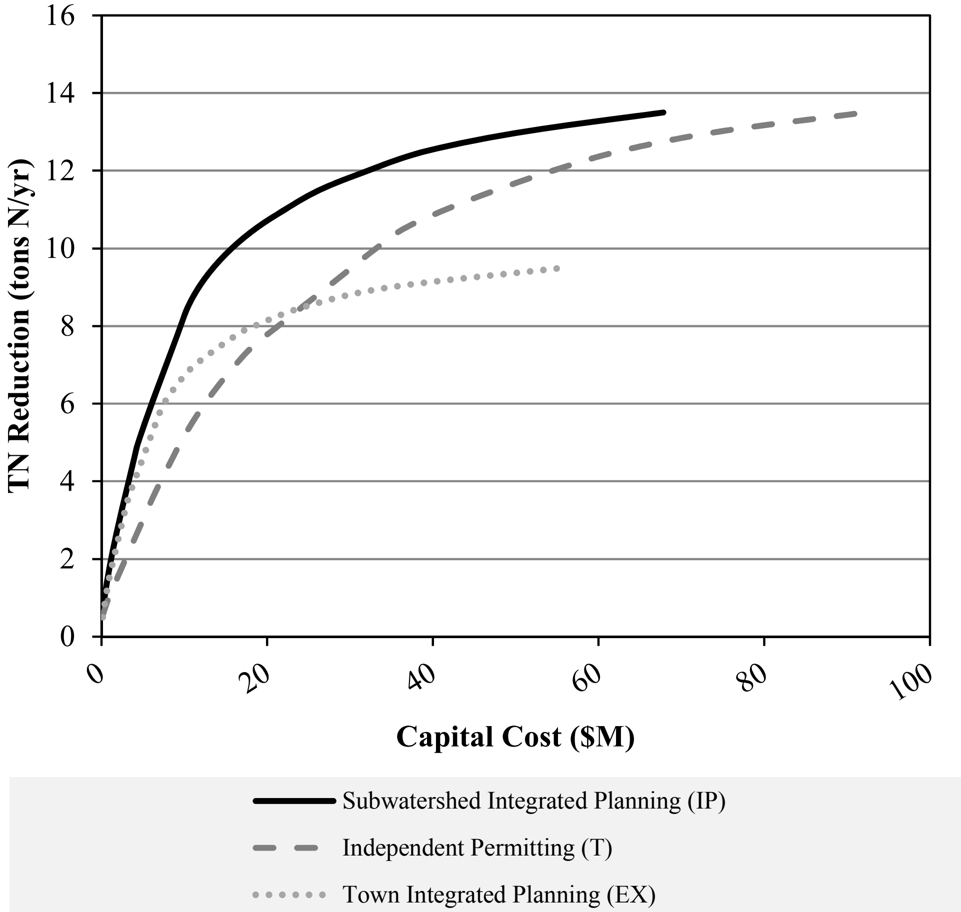


Figure 5-4. Pareto Curves relating capital cost and load reduction of optimized mix of NPS management strategies.

This is first applied at the system level to develop a series of performance curves (Figure 5-4). It is next applied at the land use scale to identify the most cost effective options for each particular land use. The optimization is then conducted at the watershed scale for the range of nutrient control measures, and the range of land uses. The optimization process is then repeated for each of the management scenarios described in Table 5-8 to determine total cost of implementation.

One of the most significant challenge in management of nutrients for communities is balancing competing resource needs. Some cost estimates developed in light of pending requirements total hundreds of millions of dollars. As part of the Integrated Plan management scenarios were evaluated for both the implementation cost and the water quality load reduction to identify both a range of strategies and an implementation schedule that would be feasible. An essential element of this is the application of nutrient control measures in a manner that prioritizes and applies those with the greatest cost benefit first. To accomplish this management scenarios were evaluated over a range of permitting scenarios to determine cost to implement wastewater upgrades and non-point source controls and assessed for unit cost performance in terms of cost per nitrogen reduction.

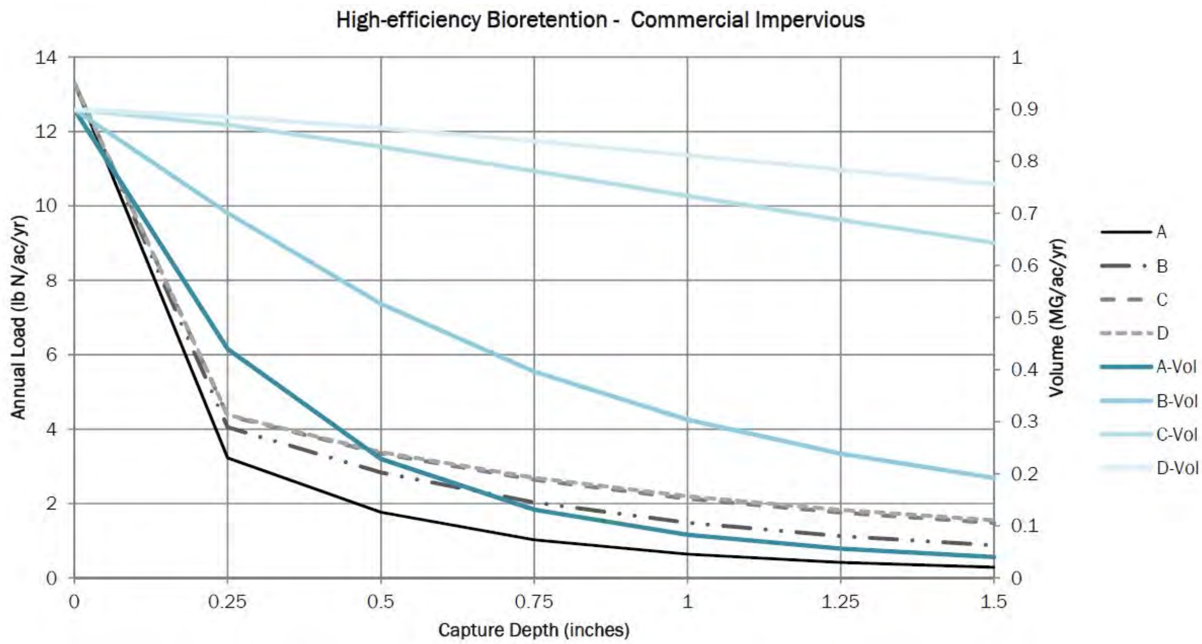


Figure 5-5. BMP Performance Curve for high-efficiency Biofiltration on commercial impervious areas illustrating annual exported load (lbs Nitrogen/acre/year) and volume (million gallons/acre /year) based on water quality volume (aka capture depth)

5.3.2 Cost and Load by Subwatershed for Nutrient Management Scenarios

Comparisons for the range of management scenarios and identified strategies which achieve the greatest benefit for the lowest cost were analyzed. Using a present worth analysis, annual costs were developed associated with debt service for wastewater and nonpoint source management.

When comparing and evaluating the management scenarios the following list of assumptions were used:

- Operating the WWTF at 3 mg/L or sending the wastewater load to the regional treatment facility does not eliminate the needs for long-term implementation of non-point source controls to satisfy the obligations under the Administrative Order of Consent and the MS4 general permit.
- Under the MS4 program, non-point source controls implemented under the integrated planning scenarios (both IP and EX) can be credited towards meeting Minimum Measure 5: Post-Construction Stormwater Management.
- The use of flexible sizing of structural management measures (i.e., capture depth range of 0.25 to 1.50 inches) can be achieved through an Integrated Planning (IP and EX) scenario. Whereas, under the traditional permitting scenarios, a fixed capture depth of 1.0 inch is used, in accordance with the NH Stormwater Manual.
- Optimized sizing of BMPs is the most cost effective mix of nutrient management measures, including wastewater treatment, non-point source controls and stormwater controls, with flexible sizing over a range of specific land uses.
- Total cost includes capitol cost and operation and maintenance.
- A present worth analysis was conducted for NPS assuming a 2% discount rate and a 50-year present worth implemented over a 30-year schedule. NPS operations and maintenance costs were conservatively estimated to be 5% of the capital cost annually.

Costs associated with wastewater capital and operations and maintenance were from Wright Pierce (2014) and Kleinfelder (2012). The management scenarios were compared to determine the most cost-effective scenario for managing receiving water load from the three towns and the watershed as a whole. Presented in Table 5-9 are the management scenarios ranked by unit performance based on total 50-year present worth cost and the receiving water total annual load. All the management scenarios trend towards a receiving water load target of 88 tons per year however none achieve that goal. As mentioned previously, the 3 communities cannot achieve the load target without participation from the upper watershed. The scenarios examined achieve between 53% (EX-3) and 74% (T-RO) load reduction.

The total annual receiving water load ranges from 114 tons per year up to 133 tons per year, with the greatest reduction representing the regional outfall (T-RO) with the highest cost to implement at $257 million or $3.75 million per ton of nitrogen reduced (68 tons and 74% reduction). The most cost effective scenario is IP-3/5/8 which phases in wastewater treatment and implements NPS control measures over 2000 acres over 6 permit cycles throughout the subwatershed. This scenario has an annual receiving water load of 126 tons per year (56 tons and 60% reduction) and a total 50-year present worth cost of $105 million or $1.88 million per ton reduced.

The least expensive scenario is EX-5 which has a total 50-year present worth cost of $97.6 million or $1.99 million per ton reduced and an annual receiving water load of 133 tons (49 tons and 53% reduction). This scenario considers only the Town of Exeter and does not include potential WWTF upgrades in Newfields, a wastewater district Stratham or non-point source controls in either of the towns.

Figure 5-6 presents the management scenarios with the relative sources (wastewater, NPS, upper watershed) compared to a baseline watershed load and a pristine (undeveloped) watershed load. The baseline watershed load represents the current condition of the entire watershed including the three towns in the subwatershed and the communities in the Upper Exeter River watershed. The dashed line on the figure represents the receiving water quality load target of 88 tons per year to support eelgrass habitat. The pristine annual load represents the undeveloped watershed condition before human impacts. It can be seen that the three towns alone do not have the ability to reduce the nitrogen load to meet the receiving water quality load target to support eelgrass habitat. The management scenarios evaluated have the potential to provide 53% to 74% reduction in the subwatershed load from the three towns. As presented in Figure 5-6, the upper watershed load contributes 89 tons per year of nitrogen to the estuary of which a 42% reduction (38 tons) would be required to meet the load target.

Table 5-9. Ranked comparison of scenario unit performance ($$/Ton)

Management Scenario	WWTF Discharge (mg/L)	Wastewater Management District	Wastewater Load (tons N/yr)	NPS Load (tons N/yr)	Load from Upper Exeter R. Watershed (tons N/yr)	Total Load (Tons N/yr)	Cost (Total PV: Capital + O&M, 50 yrs) ($M)	$M/Ton Reduced
IP-3/5/8	Phased from 8 to 5 to 3	YES	10	27	89	126	$105.0	$1.88
EX-5	5	NO	13	31	89	133	$97.60	$1.99
IP-5	5	NO	13	27	89	129	$104.9	$1.99
EX-3	3	NO	8	31	89	128	$112.70	$2.08
IP-3	3	YES	10	27	89	126	$126.4	$2.27
IP-RO	<1	YES	3	27	89	119	$150.6	$2.40
T-3	3	NO	8	22	89	119	$226.80	$3.61
T-5	5	NO	13	22	89	125	$211.30	$3.68
T-RO	<1	NO	3	22	89	114	$257.0	$3.75

Table 5-10 and Figure 5-7 present the management scenario total present value cost broken down by capital cost and operation and maintenance cost for the wastewater treatment facility and non-point source management measures.

Table 5-10. Total 50-Yr Present Value Cost by Subwatershed-Scale

MANAGEMENT SCENARIO	ANNUAL TOTAL LOAD TO RIVER (TONS)	TOTAL COST PV ($M)	WWTF PV CAPITAL COST ($M)	WWTF O&M COST ($M)	NPS CAPITAL COST ($M)	NPS O&M COST ($M)
EX-5	133.1	$97.6	$40.0	$49.0	$4.1	$4.4
IP-5	129.4	$104.9	$41.0	$50.3	$6.6	$7.1
EX-3	127.9	$112.7	$46.0	$58.1	$4.1	$4.4
IP-3	126.4	$126.4	$52.6	$60.2	$6.6	$7.1
IP-3/5/8	126.4	$105.0	$43.8	$47.6	$6.6	$7.1
T-5	124.8	$209.1	$40.0	$49.0	$57.9	$62.1
T-3	119.4	$226.8	$47.2	$59.6	$57.9	$62.1
IP-RO	119.4	$150.6	$48.1	$88.9	$6.6	$7.1

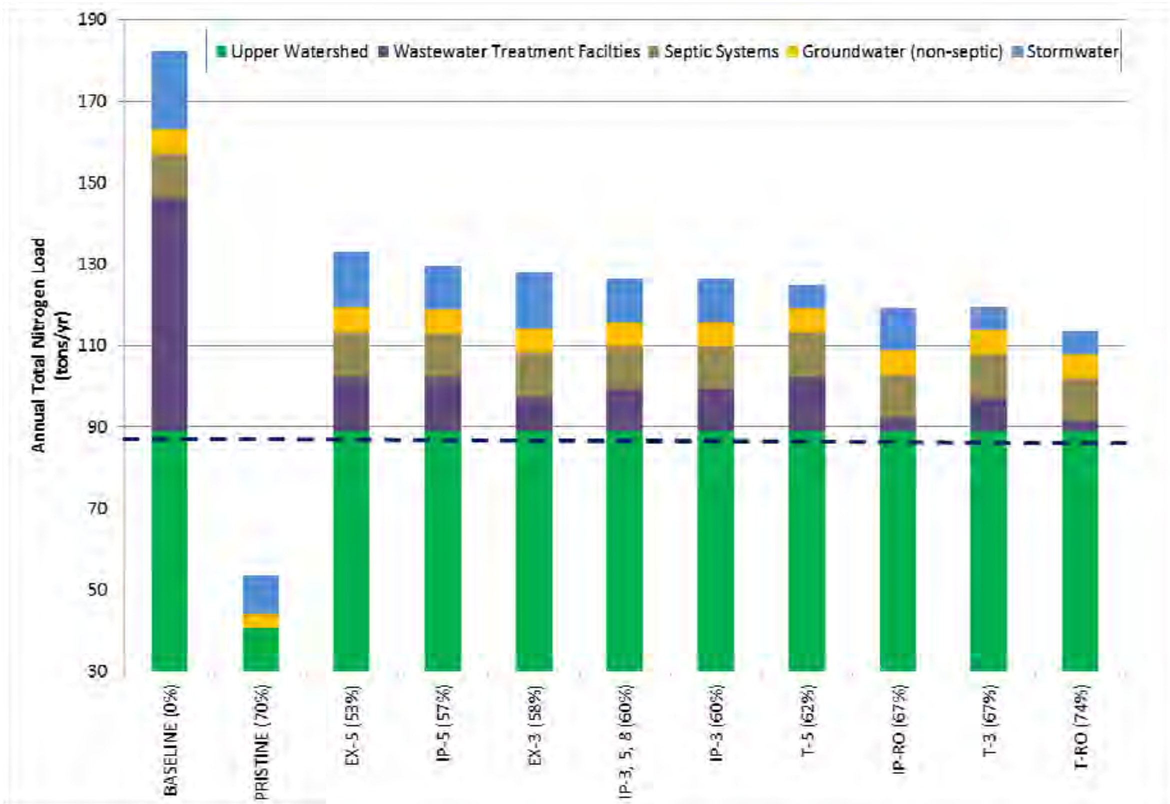


Figure 5-6. Ranked scenario by annual load reduction (% reduction relative to subwatershed load)

Figure 5-7. Ranked scenarios total PV cost (capital and O&M) for NPS and WW

5.3.3 Cost by Town for Nutrient Management Scenarios

To provide a better understanding of the total cost for municipal planning and decisions making, the management scenario total present value cost was divided up by Town for total cost, capital cost and operation and maintenance cost. Further, the cost is subdivided by implementation costs anticipated to be incurred by private (i.e., commercial, industrial, residential) property owners and by the municipal sector (i.e., roads, parks, municipal buildings) based on estimated area for which the municipality will likely be required to manage. With this approach the total cost of NPS management is covered by the land uses which generate stormwater runoff, both private and municipal sector. The approach assumes that the expenses would be part of the redevelopment cycle as with any code and modernization requirements with which owners and operators are familiar. This type of planning would require revisions to any existing stormwater ordinances and regulations, to require management of nitrogen for new and redevelopment including municipal capital improvement projects that impact stormwater management.

5.3.3.1 Cost Comparison for Town of Exeter

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Exeter is from $94 to $178 million (Table 5-11). The estimated annual cost per year for the Town of

Exeter ranges from $3.13 to $5.93 dollars inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for both wastewater treatment and non-point source controls.

All of the management scenarios presented in Table 5-11, with the exception of T-3, use integrated planning with the use of NPS management with optimized sizing. The T-3 scenario does not include an optimized sizing of BMPs and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are 90% more ($65.3 million), significantly increasing the cost for implementation of this scenario.

Table 5-11. Total 50-Yr Present Value Cost by Scenario for Exeter Individually

Management Scenario	WWTF Total Cost ($M, 50-YR PV)	NPS Total Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Average Annual Implementation Cost ($M, 50-YR PV)
IP-3/5/8	$85.5	$8.6	$94.0	$3.13
IP-5	$89.0	$8.6	$97.6	$3.25
IP-3	$104.1	$8.6	$112.7	$3.76
IP-RO	$121.7	$8.6	$130.3	$4.35
EX-3	$104.1	$8.6	$112.7	$3.76
T-3	$104.1	$73.9	$178.0	$5.93

Presented in Table 5-12 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 50% of the total implementation cost for the management measures. The same is generally true for the wastewater operation and maintenance costs with the exception of the regional outfall scenario, which represents 64% of the total wastewater cost.

Table 5-12. Total 50-Yr Present Value Capital and Operation & Maintenance Cost by Scenario for Exeter Individually

Management Scenarios	WWTF Capital Cost ($M, 50-YR PV)	WWTF O&M Cost ($M, 50-YR PV)	NPS Capital Cost ($M, 50-YR PV)	NPS O&M Cost ($M, 50-YR PV)
IP-3/5/8	$39.5	$46.0	$4.2	$4.4
IP-5	$40.0	$49.0	$4.2	$4.4
IP-3	$46.0	$58.1	$4.2	$4.4
IP-RO	$42.8	$79.0	$4.2	$4.4
EX-3	$46.0	$58.1	$4.2	$4.4
T-3	$46.0	$58.1	$35.2	$38.7

Table 5-13. Total Annual NPS Present Value Cost over 30-Year Plan for Exeter

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3/5/8	$0.285	$0.163	$0.122
IP-5	$0.285	$0.163	$0.122
IP-3	$0.285	$0.163	$0.122
IP-RO	$0.285	$0.163	$0.122
EX-3	$0.285	$0.163	$0.122
T-3	$2.463	$0.816	$1.648

Presented in Table 5-13 are the annual non-point source implementation costs for each of the management scenarios. The proposed integrated planning alternatives (IP and EX management scenarios) have an annual NPS cost of $285,000 for the Town of Exeter (Table 5-13). Based on the results from the optimization model, $163,000 or 57% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $4.89 million over 30-years. An additional $122,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $3.66 million over a 30-year period. Based on the traditional permit scenario (T-3) the Town of Exeter is expected to have an annual $2.46 million cost for implementation and operation and maintenance of non-point source controls, with an expected $816,000 incurred by the municipality and an additional $1.65 million covered by the private sector.

Currently the Town of Exeter has an annual stormwater management budget of $25,000. Under the integrated planning scenarios, the Town's stormwater management budget would increase by 6.5 times the current budget, to meet the non-point source implementation using optimized sized BMPs. The traditional permitting alternative would be nearly an increase of 33.6 times the current stormwater budget, which in general terms is not financially feasible or practicable. Therefore, for the Town of Exeter the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

5.3.3.2 Cost Comparison for Town of Stratham

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Stratham is from $3.7 to $35.1 million (Table 5-14). The estimated annual cost per year for the Town of Stratham ranges from $125,000 to $1.17 million inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for wastewater treatment and non-point source controls.

All of the management scenarios presented in, with the exception of T-3, use integrated planning with the use of NPS management sized through an optimization approach. The T-3 scenario does not include an optimization approach and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are greater than 80% more ($31.4 million), significantly increasing the cost for implementation of this scenario. Scenarios IP-5 and T-3 do not have wastewater treatment costs as it is assumed that Stratham would continue to operate with septic systems only for these scenarios.

Table 5-14. Total 50-Yr Present Value Cost by Scenario for Stratham

Management Scenario	WWTF Cost ($M, 50-YR PV)	NPS Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Average Annual Implementation Cost ($M, 50-YR PV)
IP-3/5/8	$3.26	$3.7	$7.0	$0.233
IP-5	-	$3.7	$3.7	$0.125
IP-3	$6.0	$3.7	$9.7	$0.323
IP-RO	$12.2	$3.7	$15.9	$0.530
T-3	-	$35.1	$35.1	$1.17

Presented in Table 5-15 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 52% of the total implementation cost for the management measures. The operation and maintenance for the wastewater connection operation and maintenance costs represents 10% of the total wastewater cost.

Table 5-15. Total 50-Yr Present Value Capitol and Operation & Maintenance Cost by Scenario for Stratham

SCENARIO	WWTF CAPITAL COST ($M, 50-YR PV)	WWTF O&M COST ($M, 50-YR PV)	NPS CAPITAL COST ($M, 50-YR PV)	NPS O&M COST ($M, 50-YR PV)
IP-3/5/8	$3.1	$0.2	$1.8	$1.93
IP-5	-	-	$1.80	$1.93
IP-3	$5.5	$0.6	$1.80	$1.93
IP-RO	$4.3	$7.9	$1.80	$1.93
T-3			$16.93	$18.15

Table 5-16. Total Annual NPS Present Value Cost over 30-Year Plan for Stratham

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3/5/8	$0.125	$0.065	$0.060
IP-5	$0.125	$0.065	$0.060
IP-3	$0.125	$0.065	$0.060
IP-RO	$0.125	$0.065	$0.060
T-3	$1.17	$0.605	$0.564

Presented in Table 5-16 are the annual non-point source implementation costs separated by municipal and private sector expense for each of the management scenarios. The proposed integrated planning alternatives (IP) have an annual NPS cost of $125,000 for the Town of Stratham. Based on the results from the optimization model, $65,000 or 52% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $1.95 million over 30-years. An additional $60,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $1.8 million over a 30-year period. Based on the traditional permit scenario (T-3) the Town of Stratham is expected to have an annual $1.17 million cost for implementation and operation and maintenance of non-point source controls, with an expected $605,000 incurred by the municipality and an additional $564,000 million covered by the private sector.

Currently the Town of Stratham does not have an annual stormwater management budget, as they are currently pending receipt of the draft MS4 general permit. Therefore the additional costs associated with the implementation of non-point source controls will be much more favorable under the integrated planning scenarios. The traditional permitting alternative would be nearly an additional increase of 8.3 times the integrated planning amount, which in general terms is not financially feasible or practicable. Therefore, for the Town of Stratham the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

5.3.3.3 Cost Comparison for Town of Newfields

To meet the regulatory and water quality load targets through either an integrated planning or traditional permitting scenario, the estimated cost of implementation for the Town of Newfields are from $3.6 to $13.7 million (Table 5-17). The estimated annual cost per year for the Town of Newfields ranges from $120,000 to $460,000 inclusive of capital improvements and operation and maintenance over six permit cycles or 30 years, for wastewater treatment and non-point source controls.

All of the management scenarios presented in Table 5-17, with the exception of T-3, use integrated planning with the use of NPS management sized through an optimization approach. The T-3 scenario does not include an optimization approach and selection is not based on the greatest unit cost efficiency. Instead for the T-3 it assumes stormwater management will be conducted on all areas with no flexibility on sizing. Due to this, the cost of NPS controls for the T-3 scenario are 88% more ($9.7 million), significantly increasing the cost for implementation of this scenario.

Table 5-17. Total 50-Yr Present Value Cost by Scenario for Newfields*

Management Scenario	WWTF Cost* ($M, 50-YR PV)	NPS Cost ($M, 50-YR PV)	Total Implementation Cost ($M, 50-YR PV)	Annual Implementation Cost ($M, 50-YR PV)
IP-3/5/8	$2.6	$1.3	$4.0	$0.13
IP-5	$2.3	$1.3	$3.6	$0.12
IP-3	$2.6	$1.3	$4.0	$0.13
IP-RO	$3.1	$1.3	$4.4	$0.15
T-3	$2.6	$11.0	$13.7	$0.46

* Cost for Newfields wastewater are estimated based on ratios of flow to joining Exeter. Costs for Newfields alone were not available at the time and are assumed to be the same and will need to be updated.

Presented in Table 5-18 are the capital cost and operation and maintenance cost over 30 years for both wastewater and non-point source controls for each of the management scenarios. The operation and maintenance costs for the non-point source controls generally represent 52% of the total implementation cost for the management measures. The operation and maintenance for the wastewater connection operation and maintenance costs represents 55% of the total wastewater cost.

Presented in Table 5-19 are the annual non-point source implementation costs for each of the management scenarios broken down by municipal and private sector contribution. The proposed integrated planning alternatives (IP) have an annual NPS cost of $44,000 for the Town of Newfields. Based on the results from the optimization model, $23,000 or 52% of the total annual non-point source implementation cost (capital and O&M) will be incurred by the municipality for controls on municipally owned land (i.e., roads, parks, schools), or a total of $690,000 over 30-years.

Table 5-18. Total 50-Yr Present Value Capitol and Operation & Maintenance Cost by Scenario for Newfields

SCENARIO	WWTF CAPITAL COST* ($M, 50-YR PV)	WWTF O&M COST* ($M, 50-YR PV)	NPS CAPITAL COST ($M, 50-YR PV)	NPS O&M COST ($M, 50-YR PV)
IP-3,5,8	$1.2	$1.5	$0.64	$0.69
IP-5	$1.0	$1.2	$0.64	$0.69
IP-3	$1.2	$1.5	$0.64	$0.69
IP-RO	$1.1	$2.0	$0.64	$0.69
T-3	$1.2	$1.5	$5.33	$5.71

*Cost for Newfields wastewater are estimated based on ratios of flow to joining Exeter. Costs for Newfields alone were not available at the time and are assumed to be the same and will need to be updated. It is presumed that those costs are undervalued for Newfields alone.

Table 5-19. Total Annual NPS Present Value Cost over 30-Year Plan for Newfields

Management Scenario	Total Annual NPS Cost ($M)	Annual NPS Municipal Cost ($M)	Annual NPS Private Cost ($M)
IP-3/5/8	$0.044	$0.023	$0.021
IP-5	$0.044	$0.023	$0.021
IP-3	$0.044	$0.023	$0.021
IP-RO	$0.044	$0.023	$0.021
T-3	$0.368	$0.190	$0.177

An additional $21,000 annually is estimated to be covered by the private sector for the redevelopment and operation and maintenance of non-town owned properties occurring primarily in commercial, industrial, and residential areas for a total of $630,000 over a 30- year period. Based on the traditional permit scenario (T-3) the Town of Newfields is expected to have an annual $368,000 cost for implementation and operation and maintenance of non-point source controls, with an expected $190,000 incurred by the municipality and an additional $177,000 million covered by the private sector.

Currently the Town of Newfields does not have an annual stormwater management budget, as they received a waiver from the draft MS4 general permit requirements. However, in the future Newfields expects that a waiver may not be granted and therefore the additional costs associated with the implementation of non-point source controls will be much more favorable under the integrated planning scenarios. The traditional permitting alternative would be nearly an additional increase of 7.2 times the integrated planning amount, which in general terms is not financially feasible or practicable. Therefore, for the Town of Newfields the integrated planning alternatives are favorable due to the use of adaptive management which reduces wasteload allocations for municipal stormwater and wastewater management and allows for flexibility in management strategies and crediting across permits.

5.4 Recommended Scenario, Preliminary Implementation Plan and Schedule

The recommended alternative for nonpoint source (NPS) and stormwater (SW) management is the integrated planning scenario IP-3/5/8 for the three communities. This scenario achieves a 60% load reduction (56 tons) over a 30 year implementation period with the highest unit cost performance. This would require approximately 67 acres per year treated starting in 2017 with specific target milestones listed in Table 5-20.

Scenario IP-3/5/8 has a phased implementation of both WW and NPS across 6 permit cycles. It begins with 8 mg/L at 2019, transitions to 5 mg/L at 2029, and ends at 3 mg/L by 2042. The extended implementation schedule allows for ecosystem monitoring and adaptive management at each critical stage and for participation by upper watershed communities. The schedule provides approximately 5 years for monitoring at each stage at which point a decision point would occur as whether it is needed to design and build for the next stage over another 5 year period. IP-3/5/8 satisfies elements of both the MS4 and wastewater permits for $105 million which is approximately 50% of the estimated value for individual permitting that assumes no cost sharing of wastewater, and no cost savings in the MS4 achieved by optimization from integrated planning (Table 5-9). IP-3/5/8 is about $7 million less than if Exeter chooses to manage alone. It represents about an 80% reduction in NPS management costs for Stratham and nearly $2.7 million less in wastewater costs. This approach uses combined wastewater at the Exeter wastewater treatment facility for the three communities and least cost mix (MEP) of NPS controls.

The preliminary implementation schedule parallels key milestones in the Exeter Administrative Order on Consent. For the Integrated Plan to receive EPA approval, a formal analyses using established guidance for scheduling by performing a financial capability analyses (FCA) (EPA 2014). An FCA Framework will be conducted to evaluate the impact on residential rate payers using indicators including household income, existing rates and taxes, as well as allowing a flexibility of schedule to be responsive to circumstances unique to a community, while advancing the goal to protect clean water. The schedule will provide metrics and milestones that must be tracked and accounted for and reported in the Annual Report on the Nitrogen Control Plan (NCP).

One of the critical elements of the preliminary schedule is that an extended implementation period makes use of the private sector redevelopment cycle. Specifically as redevelopment occurs enhanced stormwater management measures will be required due to revised municipal stormwater regulations. The revised stormwater regulations will require management of nitrogen for new and redevelopment including municipal capital improvement projects that impact stormwater management. As an example, in Exeter approximately 50% of the improvements would occur in the private sector. The municipal areas are associated with management of NPS for municipally owned and managed land such as parks, schools, roads, municipal offices, and the impervious areas in the urban center typically managed by the municipality. With this approach the total cost of NPS management is covered by the land uses that generate stormwater runoff, both municipal and private sector.

Table 5-20. Preliminary Implementation Schedule and Key Milestones

YEAR	WWTF GOALS	NPS/SW LOAD REDUCTION (TONS)	NPS/SW AREA TREATED (ACRES)	CUMULATIVE LOAD REDUCTION (TONS)	COST ($M)
2016	Design for 8 mg/L	Begin implementation of optimized BMPs	0	0	$0.5
2019	Operate at 8 mg/L	0.85	200	36.9	$37.3
2023	Operate at or below 8 mg/L	1.98	467	38.0	$45.9
2029	Operate at 5 mg/L	3.68	867	47.6	$61.9
2039	Design for 3 mg/L	6.52	1533	50.4	$83.3
2044	Operate at 3 mg/L	7.93	1867	55.2	$100.6
2046	Operate at 3mg/L, Stratham WW District	8.50 Complete	2000	55.8	$105.0

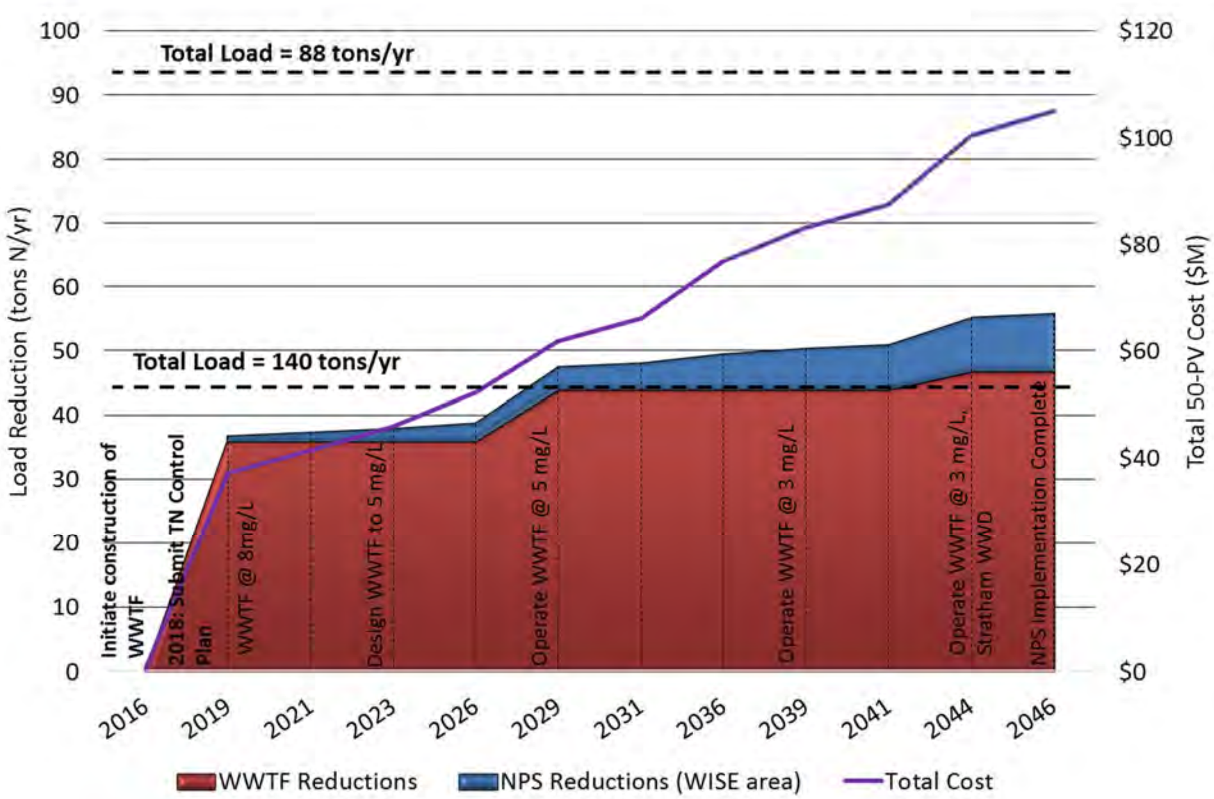


Figure 5-8. Preliminary Implementation Schedule and Key Milestones

5.4.1 Source Areas Identified for Stormwater Management and Retrofit

To achieve the targeted load reduction source areas have been identified that will have the greatest benefit for stormwater management and retrofitting with nutrient control measures. Table 5-21 presents the recommended least cost mix of nutrient management measures selected from the optimization model. Table 5-22 presents the same recommended least cost mix as presented in Table 5-21; however, shows additional water quality benefits for nitrogen, phosphorus, total suspended solids and bacteria. Specific land use area targets, nitrogen control measures, and capture depths are presented along with available acreage for tracking purposes. The measures, both structural and non-structural, target a wide variety of land uses and if implemented would provide 17,000 lbs (8.5 tons) of nitrogen removal from 2,000 acres of developed land in the subwatershed. Over a 30 year period approximately 67 acres per year will need to be treated across the three towns, with about half due to redevelopment. The structural measures selected are sized to treat a capture depth or water quality volume equivalent to 0.25-0.5 inches, which is more cost effective than sizing and constructing larger structural measures as the largest pollutant load is typically in the “first flush” of a storm event.

For example, proposed future developments that apply for Town building permits should be directed to use the recommendations below for determining which practices should be considered for their projects. It is in the best interest of the project applicants to follow the recommendations as they represent cost savings that can be achieved when compared with other practices.

Town staff will be Stormwater management is often opportunistic and may not be implemented based on the recommendations below. The recommendations represent the lowest cost alternative which need not be strictly adhered to. Tracking and accounting of retrofit implementation over time will enable adaptive management of the various nutrient control strategies and adjust practices as necessary.

A detailed Implementation Plan with specific details as to location and timing of nitrogen control practices will need to be developed for this Plan to fulfill the AOC requirements and receive EPA approval.

Table 5-21. Proposed Target Areas for Retrofit and Management Listed by Land-Use Use, Area and Water Quality Volume Treated; Total Present Value of NPS Management (including O&M): $13.6 M, Total Load Reduction from NPS Management: 17,000 lb N/yr, Total Acres Treated: 2,000 acres

BMP TYPE	SIZE	LAND USE	COVER	ACRES TREATED	ACRES AVAILABLE	%
Cover Crops	-	Agriculture	-	28	28	100%
Slow Release Fertilizer Program	-	Agriculture	-	253	253	100%
Gravel Wetland	0.25	Commercial	Impervious	104	144	72%
High Efficiency Biofiltration	0.25	Commercial	Impervious	29	144	20%
Subsurface Infiltration	0.25	Commercial	Impervious	12	144	8%
Dry Well	0.25	Commercial	Roof	36	36	100%
Gravel Wetland	0.25	Industrial	Impervious	47	47	100%
Dry Well	0.25	Industrial	Roof	25	25	100%
Gravel Wetland	0.25	Institutional	Impervious	94	113	83%
High Efficiency Biofiltration	0.25	Institutional	Impervious	19	113	17%
Dry Well	0.25	Institutional	Roof	39	39	100%
Gravel Wetland	0.25	Outdoor and Other Built-up Land	Impervious	30	30	99%
Raingarden	0.25	Residential	Impervious	300	369	81%
Raingarden	0.5	Residential	Impervious	69	369	19%
Dry Well	0.25	Residential	Roof	252	252	100%
Lawn Fertilizer Program	-	Residential	-	-	-	-
Biofiltration	0.25	Road	Impervious	112	658	17%
Gravel Wetland	0.25	Road	Impervious	546	658	83%
Street Sweeping Program	-	Road	Impervious	658	658	100%

Table 5-22. Proposed Target Areas for Retrofit and Management Listed by Land-Use Use, Area and Water Quality Volume Treated for Nitrogen, Phosphorus, TSS and Bacteria

BMP TYPE	SIZE	LAND USE	COVER	ACRES TREATED	Load Reduction (lb N/yr)	Load Reduction (lb P/yr)	Load Reduction (lb TSS/yr)	Load Reduction (col FC/yr)
Cover Crops	-	Agriculture	-	28	33	-	-	-
Slow Release Fertilizer Program	-	Agriculture	-	253	68	-	-	-
Gravel Wetland	0.25	Commercial	Impervious	104	1,103	117	47,674	1.0E+13
High Efficiency Biofiltration	0.25	Commercial	Impervious	29	265	44	10,893	2.9E+12
Subsurface Infiltration	0.25	Commercial	Impervious	12	45	10	2,477	5.9E+11
Dry Well	0.25	Commercial	Roof	36	470	37	3,384	1.2E+12
Gravel Wetland	0.25	Industrial	Impervious	47	503	72	77,432	3.4E+12
Dry Well	0.25	Industrial	Roof	25	328	13	2,866	4.4E+12
Gravel Wetland	0.25	Institutional	Impervious	94	1,229	99	19,961	9.1E+12
High Efficiency Biofiltration	0.25	Institutional	Impervious	19	221	27	3,363	2.0E+12
Dry Well	0.25	Institutional	Roof	39	511	63	7,749	1.3E+12
Gravel Wetland	0.25	Outdoor and Other Built-up Land	Impervious	30	228	16	5,841	4.0E+12
Raingarden	0.25	Residential	Impervious	300	2,392	632	346,722	8.2E+12
Raingarden	0.50	Residential	Impervious	69	702	180	84,254	2.9E+12
Dry Well	0.25	Residential	Roof	252	2,392	170	47,511	1.8E+13
Lawn Fertilizer Program	-	Residential	-	-	935	-	-	-
Biofiltration	0.25	Road	Impervious	112	536	134	170,525	2.0E+12
Gravel Wetland	0.25	Road	Impervious	546	4,649	786	973,784	3.8E+13
Street Sweeping Program	-	Road	Impervious	658	385	-	-	-
				Total:	**16,994**	**2,401**	**1,804,438**	**1.1E+14**

5.4.2 Guidance for Developing an Implementation Schedule

Scheduling approaches include guidance for CSO management, Integrated Planning, and MS4 implementation.

- Wastewater scheduling typically follows the FCA analysis. "Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development" (FCA Guidance) (EPA 832-B-97-004)
- Integrated planning is using similar info FCA Framework 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements (EPA, 2014)
- MS4 implementation for NH currently does not indicate a specific implementation schedule. No minimum period for an implementation schedule for Post Construction Stormwater Management (Minimum Measure 5) is currently required in the 2013 Draft NH MS4 General Permit. We have heard from EPA in the public forum that an extended period of time will be allowable.
- Similarly, EPA Headquarters, and Region 1 Leadership spoke at the September 2013 NACWA Integrated Planning Workshop in Portsmouth, NH, that extended implementation periods similar to CSO implementation are conceivable in the range of 4 or more permit cycle period. Environmental Monitoring

6. REFERENCES

Adamus, C.L., and Bergman, M.J. (1995). "Estimating nonpoint-source pollution loads with a GIS screening model." *Journal of the American Water Resources Association* 34(4), 647-655.

Bannerman, R.T, et. al. (1993). "Sources of pollutants in Wisconsin Stormwater." *Water Science and Technology* 28(3-5), 241-259.

CH2MHill. (2001). "Urban Stormwater Pollutant Assessment." *Technical Memorandum for North Carolina DENR*.

Claytor, R.A, and Schueler, T.R. (1996). "Design of Stormwater Filtering Systems." Center for Watershed Protection, Silver Spring, MD.

Collins, K., et. al. (2008). "Runoff Reduction Method Technical Memo – Appendix F: BMP Research Summary Tables." Center for watershed Protection & Chesapeake Stormwater Network, Ellicott City, MD.

Environmental Protection Agency (EPA). (1983). "Results of the Nationwide Urban Runoff Program: Volume I – final report," U.S. Environmental Protection Agency, PB84-185552.

EPA. (1999). "Urban Stormwater Best Management Practices Study, Part D."

EPA. (2009). "Stormwater Management Model Applications Manual." United States Environmental Protection Agency, EPA/600/R-09/000. July 2009.

EPA. (2014). "EPA's Methodology to Calculate Baseline Estimates of Impervious Area (IA) and Directly Connected Impervious Area (DCIA) for Massachusetts Communities." April 2014.

FB Environmental Associates, Inc. (2009). "Long Creek Watershed Management Plan," Appendix 7.

Geosyntec Consultants, Inc. (2014). "Least Cost Mix of BMPs Analysis, Evaluation of Stormwater Standards Contract No. EP-C-08-002, Task Order 2010-12." Prepared for Jesse W. Pritts, Task Order Manager, U.S. Environmental Protection Agency

Guerard, P. and Weiss, W.B. (1995). "Water quality of Storm Runoff and Comparison of Procedures for estimating storm-runoff loads, volume, event-mean concentrations, and the mean load for a storm for selected properties and constituents for Colorado Sprints, Southeastern Colorado, 1992." *USGS Water Resources Investigation Report 94-4194*.

Harper, H.H. (1998). "Stormwater chemistry and water quality." <http://www.stormwater-resources.com/Library/045PlChemistry.pdf>

Leisenring, M., Clary, J., and Hobson, P. (2014). "International Stormwater Best Management Practices (BMP) Database Pollutant Category Statistical Summary Report: Solids, Bacteria, Nutrients and Metals." Geosyntec Consultants, Inc. and Wright Water Engineers, Inc.. December 2014.

Lin, J.P. (2004). "Review of Published Export Coefficient and Event Mean Concentration (EMC) Data. U.S. Army Engineer Research and Development Center TN-WRAP-04-3.

Line, D.E, et. al. (2002). "Pollutant export from various land uses in the Upper Neuse River Basin." *Water Environment Research* 74(1), 100-108.

Los Angeles County Department of Public Works. (1999). 1998-99 "Stormwater Monitoring Report."

Narayanan, A. and Pitt, R. (2006). "Costs of Urban Stormwater Control Practices" (Preliminary Report).

National Agricultural Statistics Service (NASS). (2013). "Cropland Data Layer." United States Department of Agriculture Geospatial Data Gateway.

National Climate Data Center (NCDC). (2013). Historic 1-hr Precipitation Data. Station ID: COOP272174.

National Resources Conservation Service (NRCS). "Manure Spreading Calculator for Animal Feeding Operations."

New Hampshire Department of Environmental Services (NH DES). (2014). "Great Bay Nitrogen Non-Point Source Study."

New Hampshire Department of Environmental Services (NH DES). (2008). "New Hampshire Stormwater Manual."

NH GRANIT. (2014). "Impervious Surfaces 2010." University of New Hampshire Earth Systems Research Center.

NH GRANIT. (2009). "Soil Survey Geographic (SSURGO) Database for New Hampshire." University of New Hampshire Earth Systems Research Center.

Northeast Regional Climate Center (NRCC). (2009). "Monthly average PET (potential evapotranspiration) estimates in inches." <http://www.nrcc.cornell.edu/PET.pdf>

Pitt, R. (2004). "National Stormwater Quality Database v1.1."

Rockingham Planning Commission. (2012). "2010 Land Use Data, Rockingham Planning Commission Region, Rockingham County, NH."

Roseen, R. M., Stone, R., Collins, M. R., and Watts, A. W. (2013). "Final Report on Evaluation And Optimization Of The Effectiveness Of Stormwater Control Measures For Nitrogen And Phosphorus Removal." US EPA Region 1 TMDL Program, University of New Hampshire Stormwater Center, Boston, MA.

Steuer, J. et. al. (1996). "Sources of Contamination in an Urban Bain in Marquette, Michigan, and an Analysis of Concentrations, Loads, and Data Quality." *USGS Water Resources Investigation Report 97-424.*

Tetra Tech. (2009). "Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities, Final Report." Prepared for United States Environmental Protection Agency and Massachusetts Department of Environmental Protection.

University of New Hampshire Stormwater Center (UNHSC). (2012). "2012 Biennial Report."

Waschbusch, R.J. (1996). "Stormwater-runoff data, Madison, Wisconsin, 1993-94." *USGS Open File Report 95-733.*

Wright-Pierce. (2014a). “Exeter – Wastewater Facilities Planning Cost Estimates for WWTF Upgrades for Total Nitrogen for Use by WISE.” Memorandum.

Wright-Pierce. (2014b). “Wastewater Facilities Plan for the Town of Exeter, New Hampshire.” Preliminary Draft.

Wright Water Engineers, Inc. & Geosyntec Consultants, Inc. (2012). “International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals.” < http://www.bmpdatabase.org/performance-summaries.html>

Appendix C:

BMP Performance Curves for Accounting of Pollutant Load Reductions

APPENDIX C: BMP Performance Curves for Accounting of Pollutant Load and Runoff Volume

This appendix provides a series of design tools for determining the annual pollutant load and runoff volume for a given nutrient control measure based on system, soil, and water quality capture volume. The BMP performance curves include 8 systems, each for 8 land uses for both impervious areas (road, driveway, sidewalks), rooftop (in some instances loading values are different), and developed pervious areas (lawns, landscaped areas). Some systems are excluded from some land uses based on selection by municipalities and preferred practices. The matrix of structural practices are listed in Table 1. An example of the usage of the design tools is presented below. Land use classification was based on the 2008 NH GRANIT Land Use Mapping Standard by the Complex Systems Resource Center. Pollutant load export rates (PLER) were developed based in part from pollutant concentration data provided in references below. See related appendix on Modeling Method for complete explanation on the development of PLERs.

Nutrient Control Measures:

1. Bioretention with underdrains
2. Bioretention without underdrains
3. High-efficiency bioretention
4. Drywells
5. Extended Detention Pond
6. Gravel Wetland
7. Sand filter
8. Subsurface infiltration

Land Uses:

1. Residential,
2. Commercial,
3. Industrial,
4. Institutional (ie municipal, state, federal buildings),
5. Roads,
6. Freeway,
7. Mixed developed uses,
8. Outdoor and other built-up lands

Example use of BMP performance curve to determine annual nitrogen load:

What is the nitrogen load reduction of 1 system designed to treat a 1" water quality volume (WQV) from 1 acre in contrast with 4 systems designed to each treat 1 acre at 0.25" WQV from a commercial property on a Type A soil?

From the BMP performance curve (Figure 1) on a Type A soil, a system treating a 1" water quality volume for 1 acre will export approximately 0.7 lbs N/acre/year which is a reduction of

13 lbs N/acre/year. The pollutant load export rates is 13.7 N/acre/year for untreated commercial impervious areas (parking, sidewalks, roads, etc.).

Whereas 4 smaller systems across 4 acres designed to treat 0.25” water quality volume per acre will each export approximately 3.3 lbs N/acre/year which is a reduction of 10.4 lbs N/acre/year for a total reduction of 41.6 lbs N per year.

For a high-performance bioretention we can see that 4 systems designed to treat a 0.25” water quality volume in replace of one system to treat a 1” water quality volume would remove an additional 28.6 lbs of Nitrogen per year or approximately 320% greater load reduction.

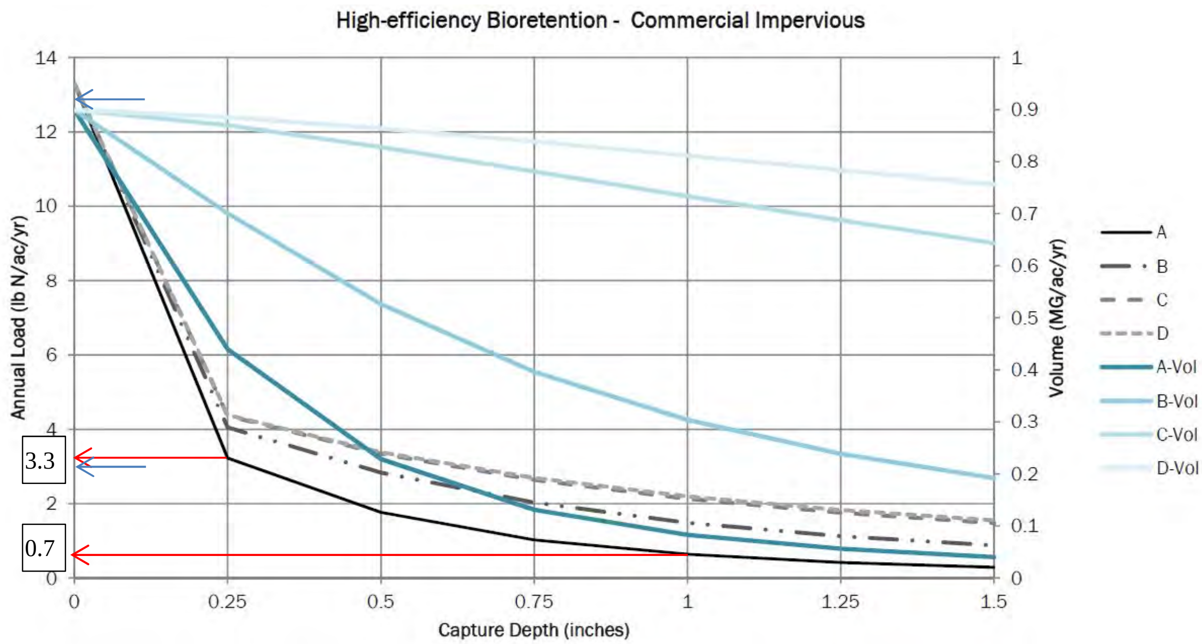


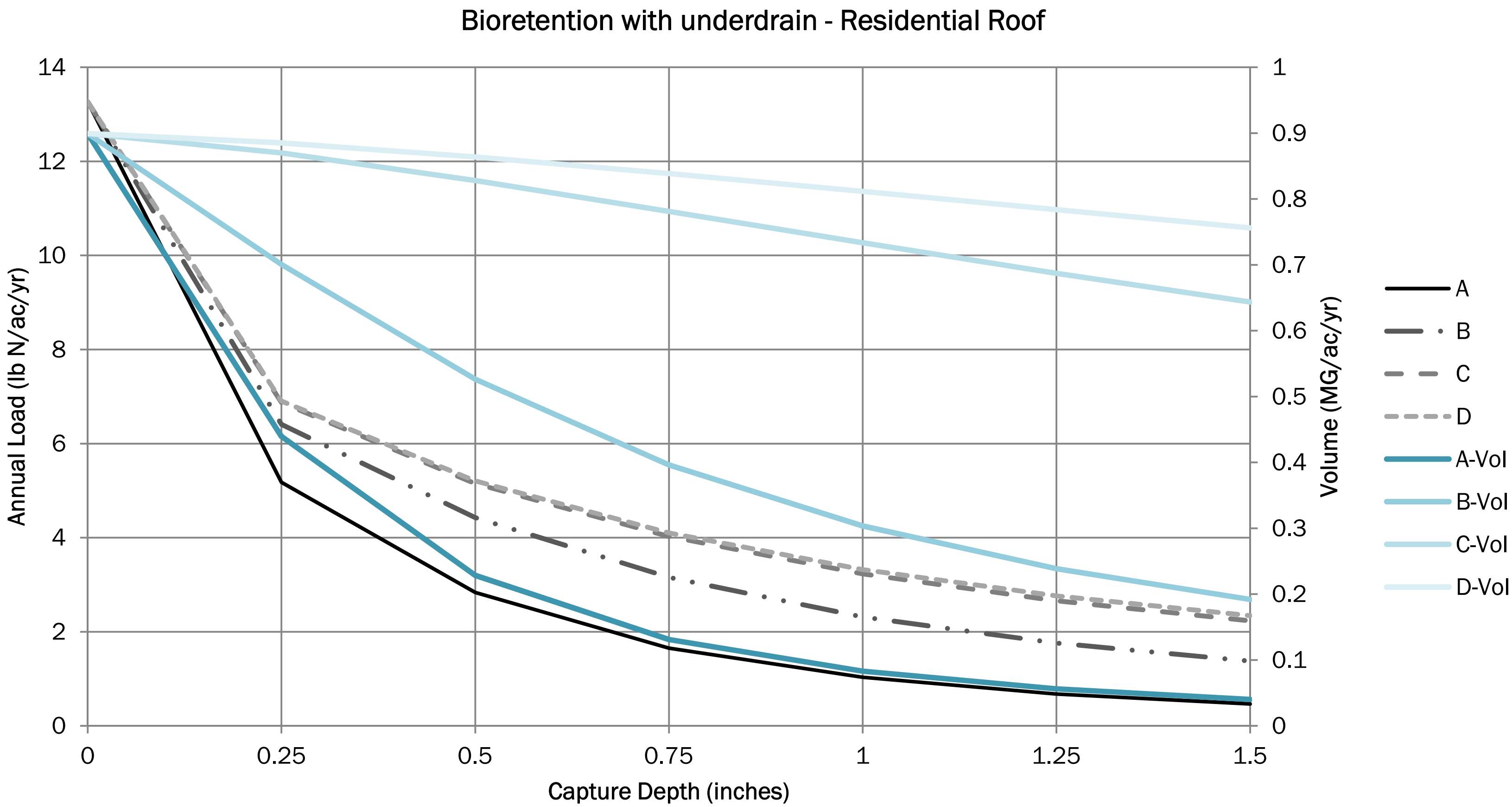
Figure 1. BMP Performance Curve for high-efficiency bioretention on commercial impervious areas illustrating annual exported load (lbs Nitrogen/acre/year) and volume (million gallons/acre /year) based on water quality volume (aka capture depth)

Table 1. Matrix of structural nutrient control measures by land use

CATEGORY		COVER TYPE	STRUCTURAL NUTRIENT MANAGEMENT MEASURES									
			ED Wet Pond	Gravel Wetland	Subsurface Infiltration	Sand Filter	Biofiltration	High Efficiency Biofiltration	Tree Pits	Raingarden	Dry Well	Permeable Pavement
LAND USE	Residential	Pervious						•		•	•	
		Impervious						•		•	•	
		Roof						•		•	•	
	Residential Subdivision	Pervious					•	•				
		Impervious					•	•				•
		Roof					•	•			•	
	Commercial/ Industrial/ Institutional	Pervious	•	•	•	•	•	•	•			
		Impervious	•	•	•	•	•	•	•			•
		Roof			•		•	•			•	
	Road/ Freeway	Impervious	•	•			•					
	Outdoor/ Other Urban Land	Pervious		•	•	•	•	•	•			
		Impervious		•	•	•	•	•	•			•

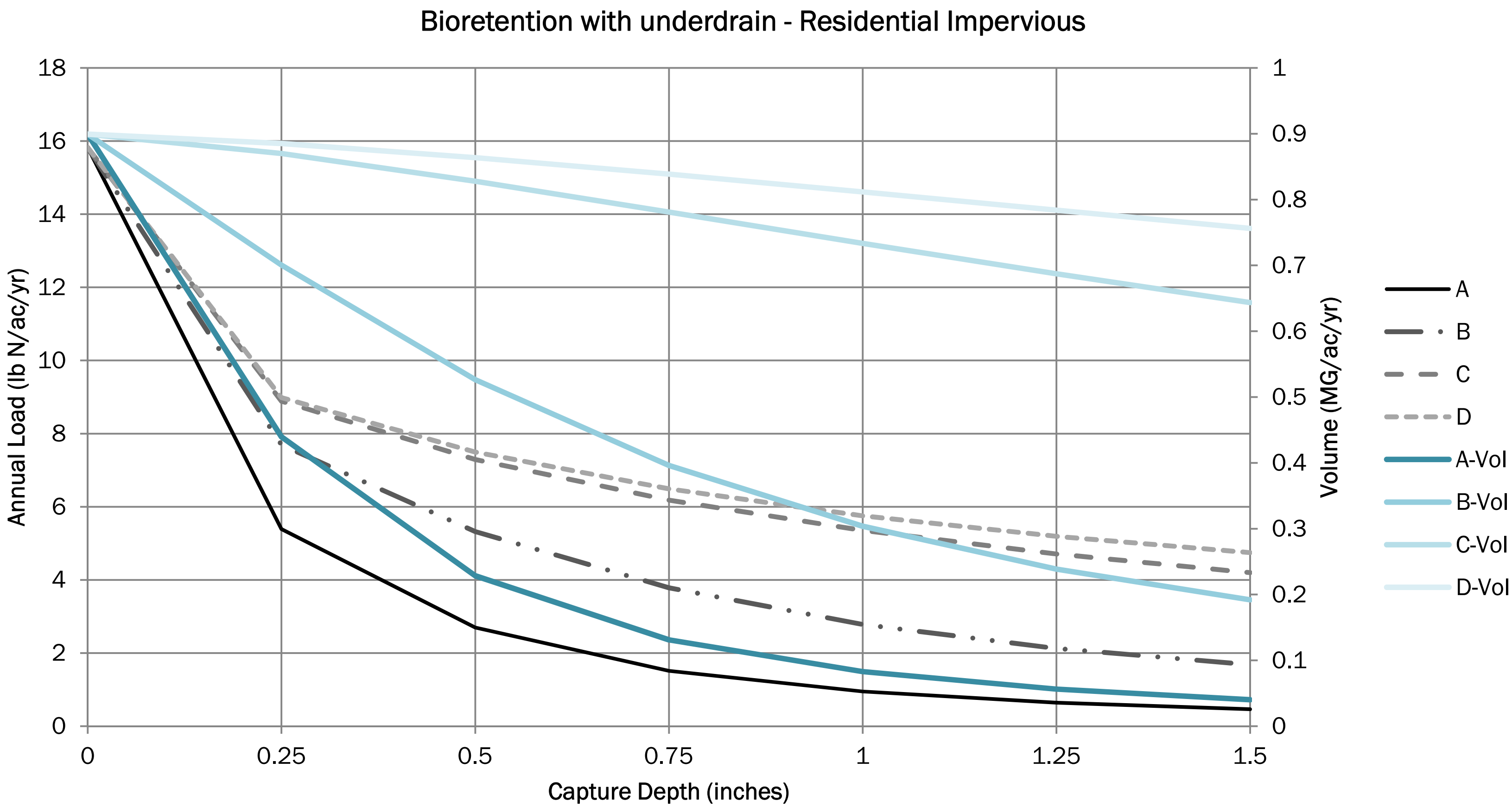
References for Pollutant Concentration

1. Adamus and Bergman (1995). Estimating Nonpoint Source Pollution Loads with a GIS Screening Model
2. Bannerman et al (1992). Sources of Pollutants in Wisconsin Stormwater
3. CH2MHill Technical Memo. Urban Stormwater Pollutant Assessment, NC DENR 2001.
4. Claytor & Shueler (1996). Design of Stormwater Filtering Systems
5. EPA. (1983). "Results of the Nationwide Urban Runoff Program: Volume 1 - Final Report." Water Planning Division, U.S. Environmental Protection Agency, Washington, DC.
6. Guerard, P., and Weiss, W.B. (1995). Water quality of Storm Runoff and Comparison of Procedures for Estimating Storm-Runoff Loads, Volume, Event-Mean Concentrations, and the Mean Load for a Storm for Selected Properties and Constituents for Colorado Springs, Southeastern Colorado.
7. Harper, H.H. (1998). Stormwater Chemistry and Water Quality Line, D.E. et al (2002). Pollutant Export from Varous Land Uses in the Upper Neuse River Basin.
8. Los Angeles County Stormwater Monitoring Report: 1998-1999
9. New Hampshire Stormwater Manual, Appendix D.
10. Pitt, R. National Stormwater Quality Database v1.1. Summary Table.
11. Steuer et al (1996). Sources of Contamination in an Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality.
12. Waschbusch et al (2000). Sources of Phosphorus in Stormwater and Street Dirt from Two Urban Residential Basins in Madison, WI.



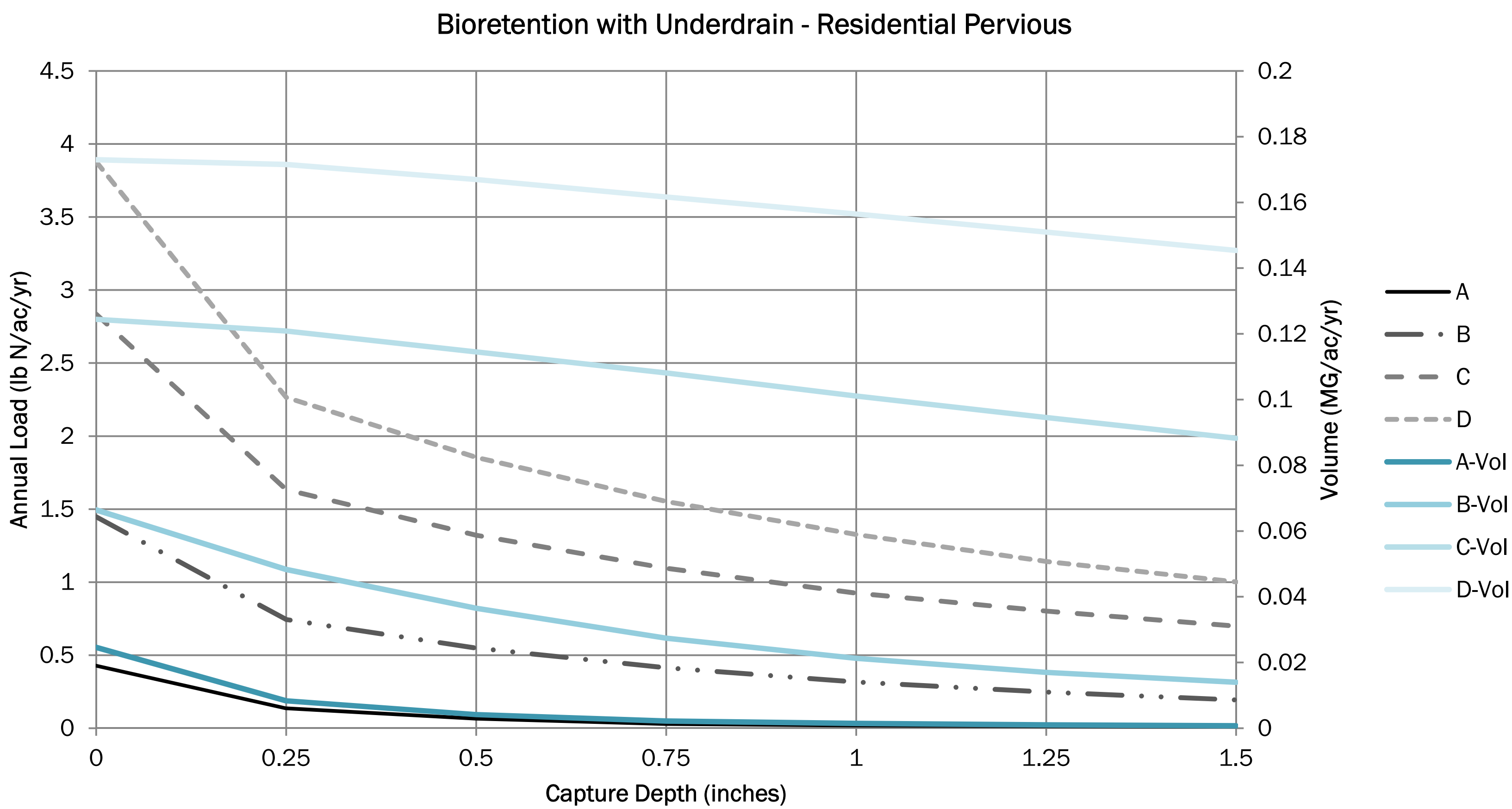
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



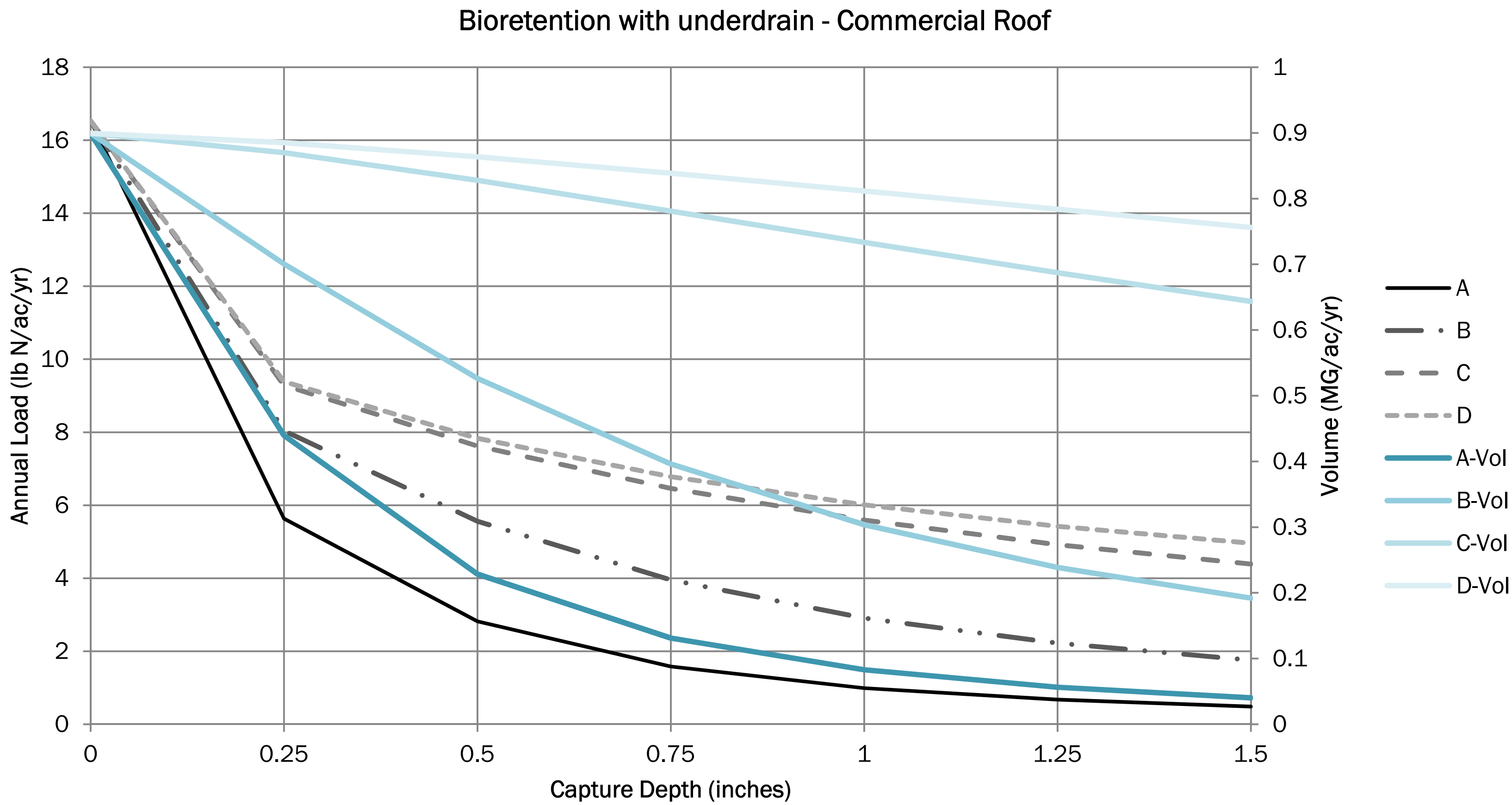
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



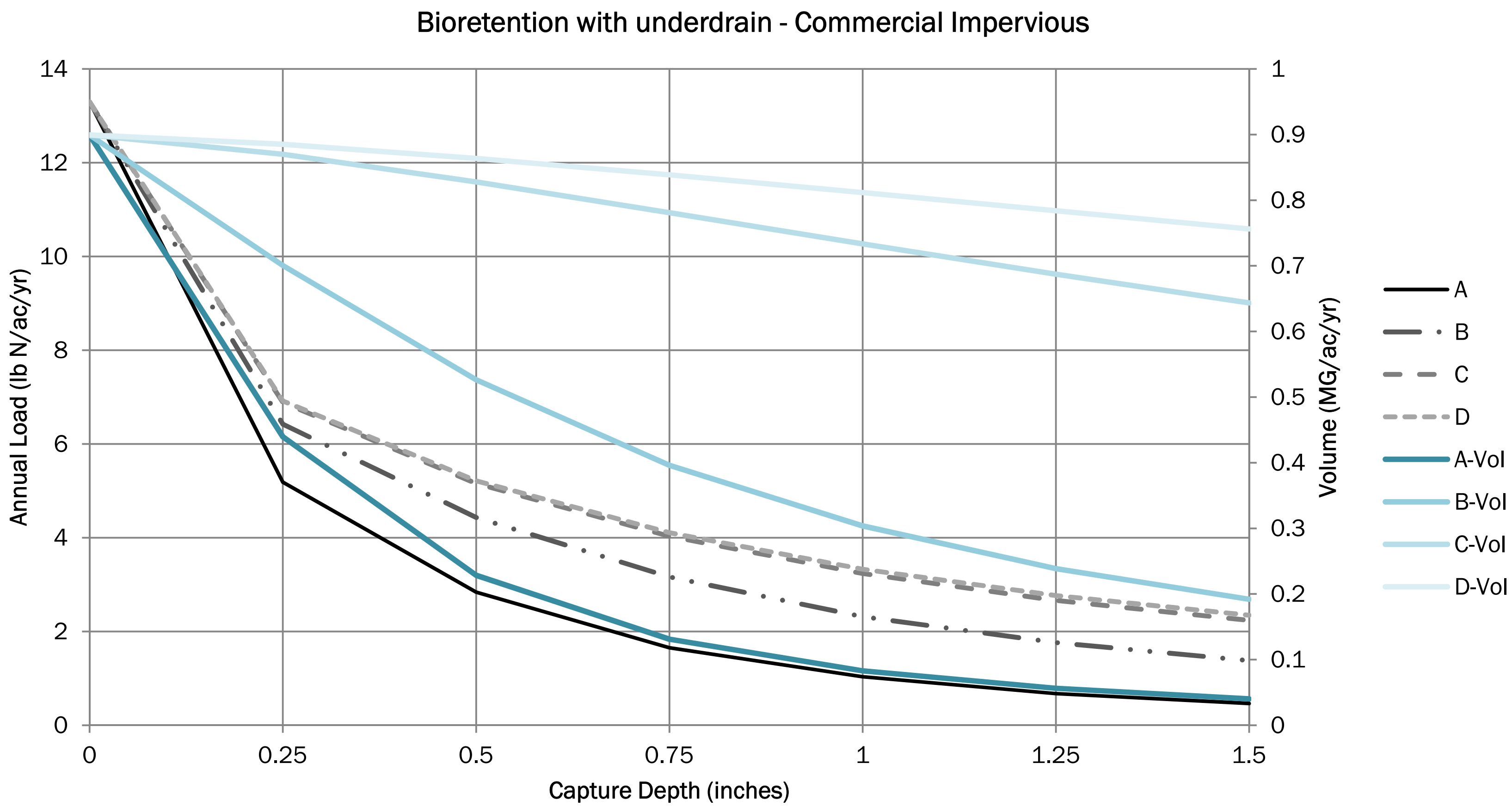
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



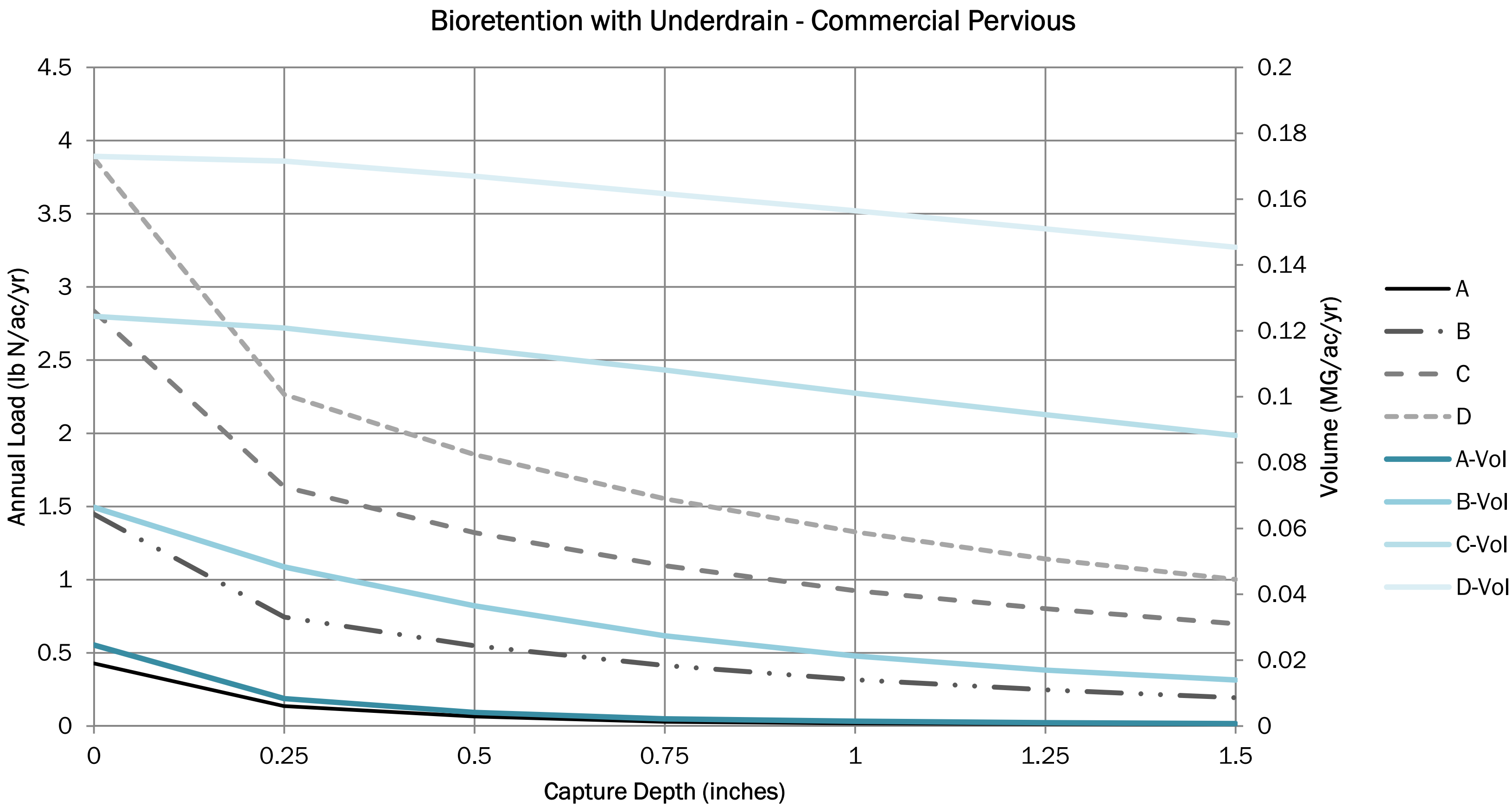
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



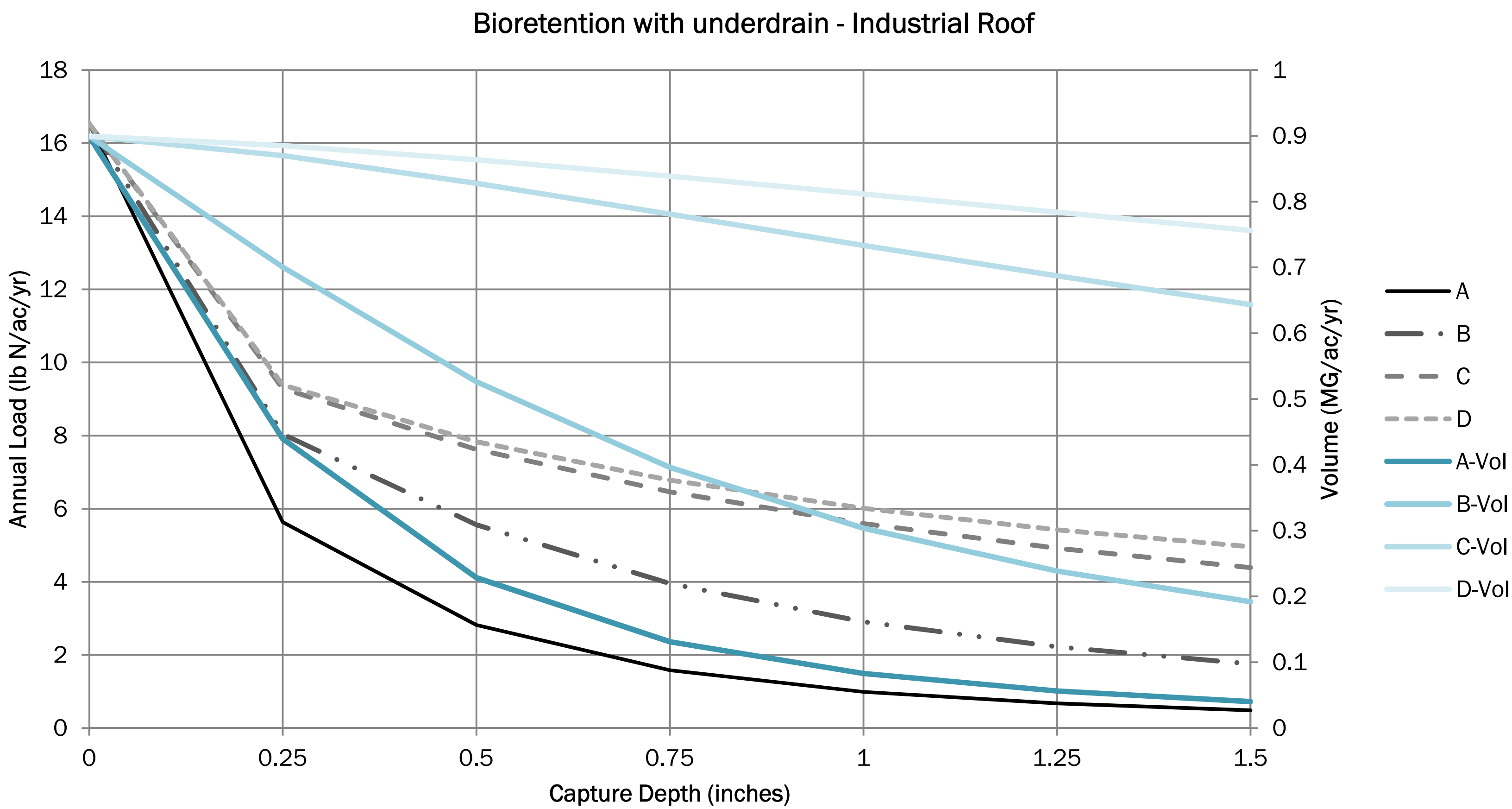
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



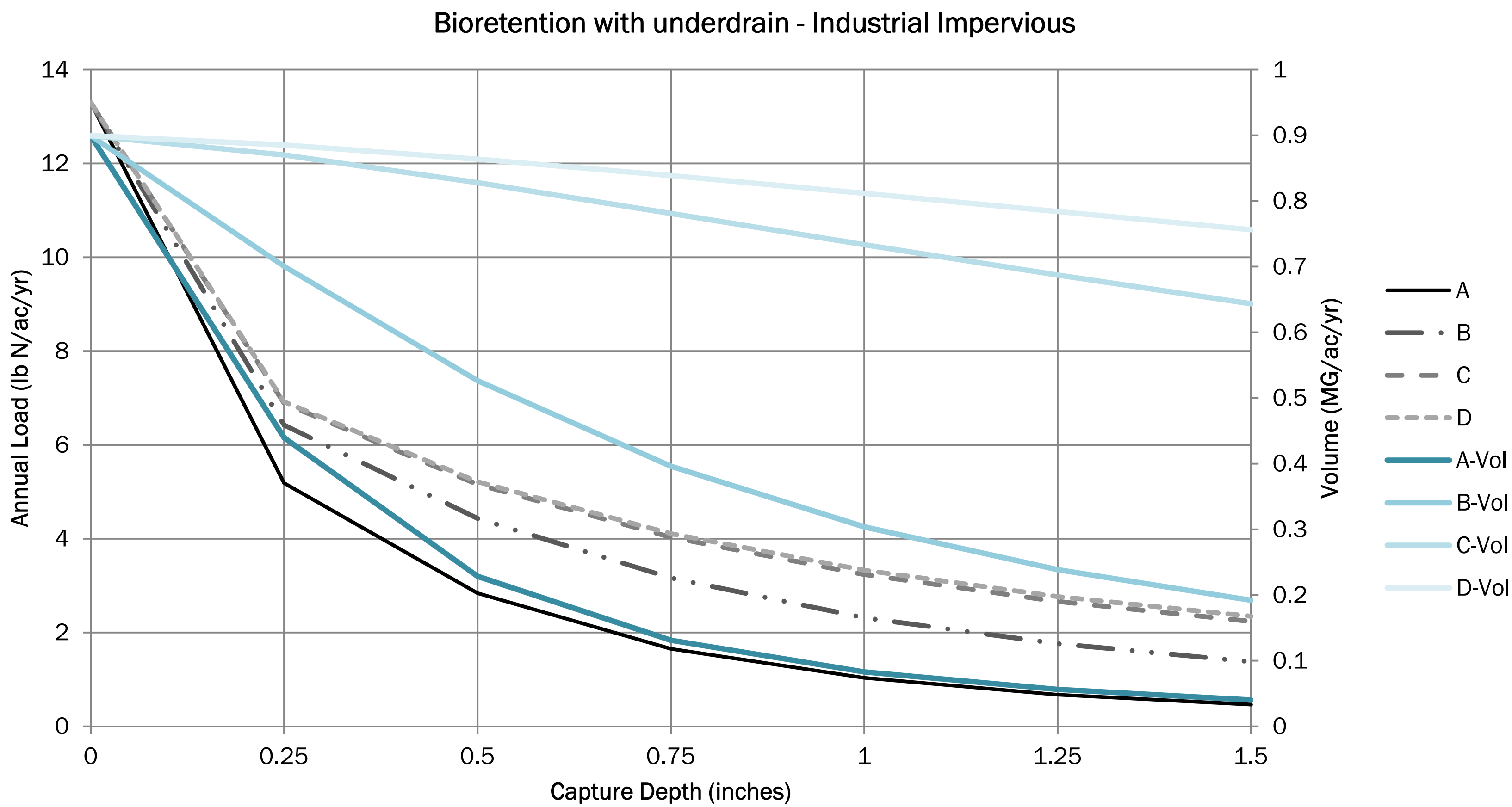
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



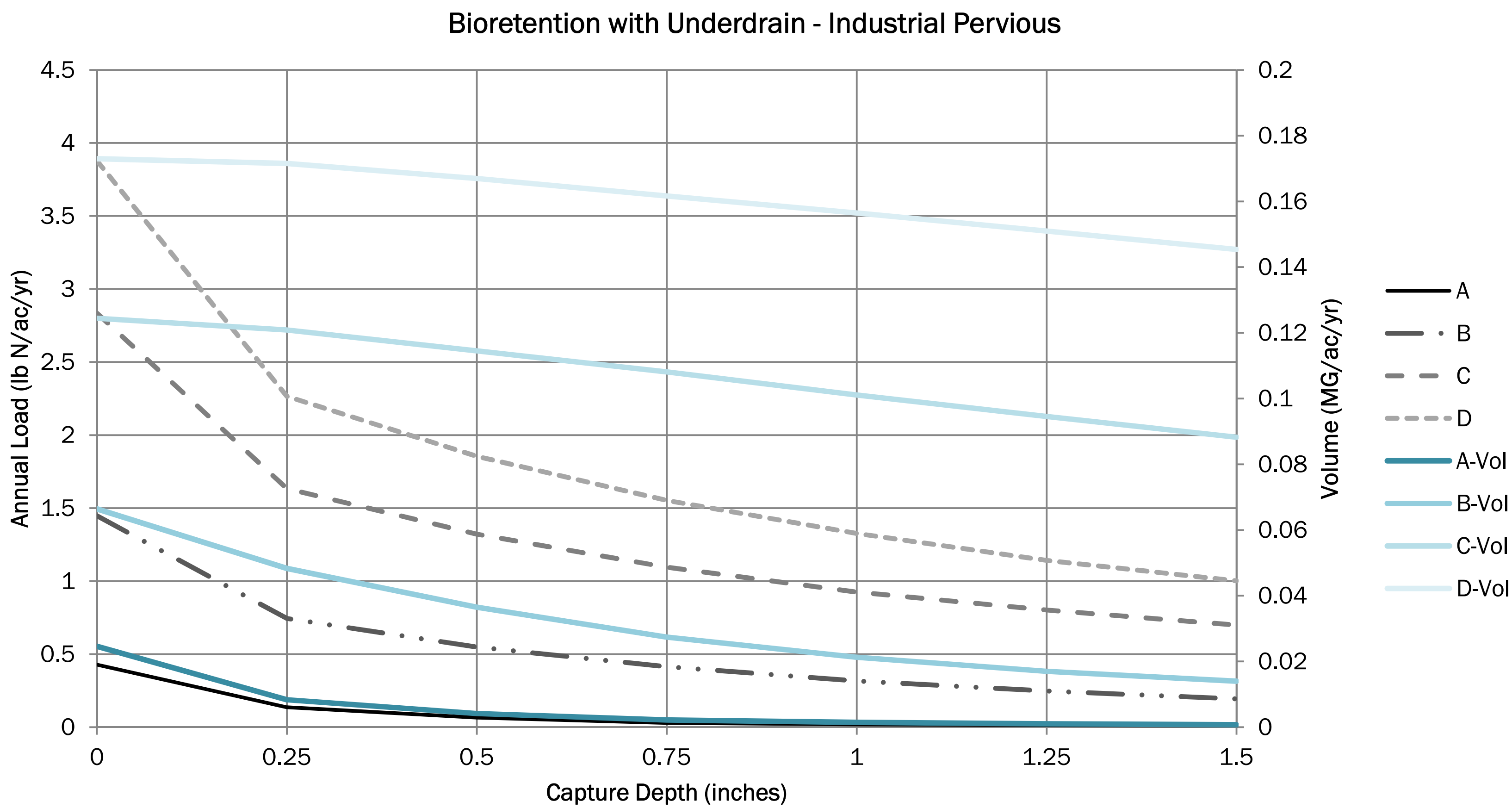
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



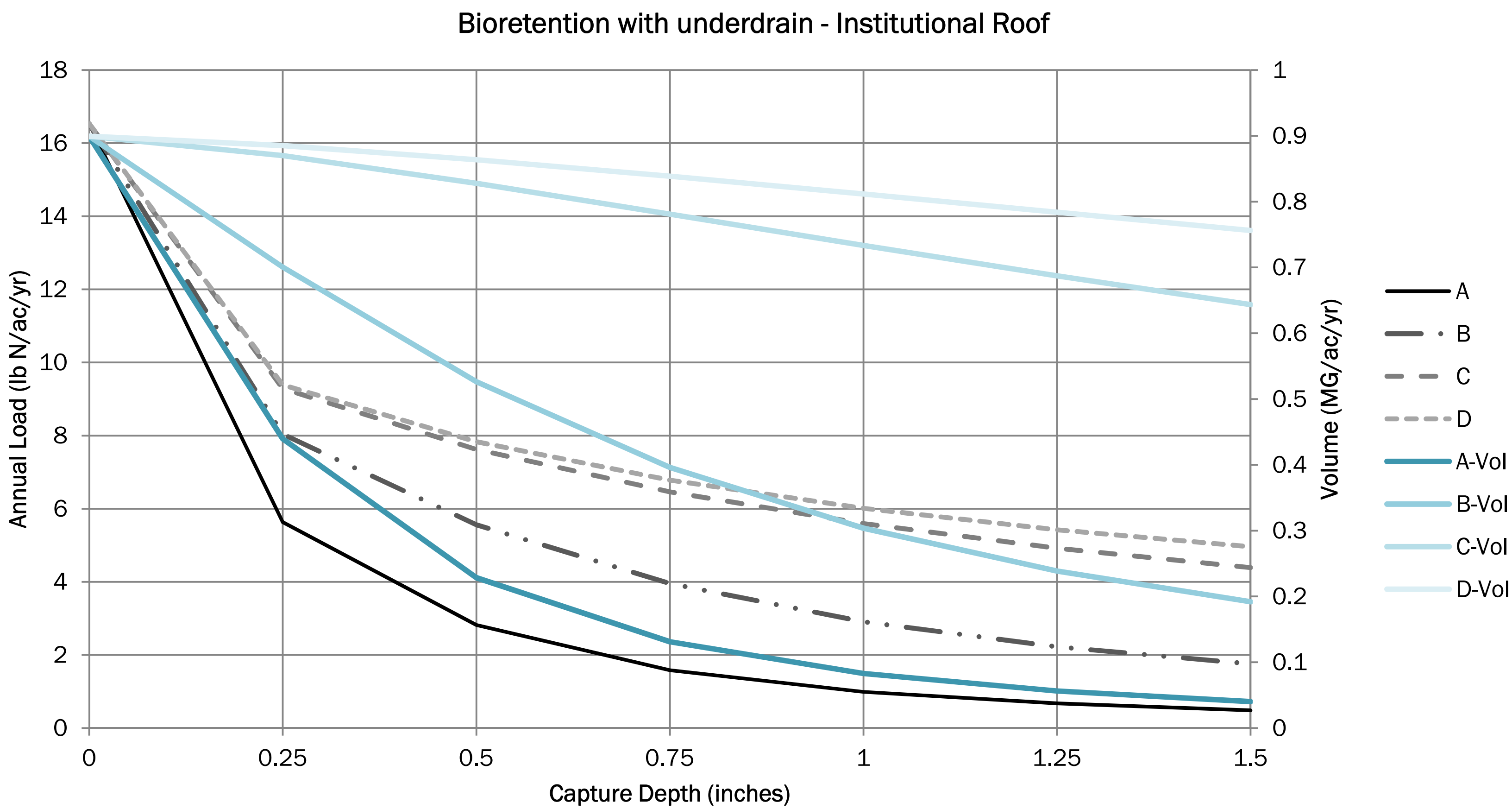
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



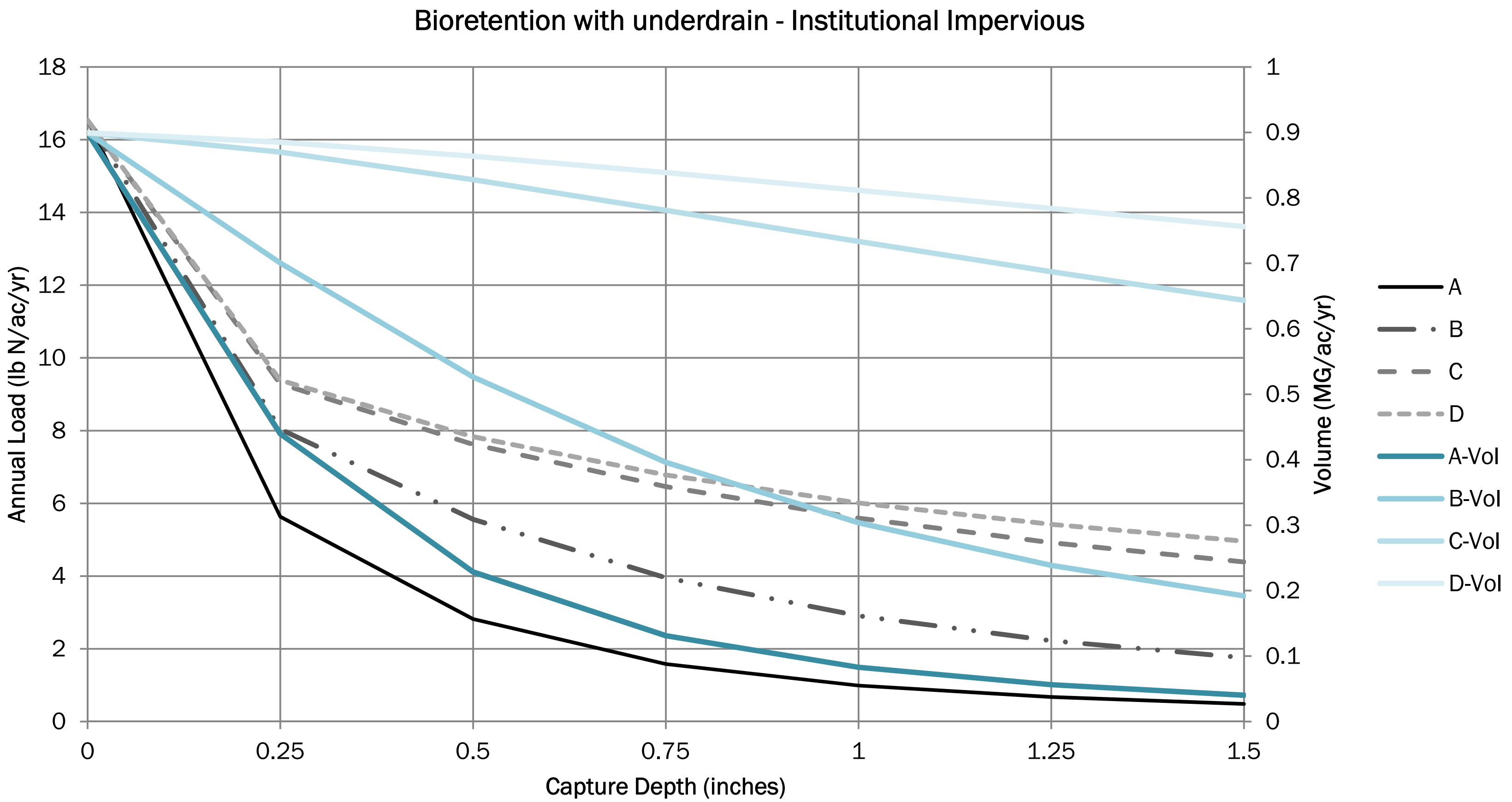
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



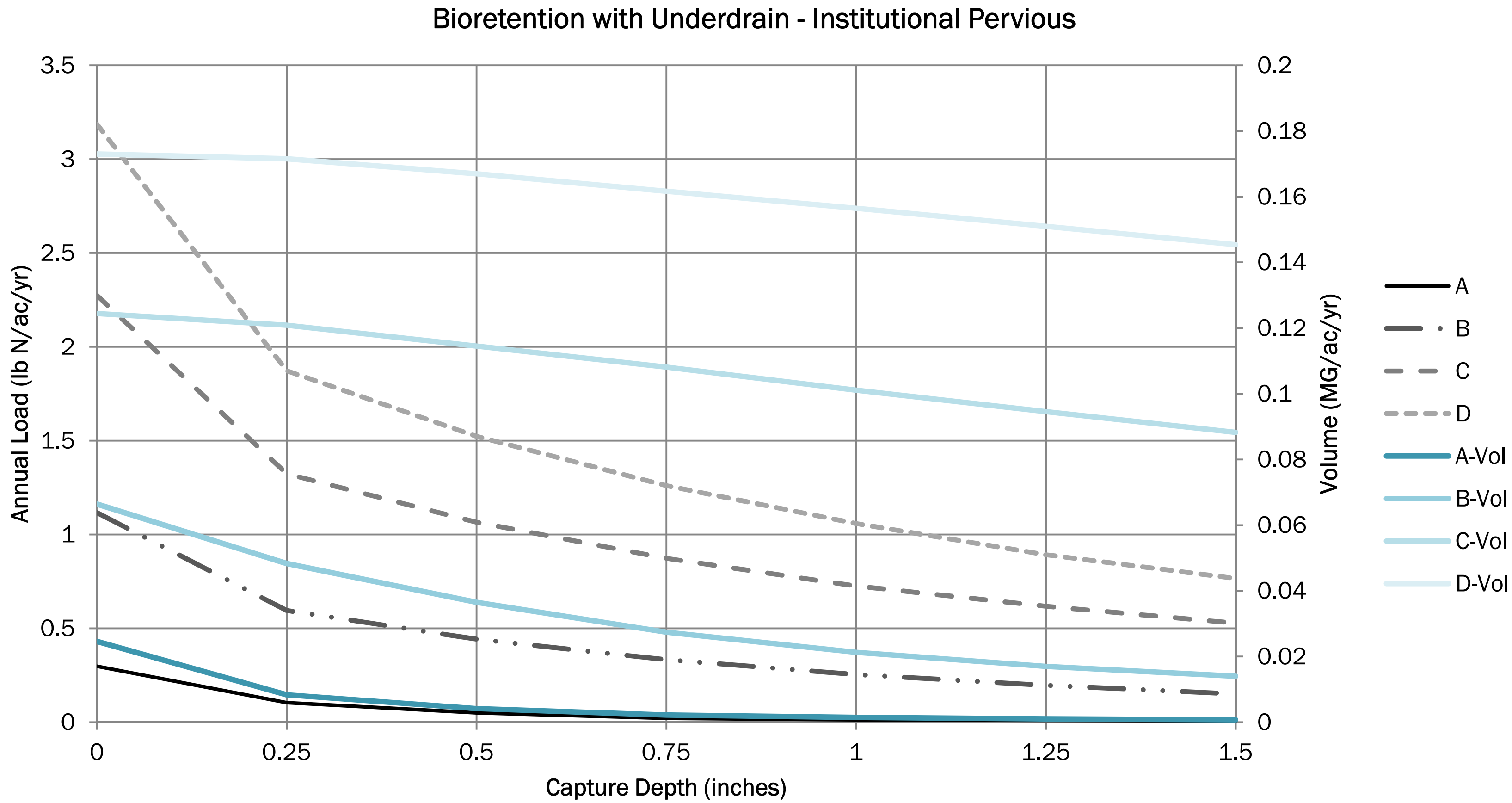
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



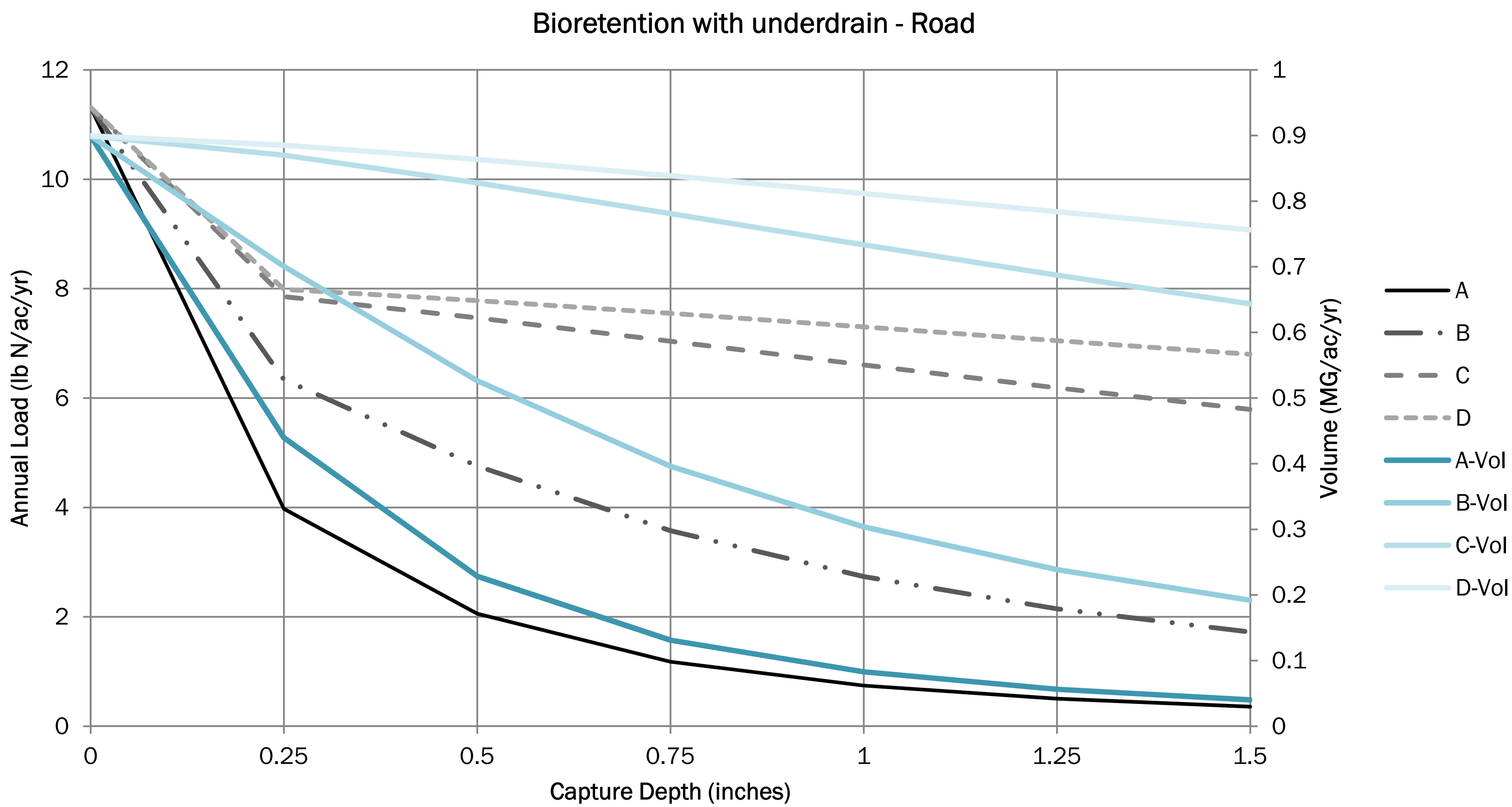
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



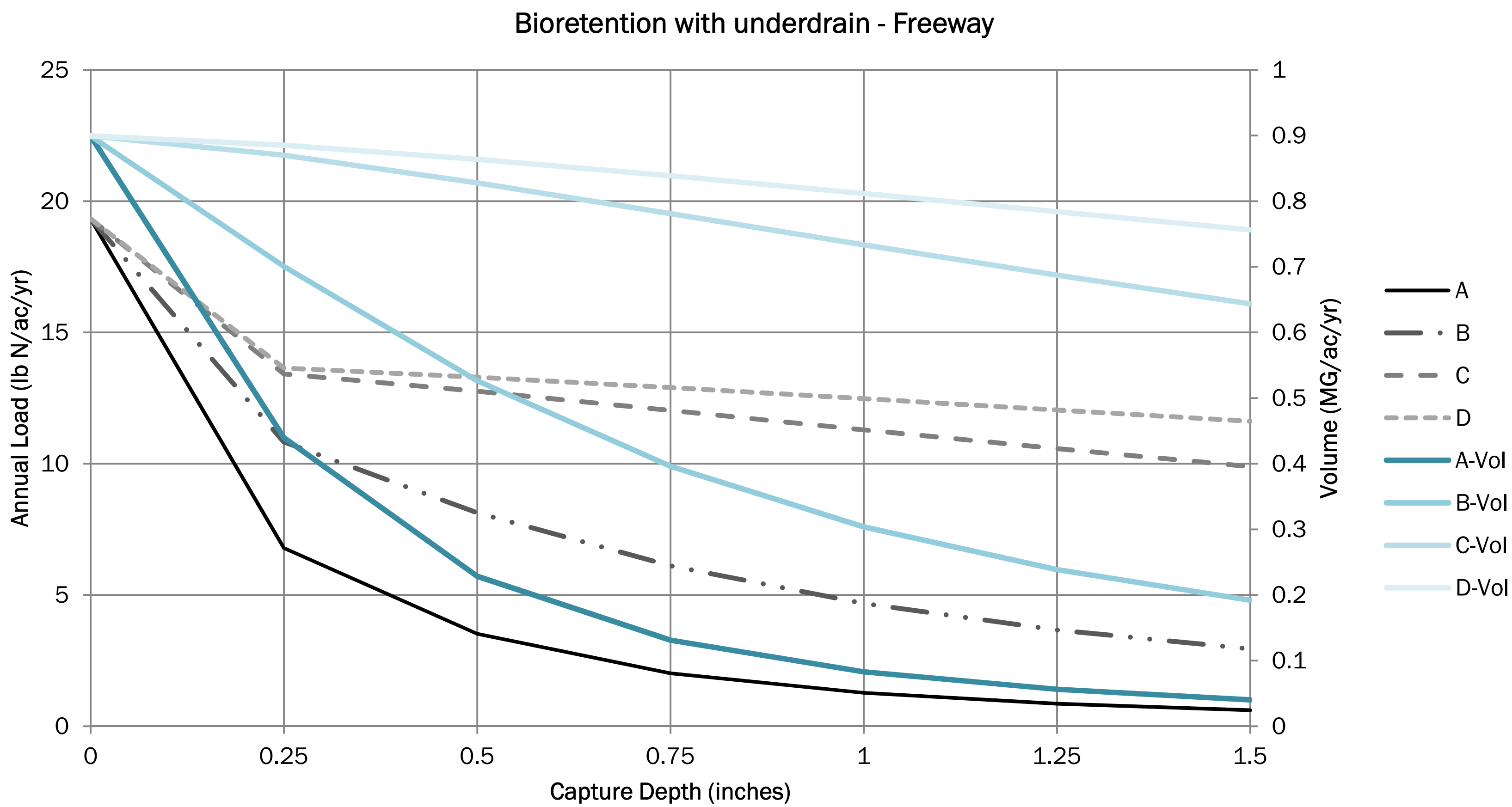
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



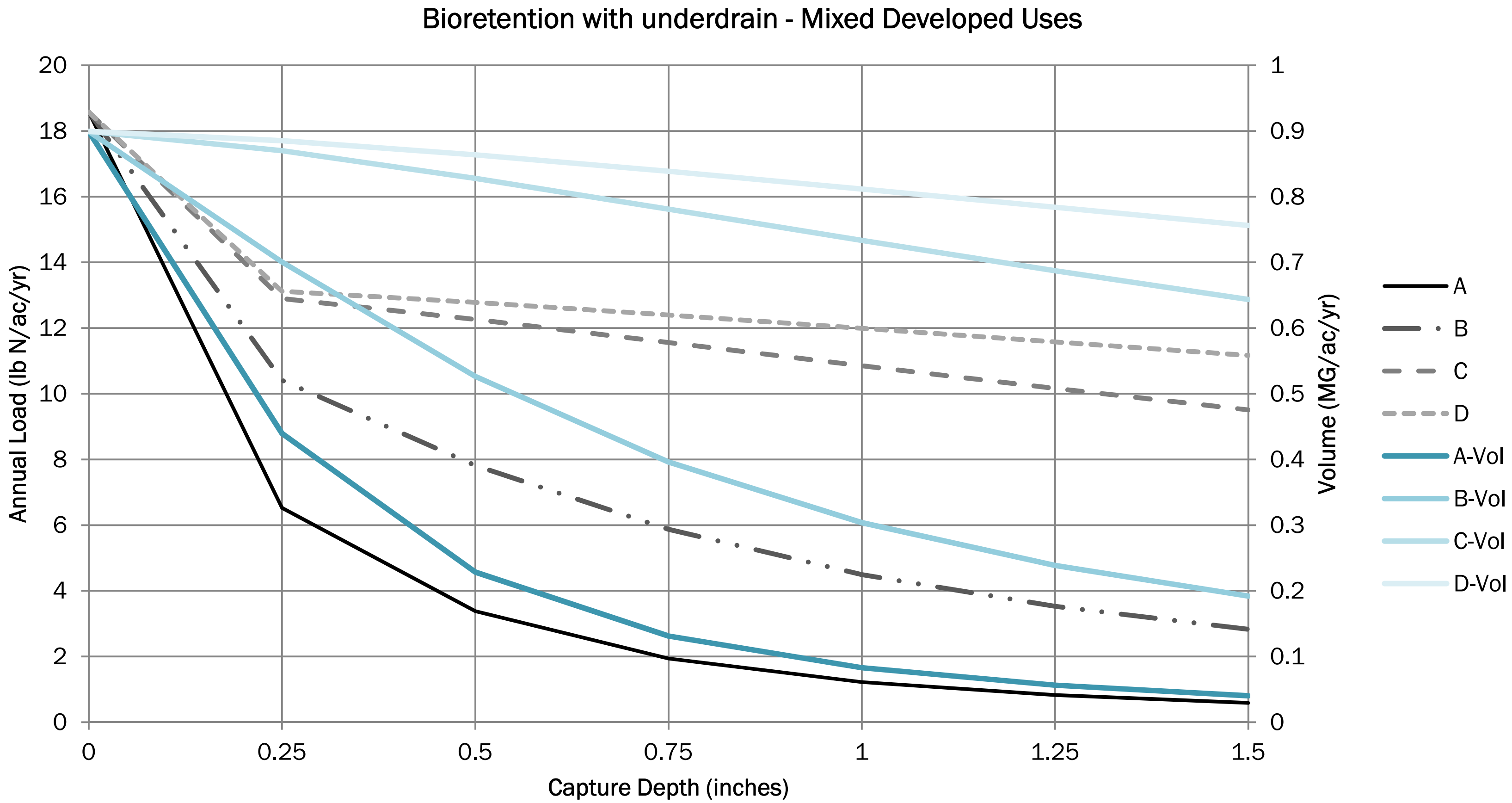
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



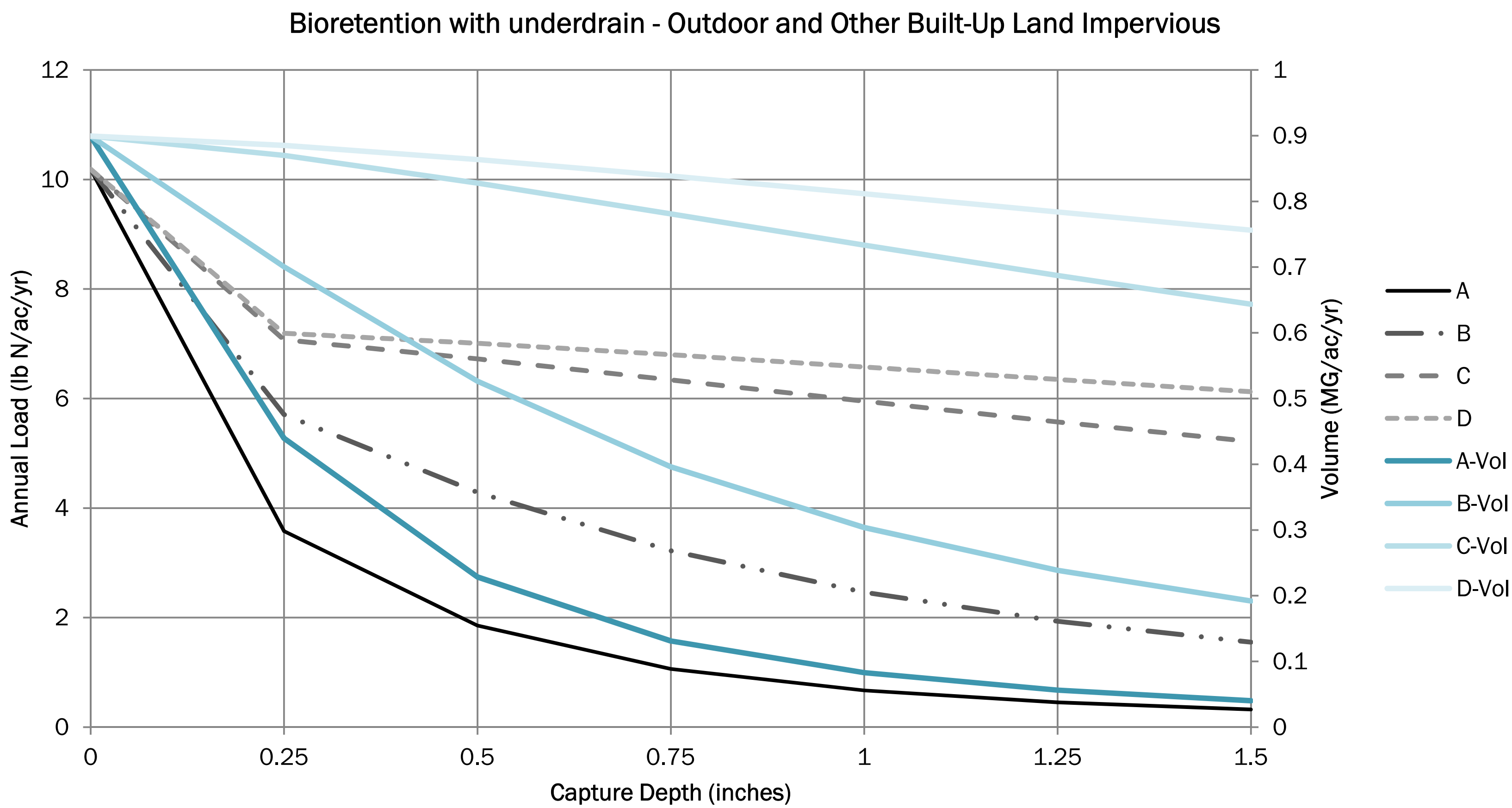
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



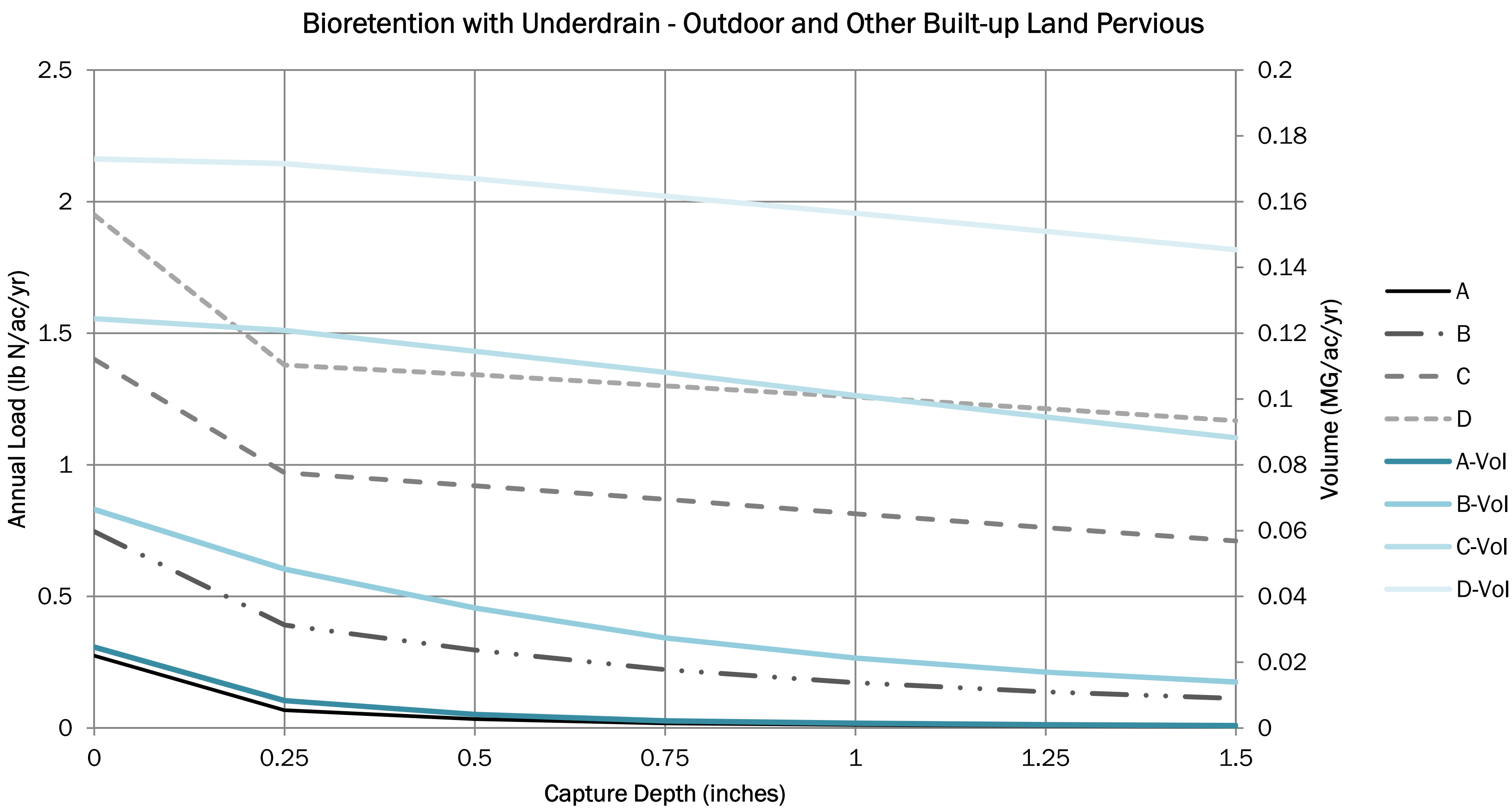
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



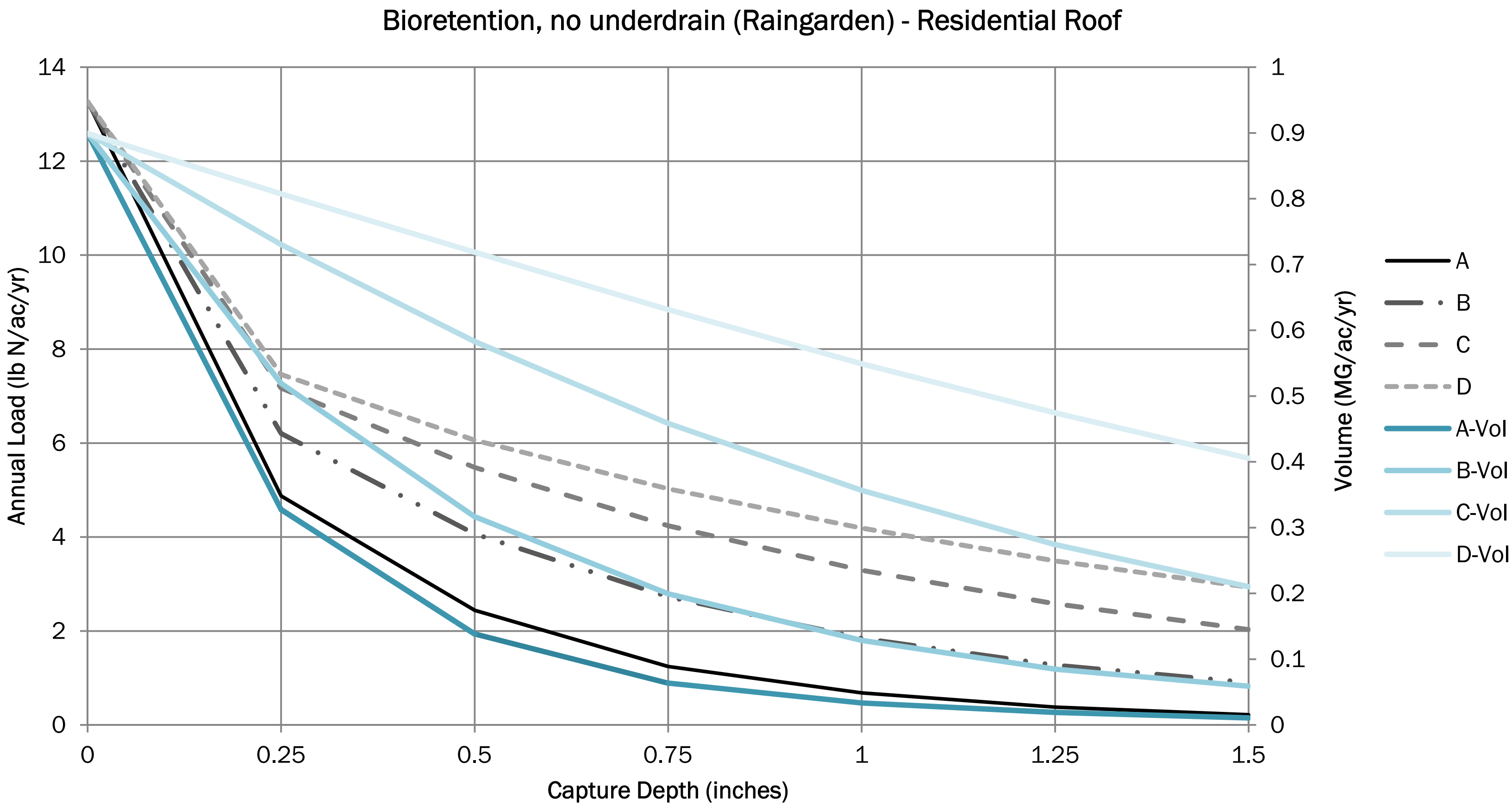
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



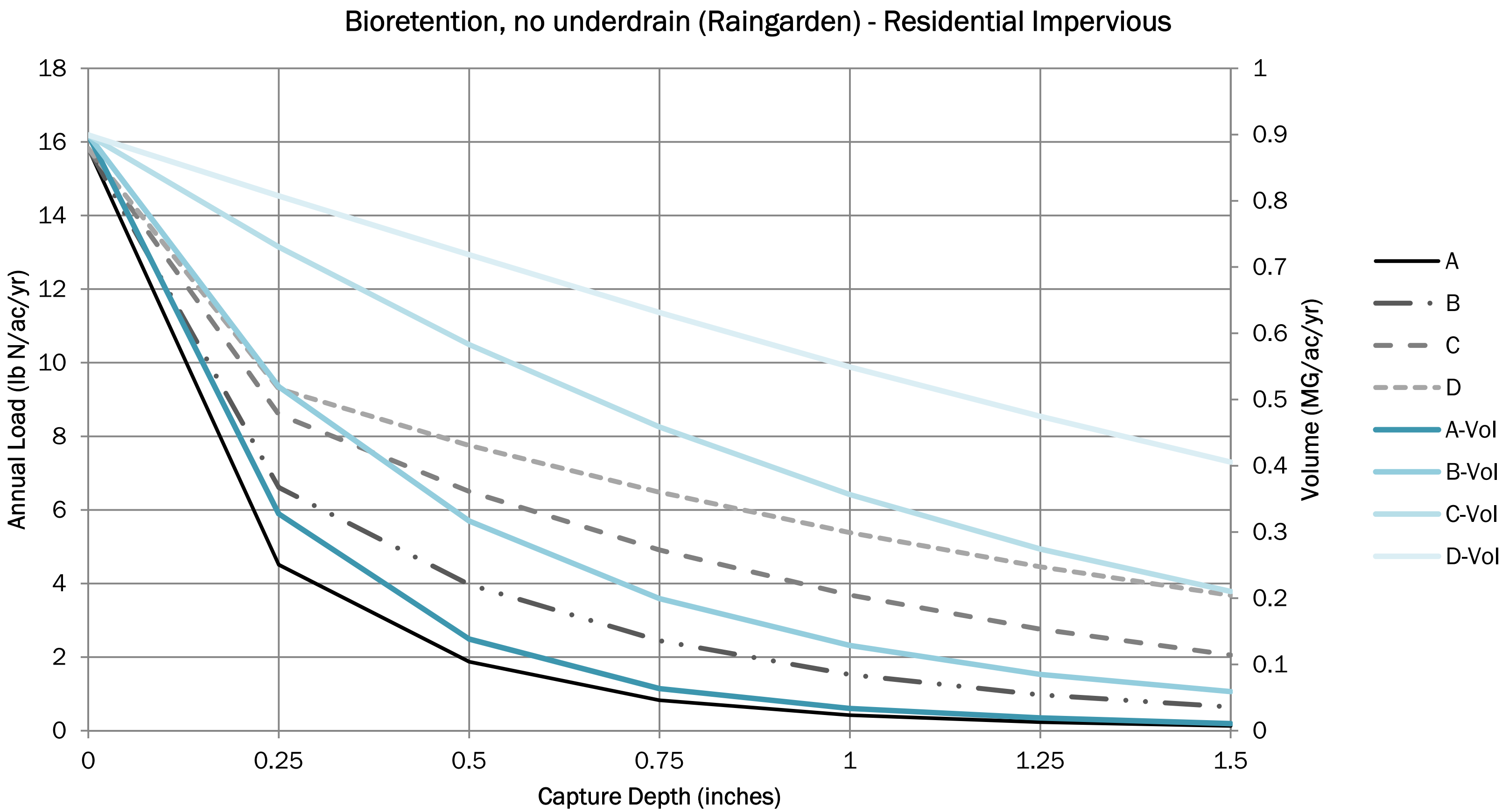
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



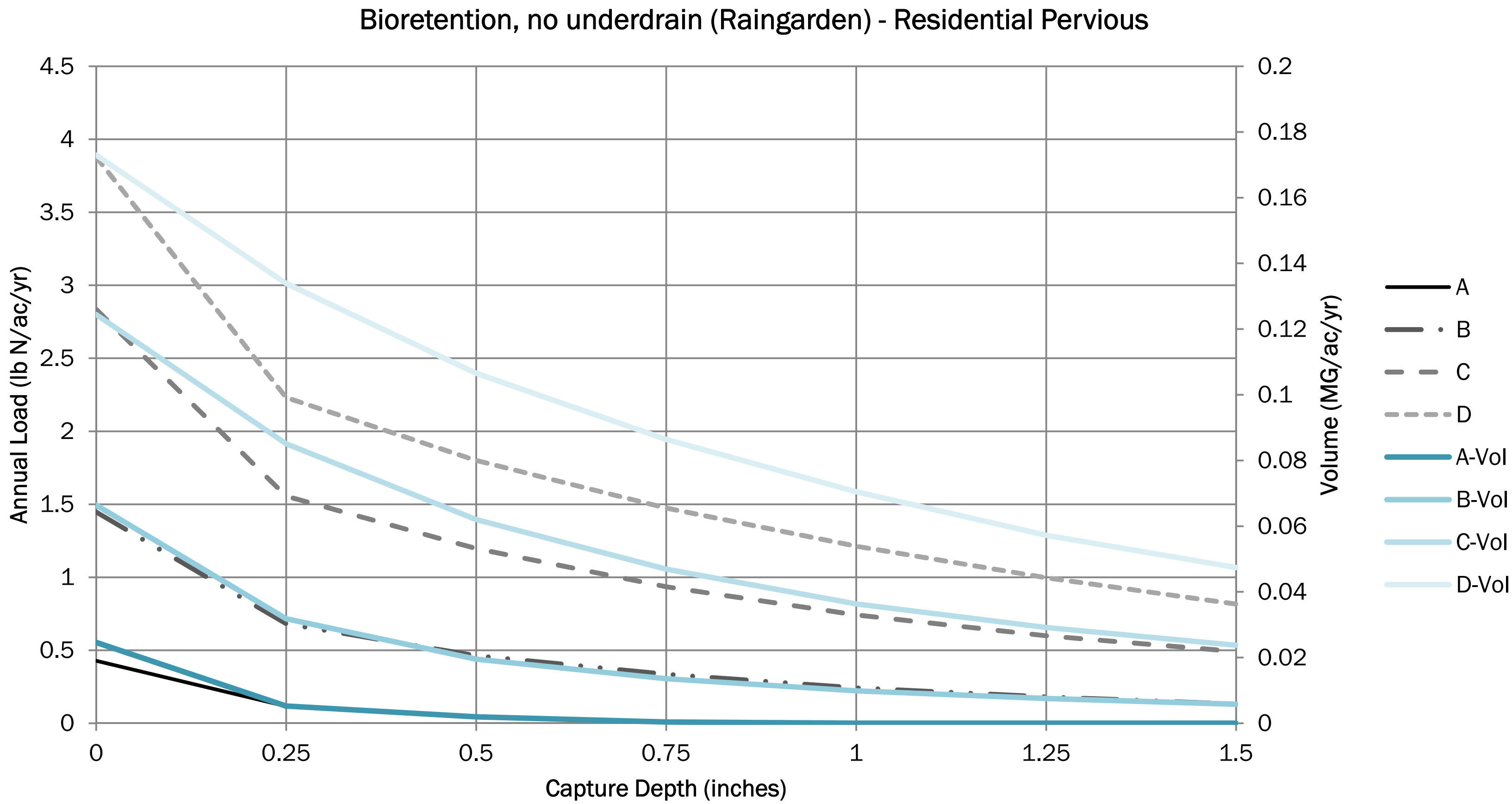
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



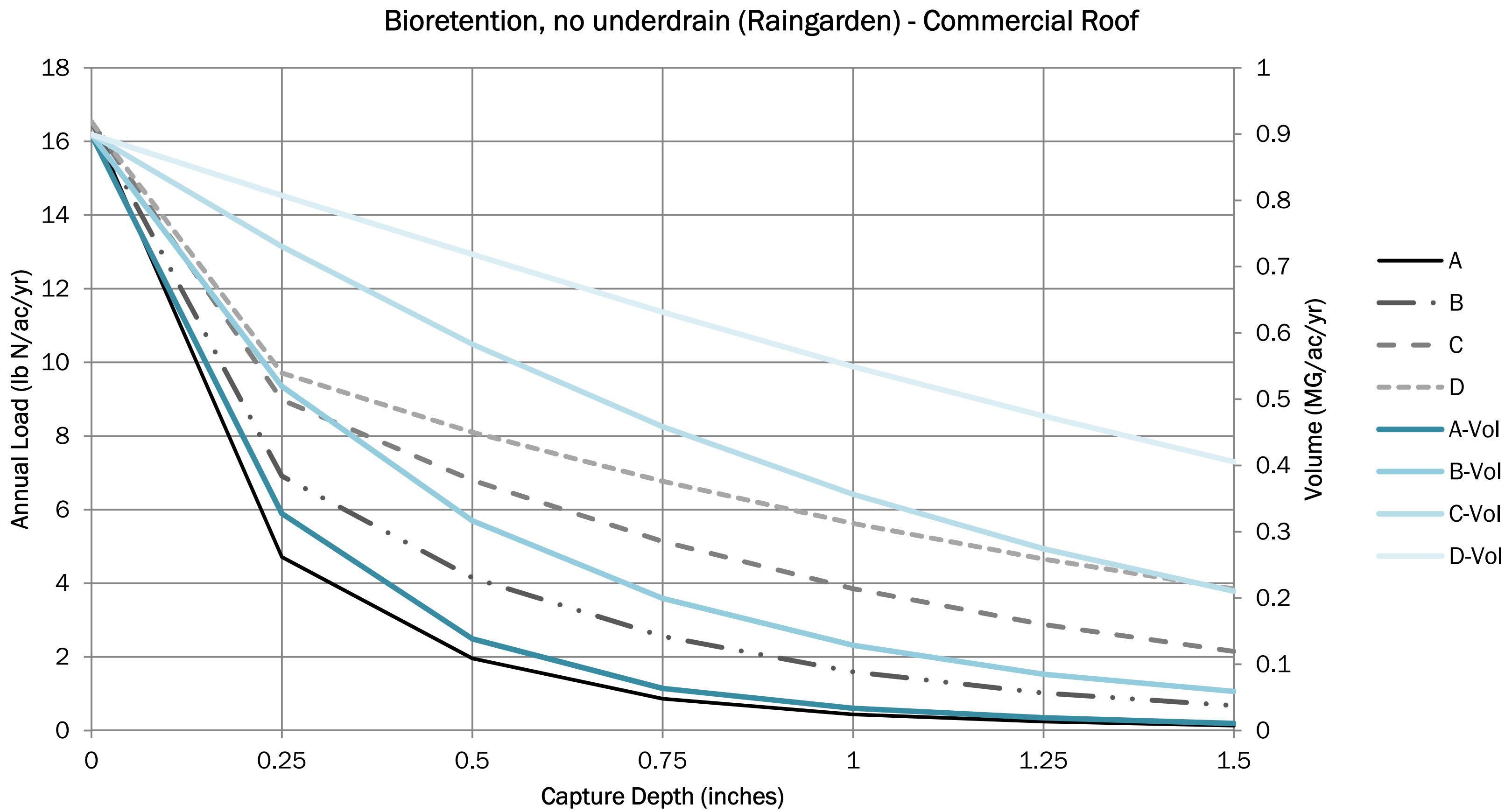
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



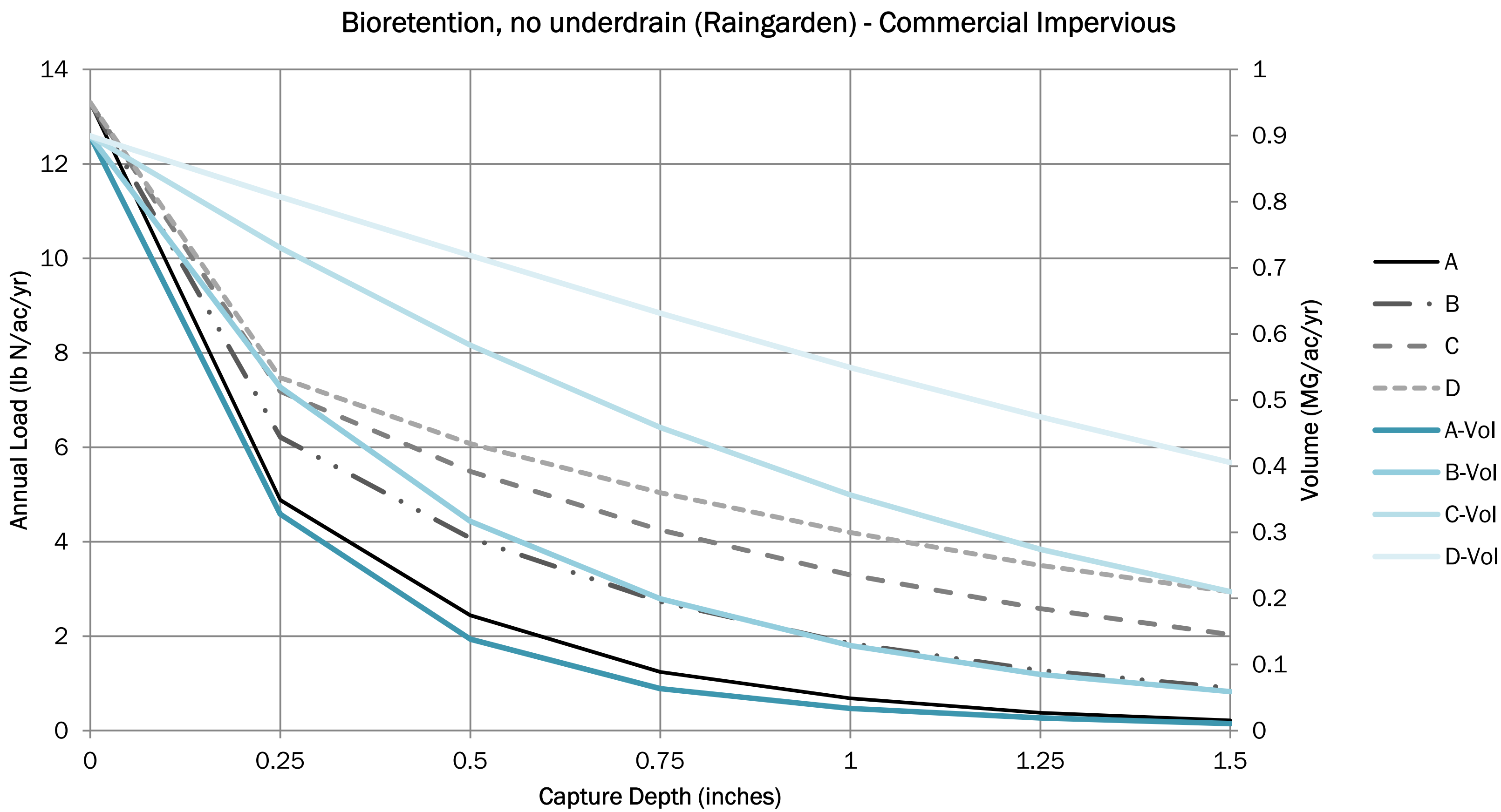
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



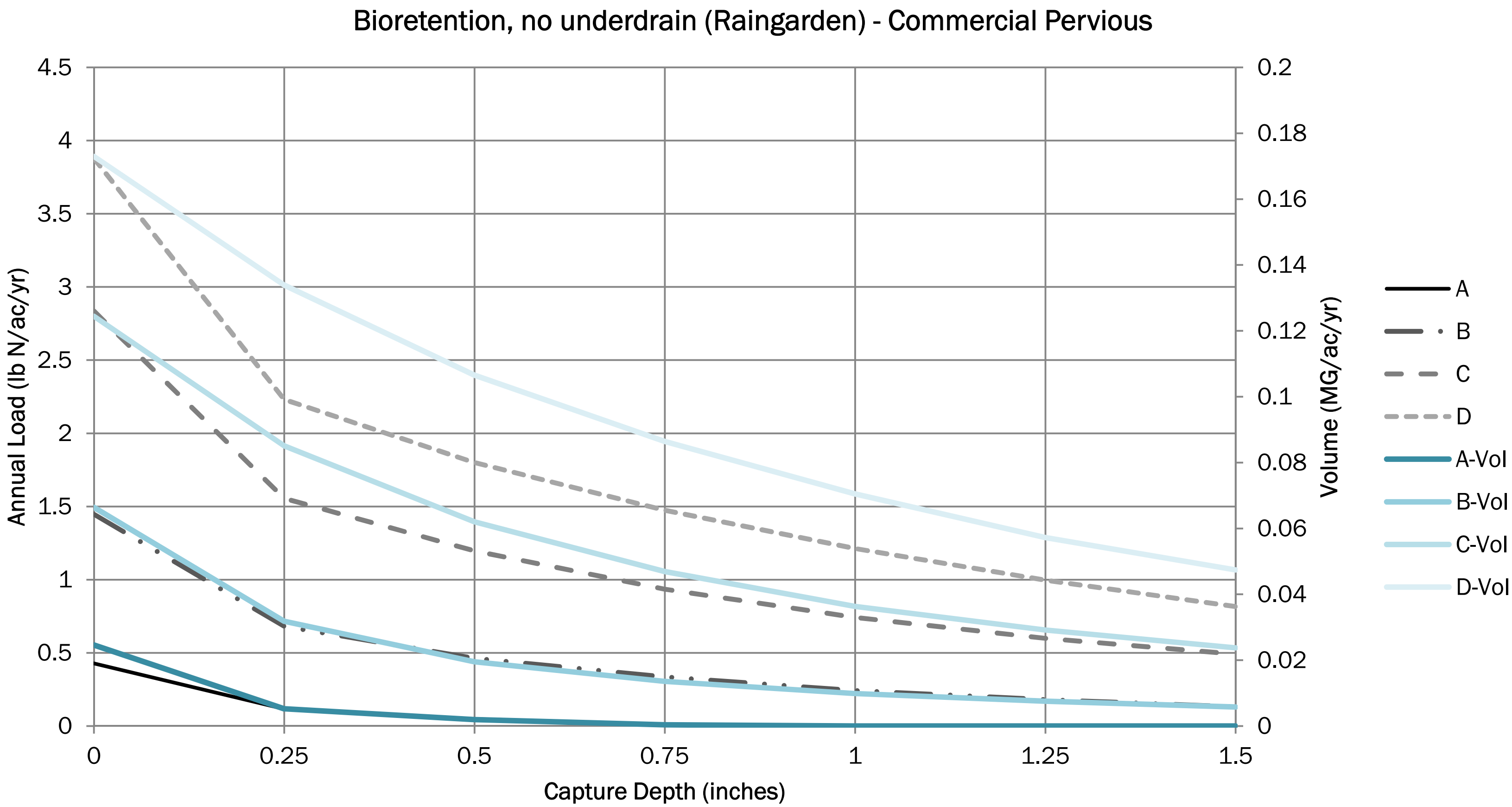
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



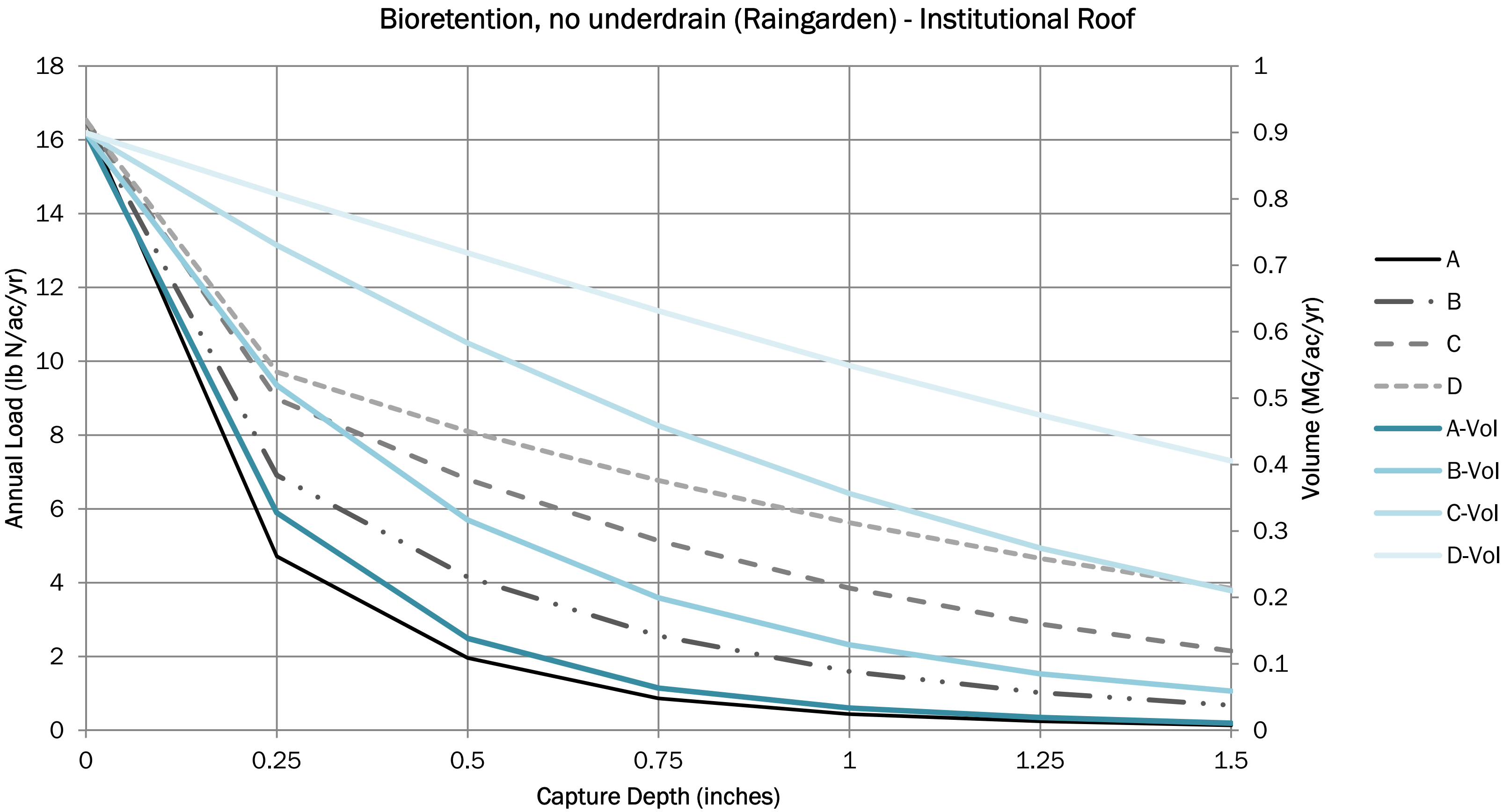
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



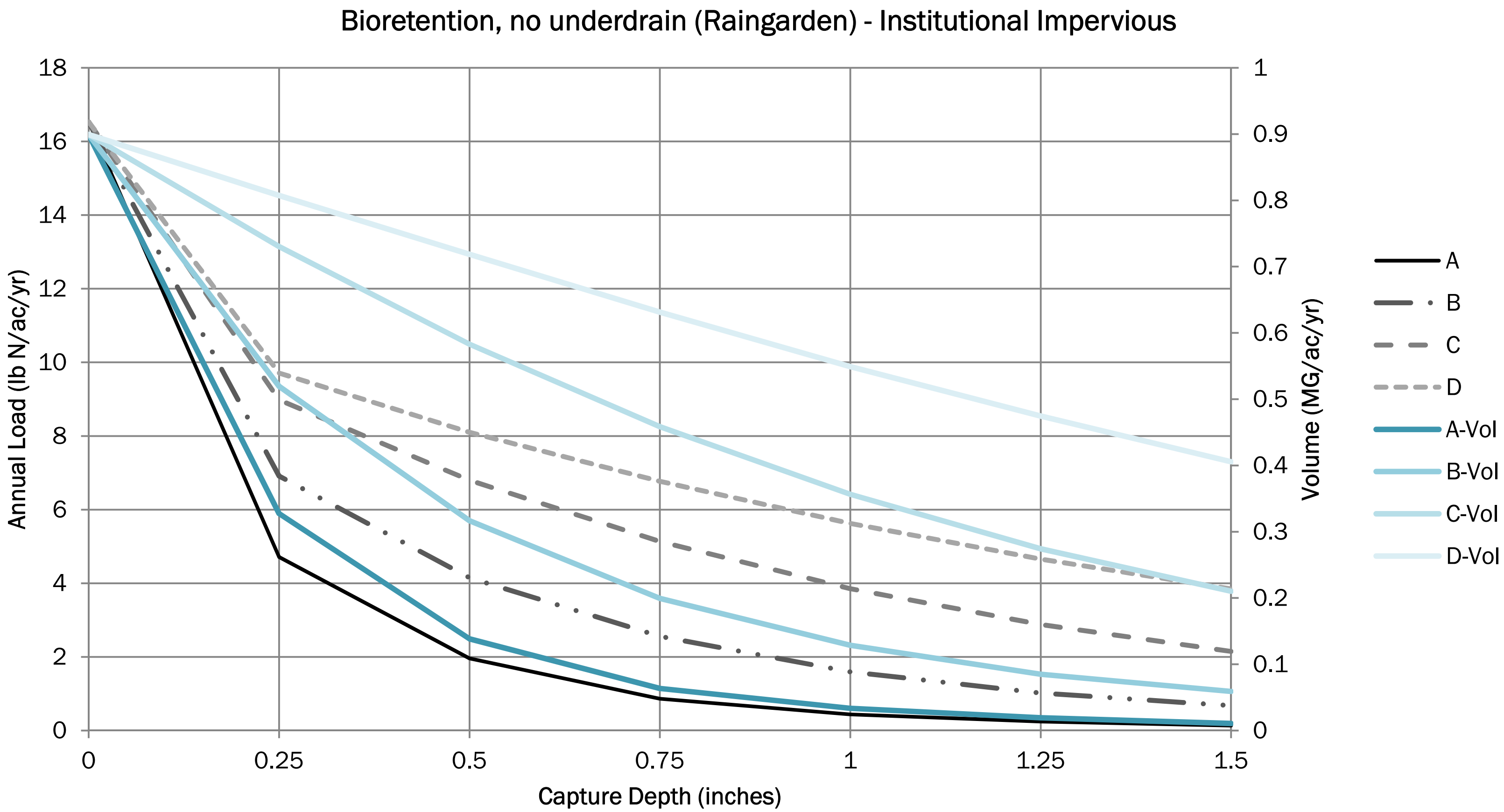
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



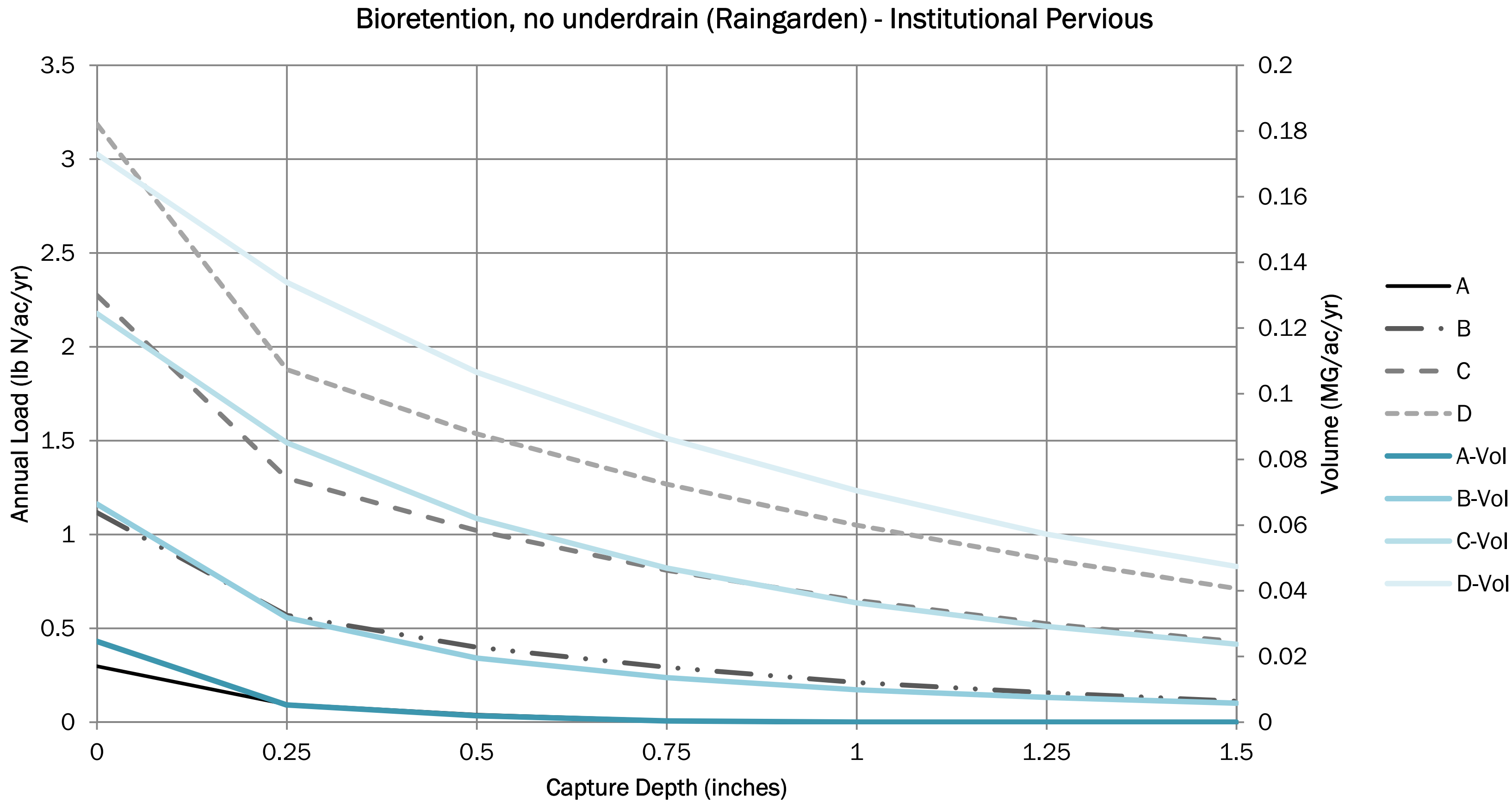
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



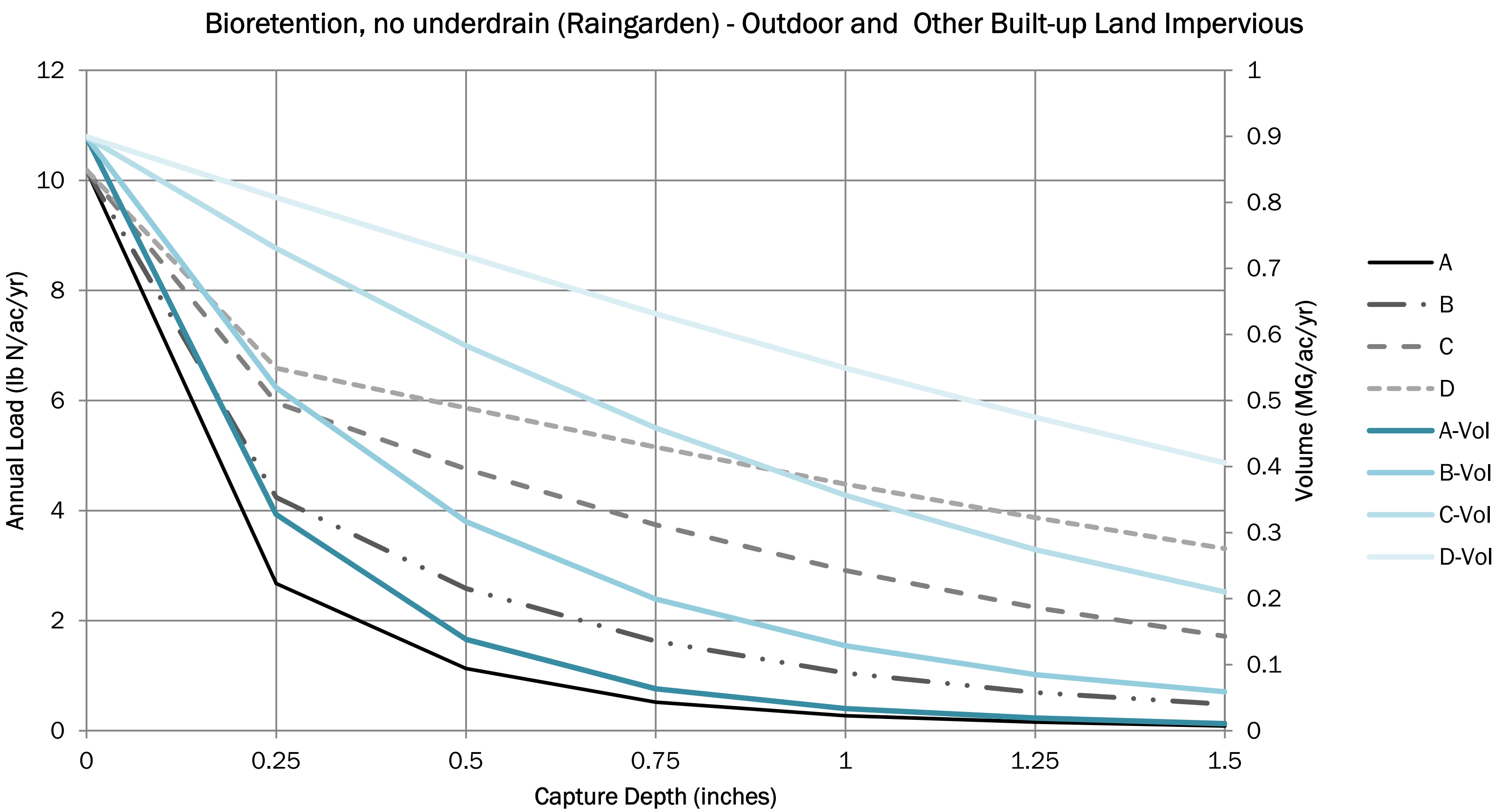
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



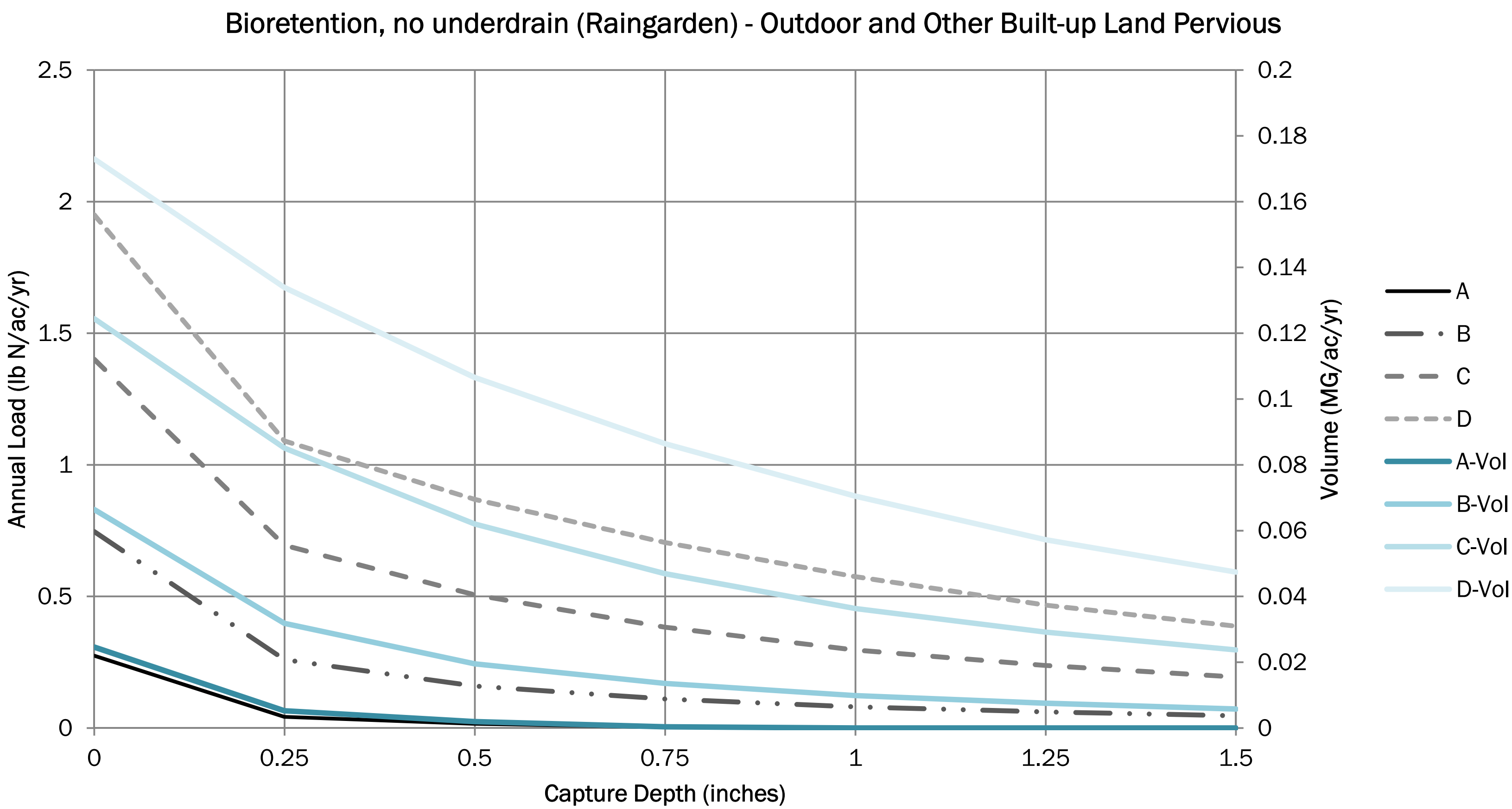
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



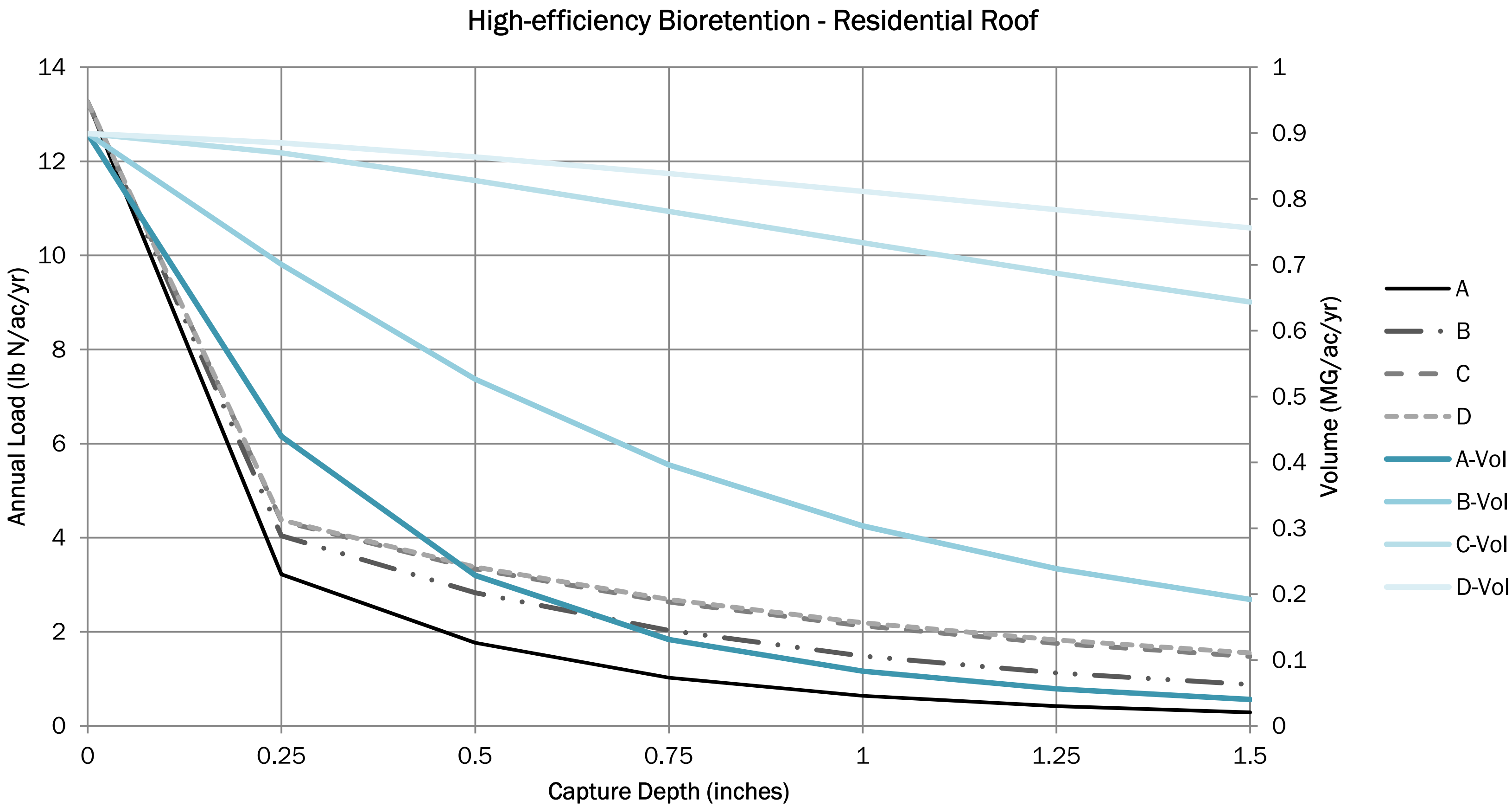
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



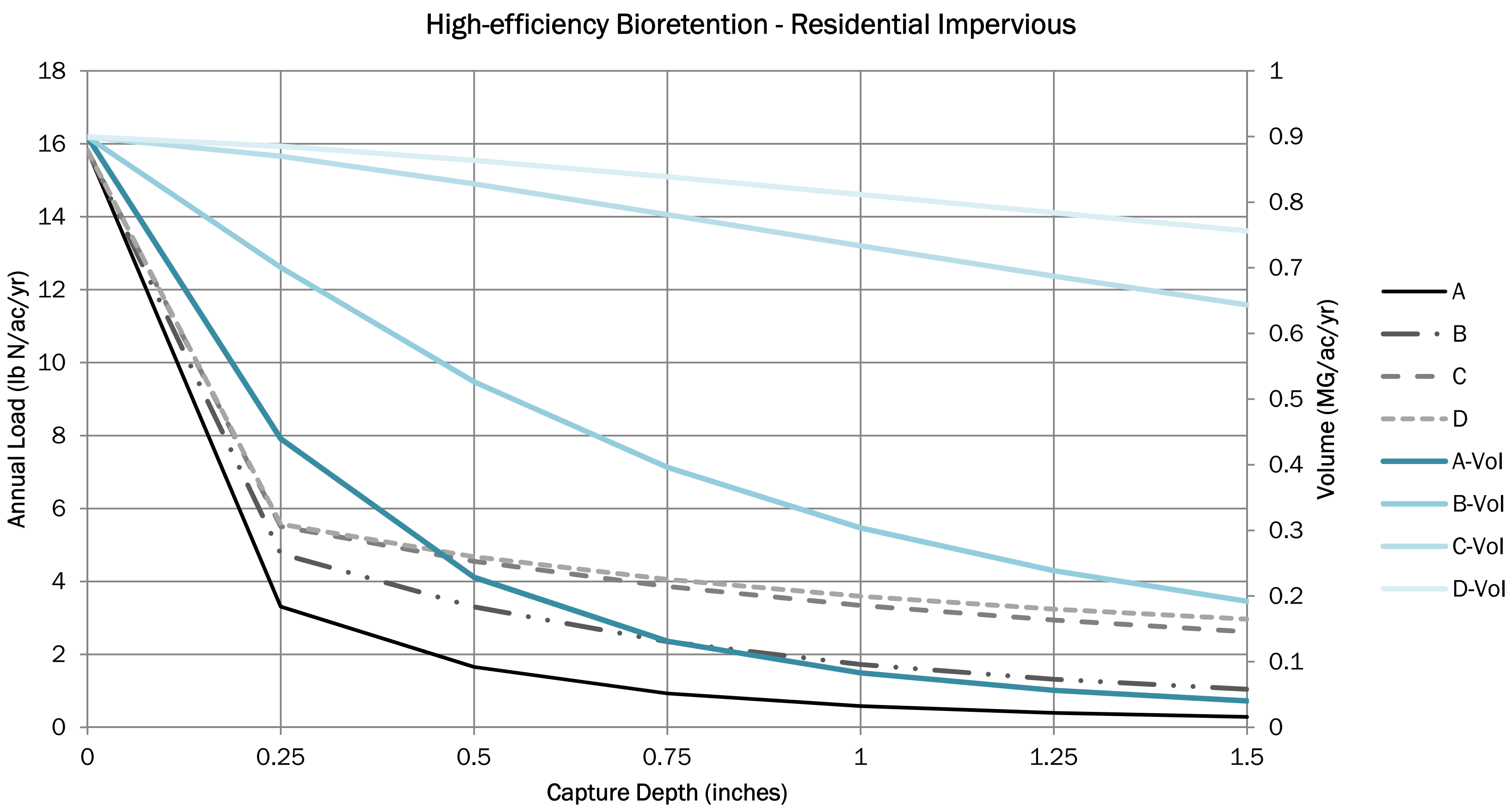
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



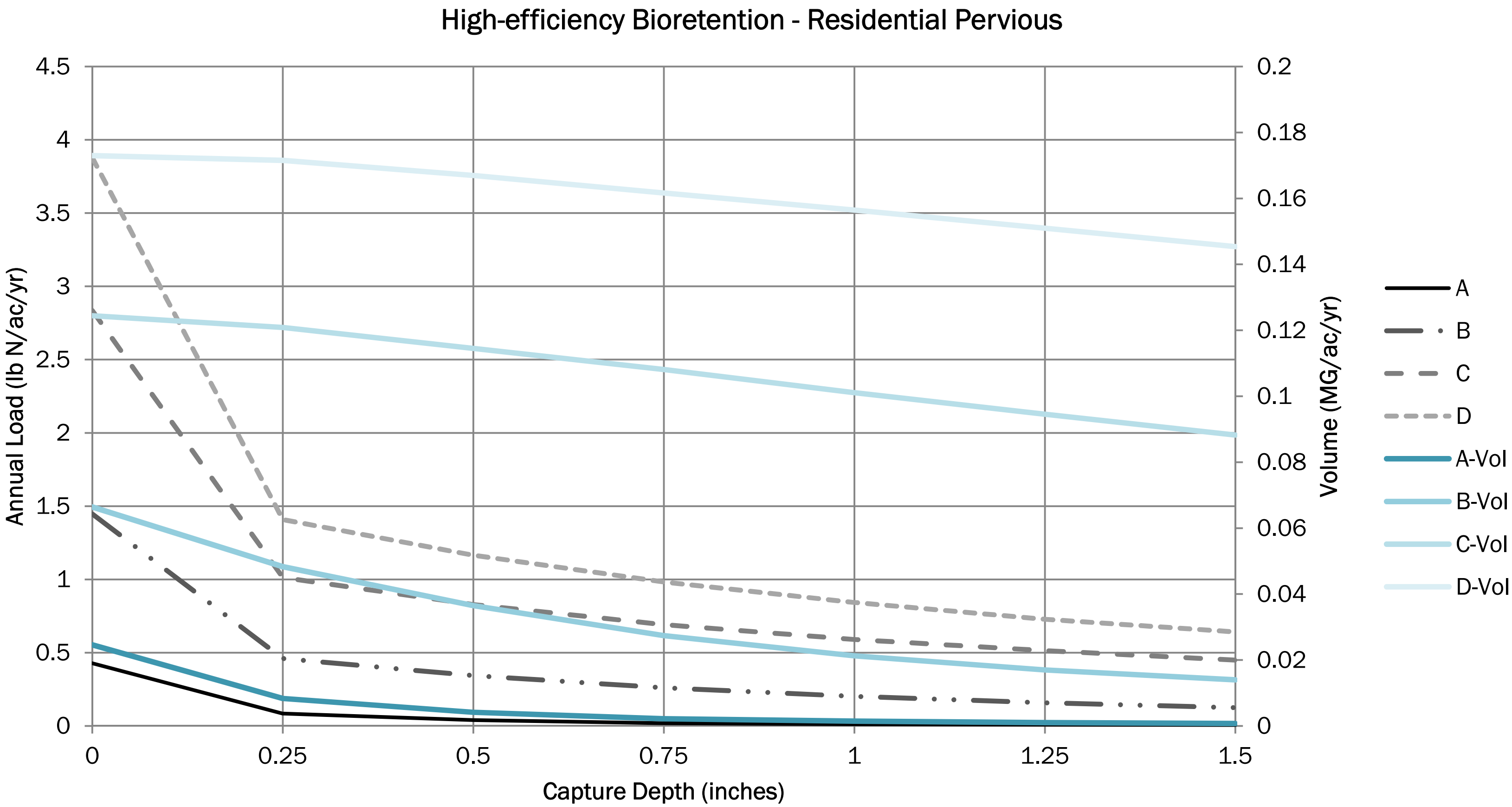
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



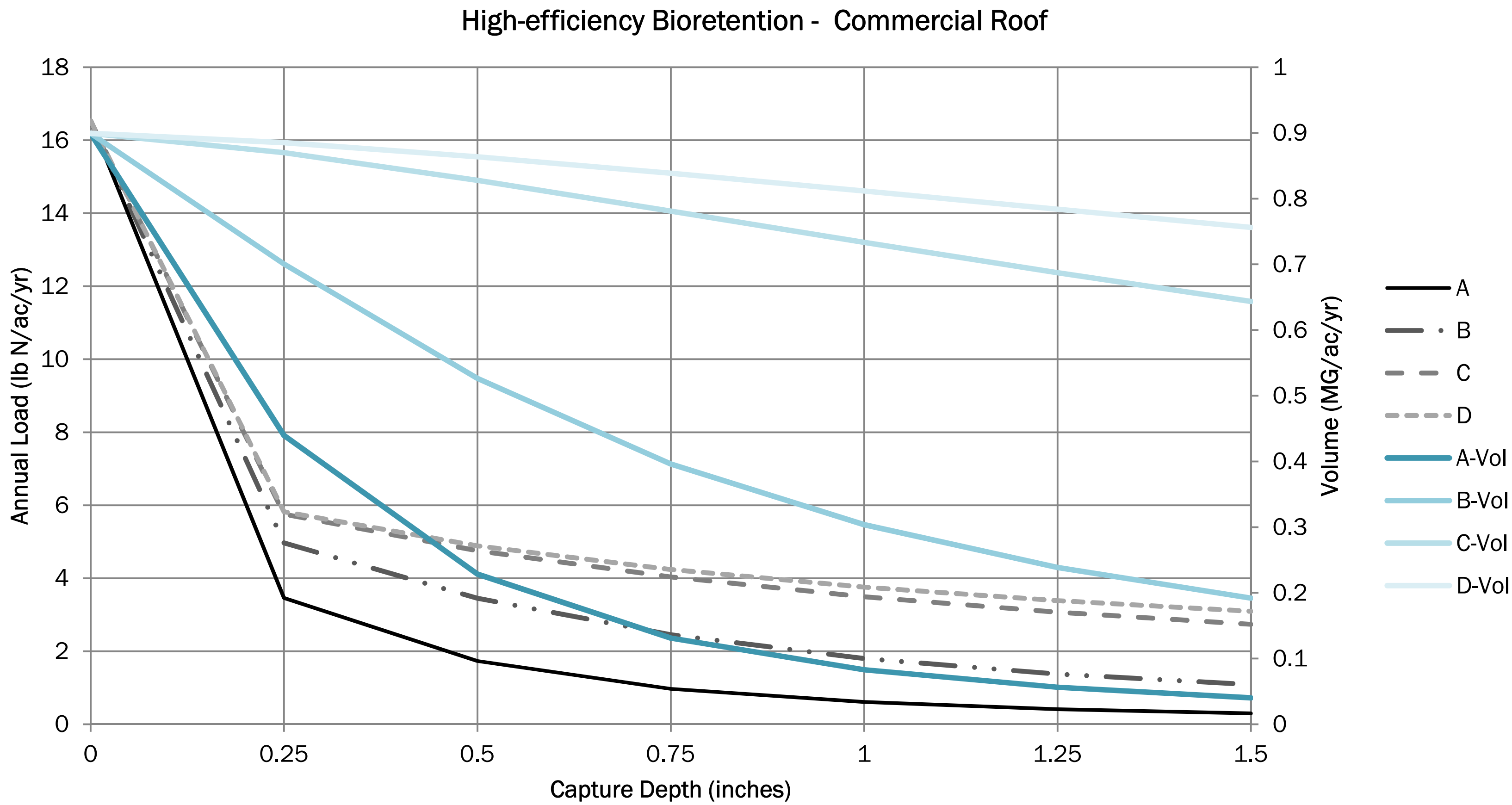
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



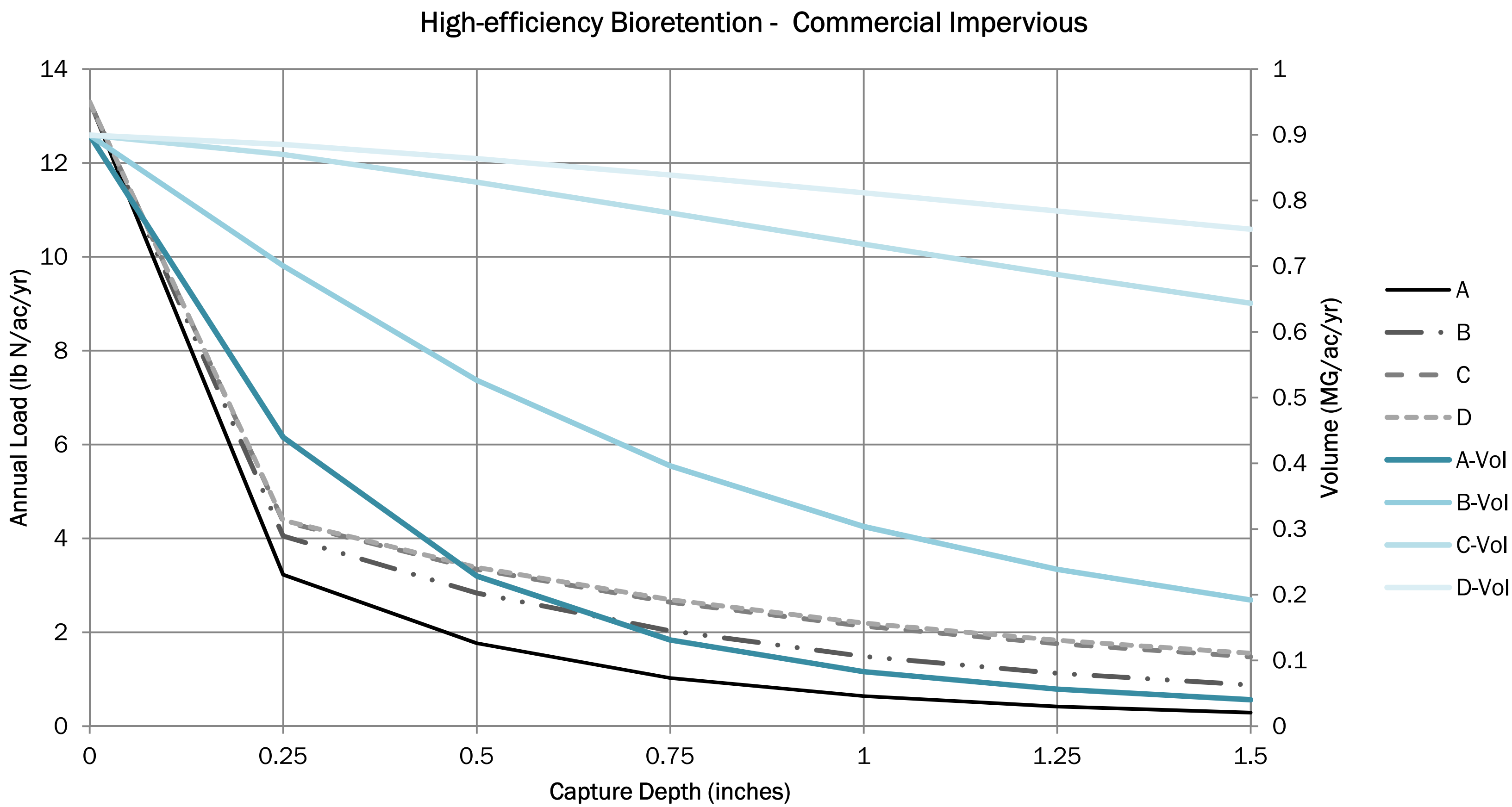
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



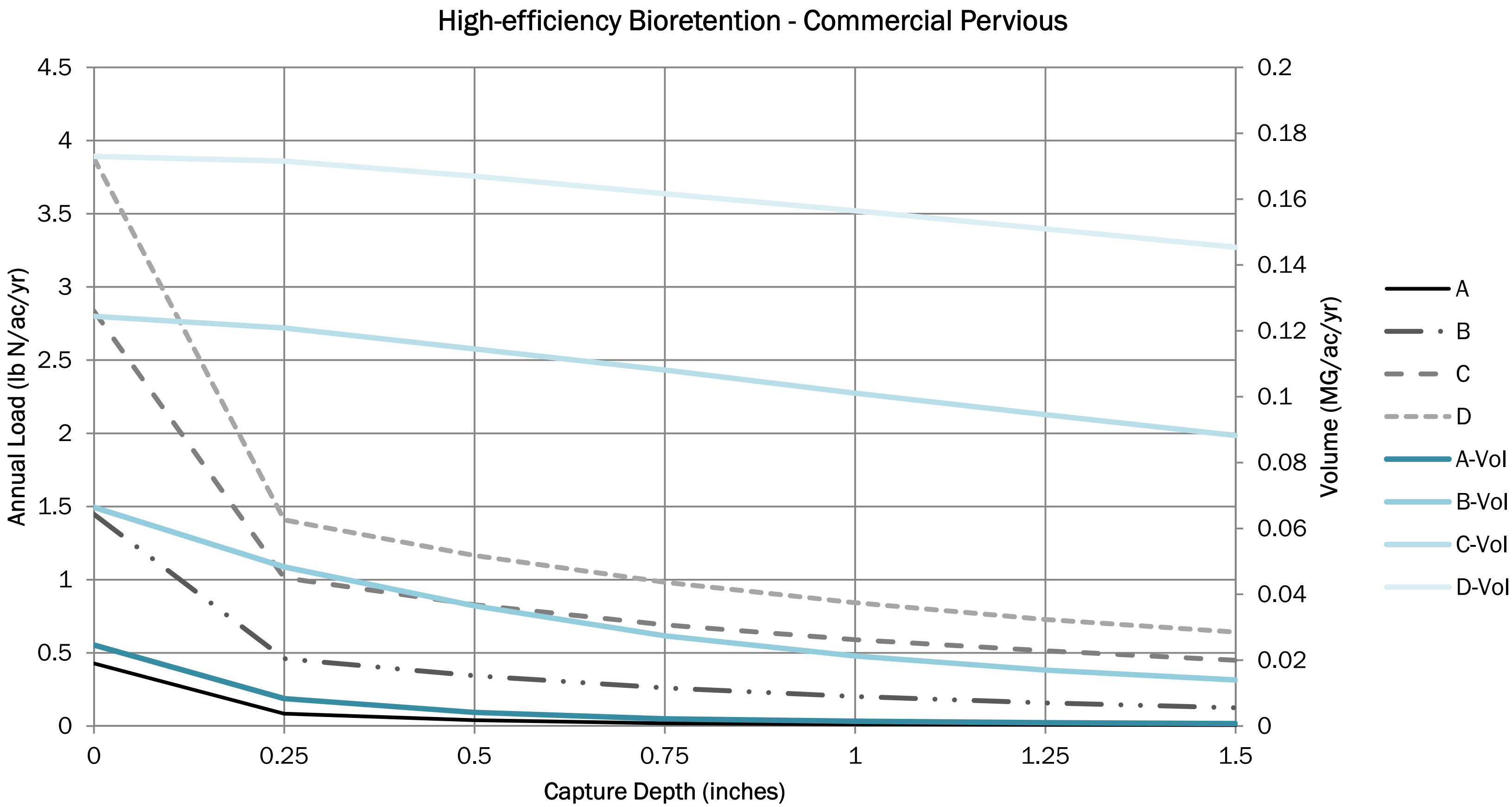
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



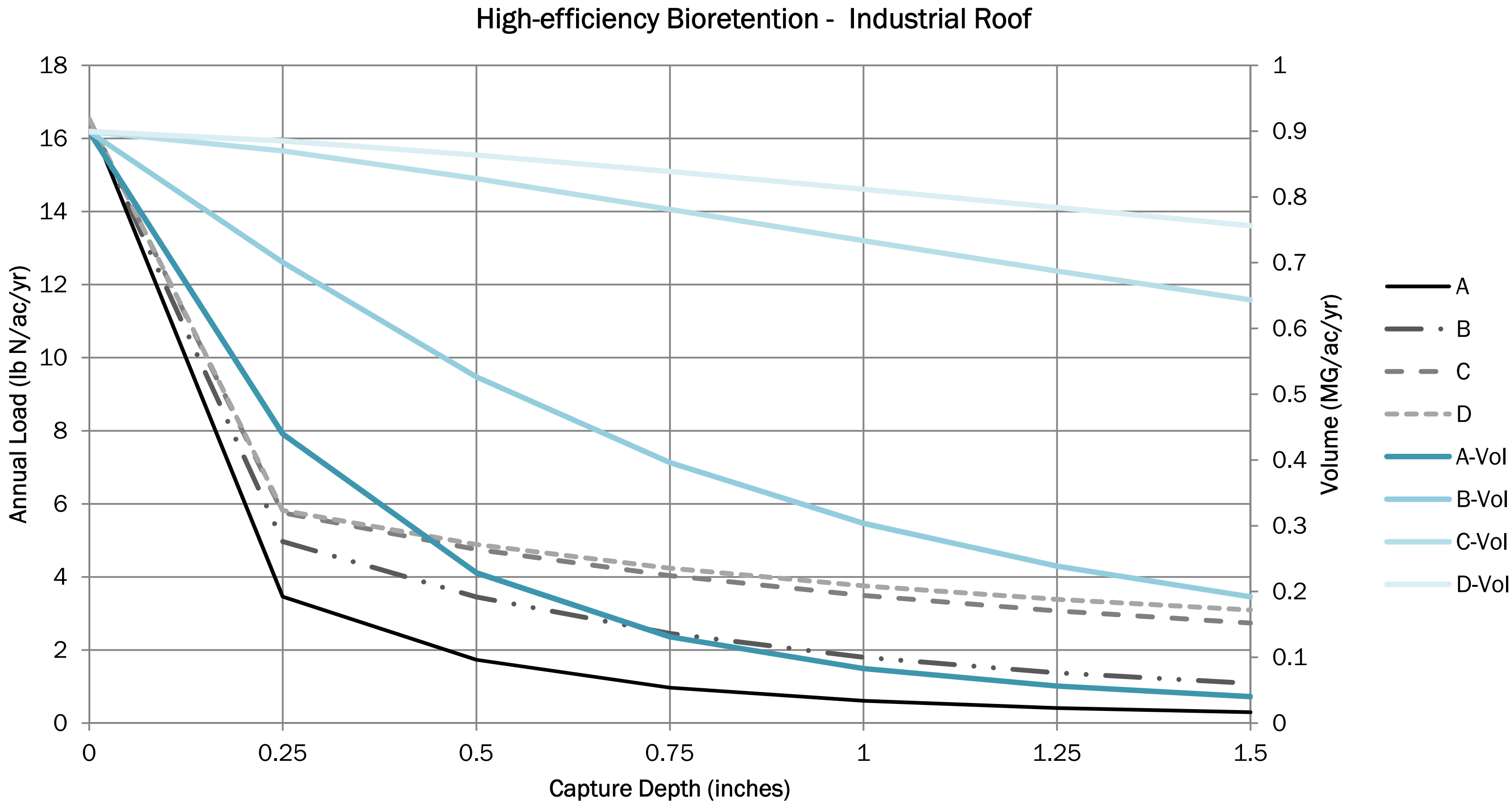
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



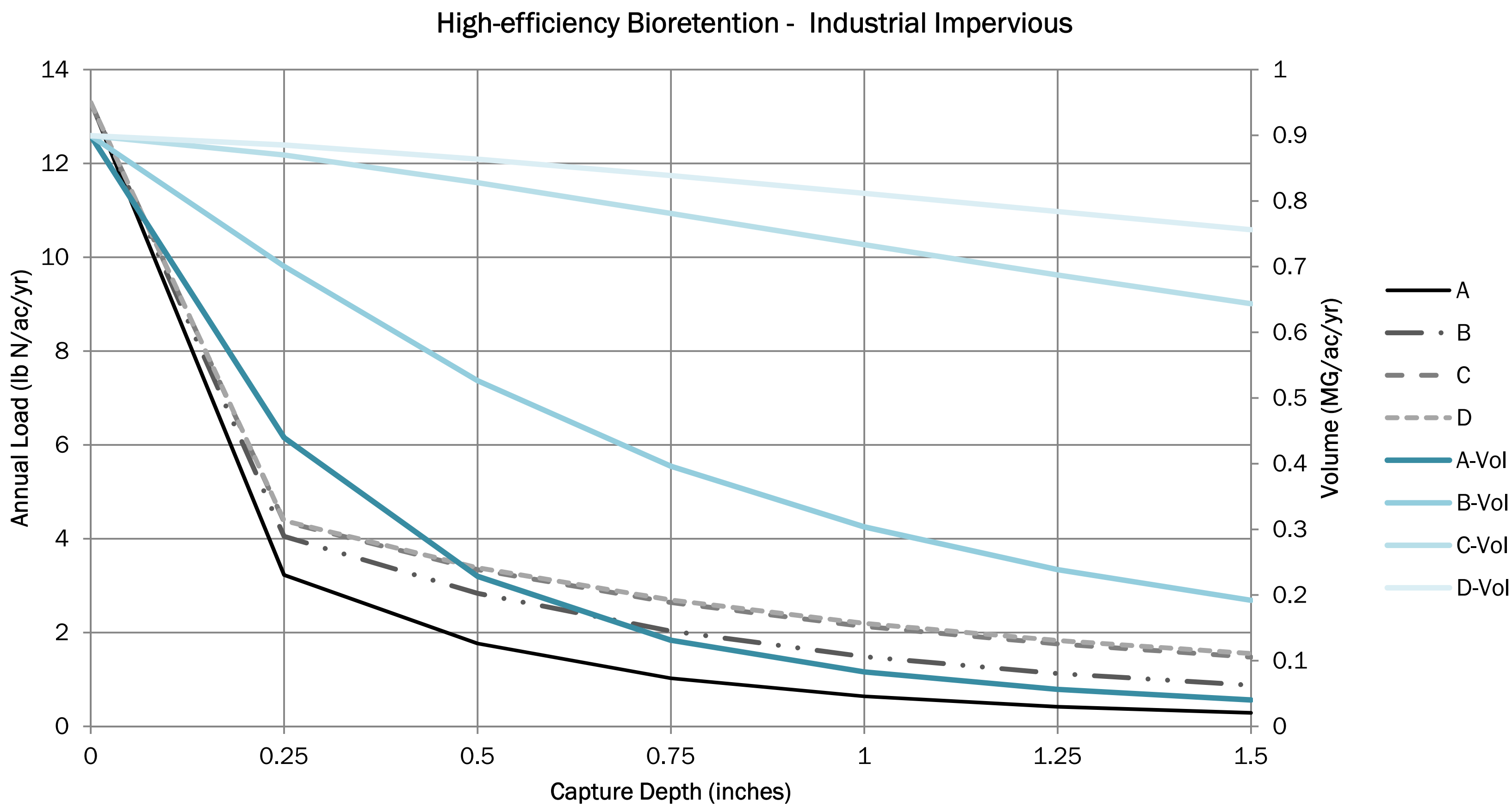
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



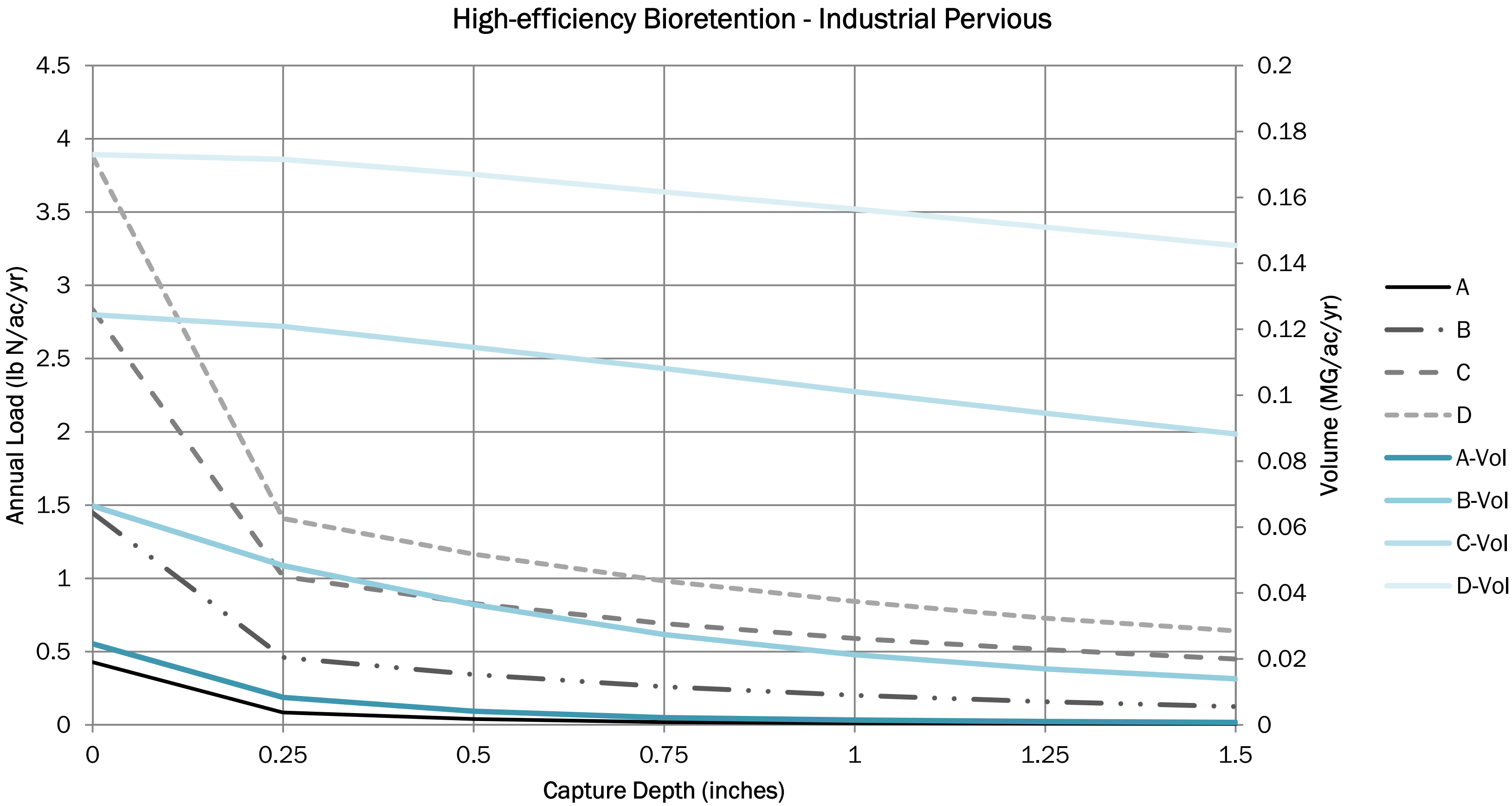
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



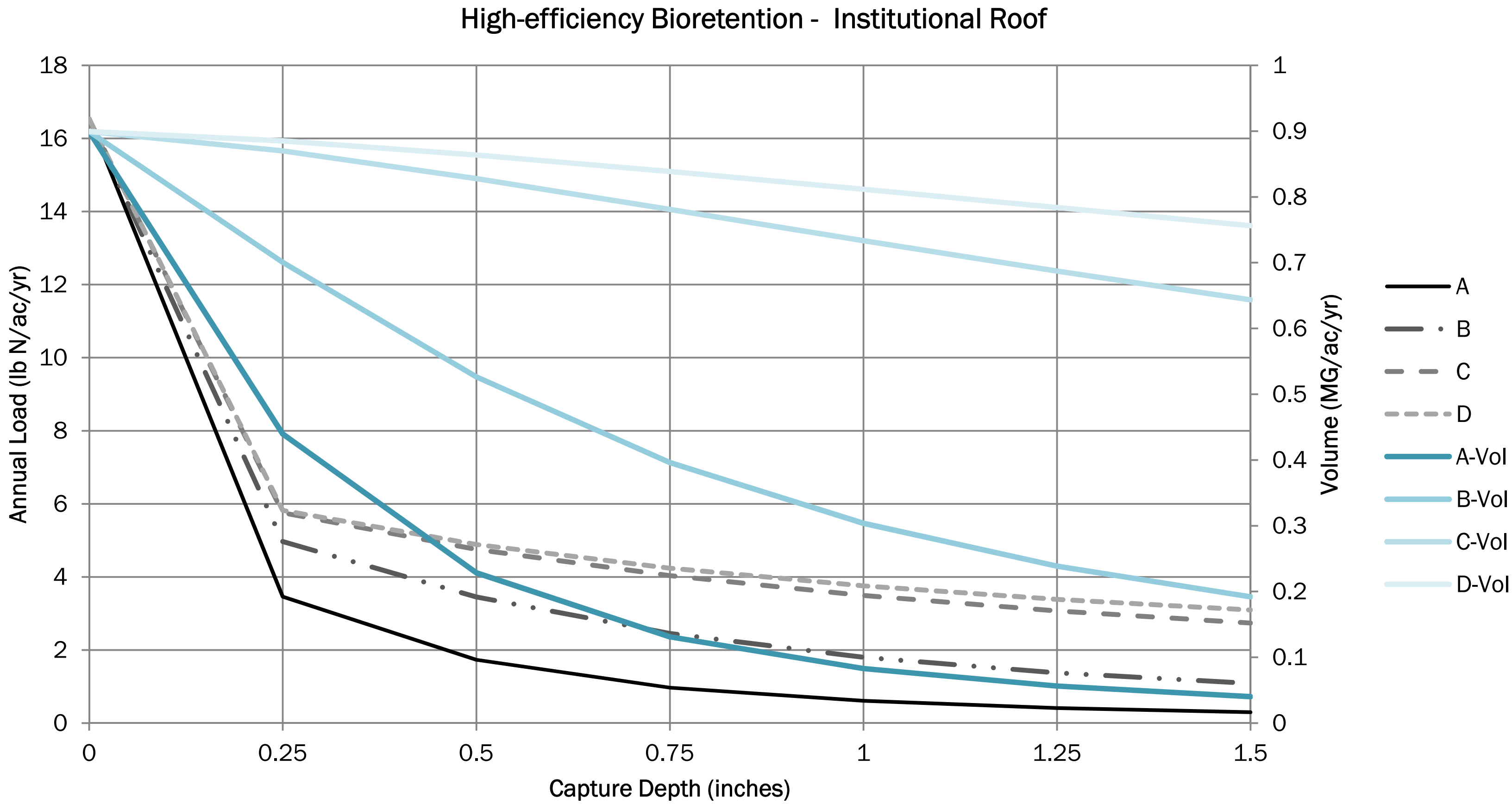
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



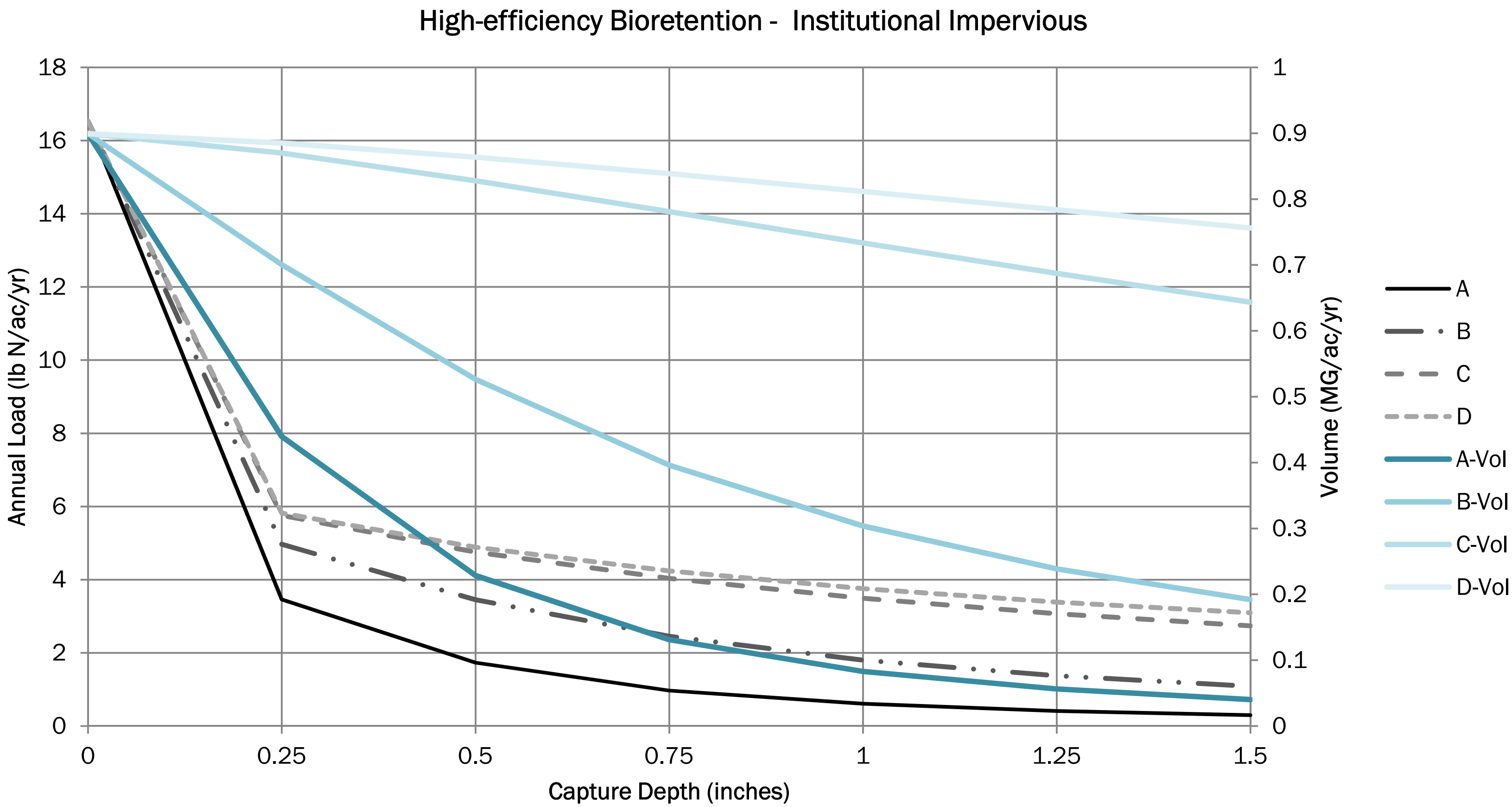
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



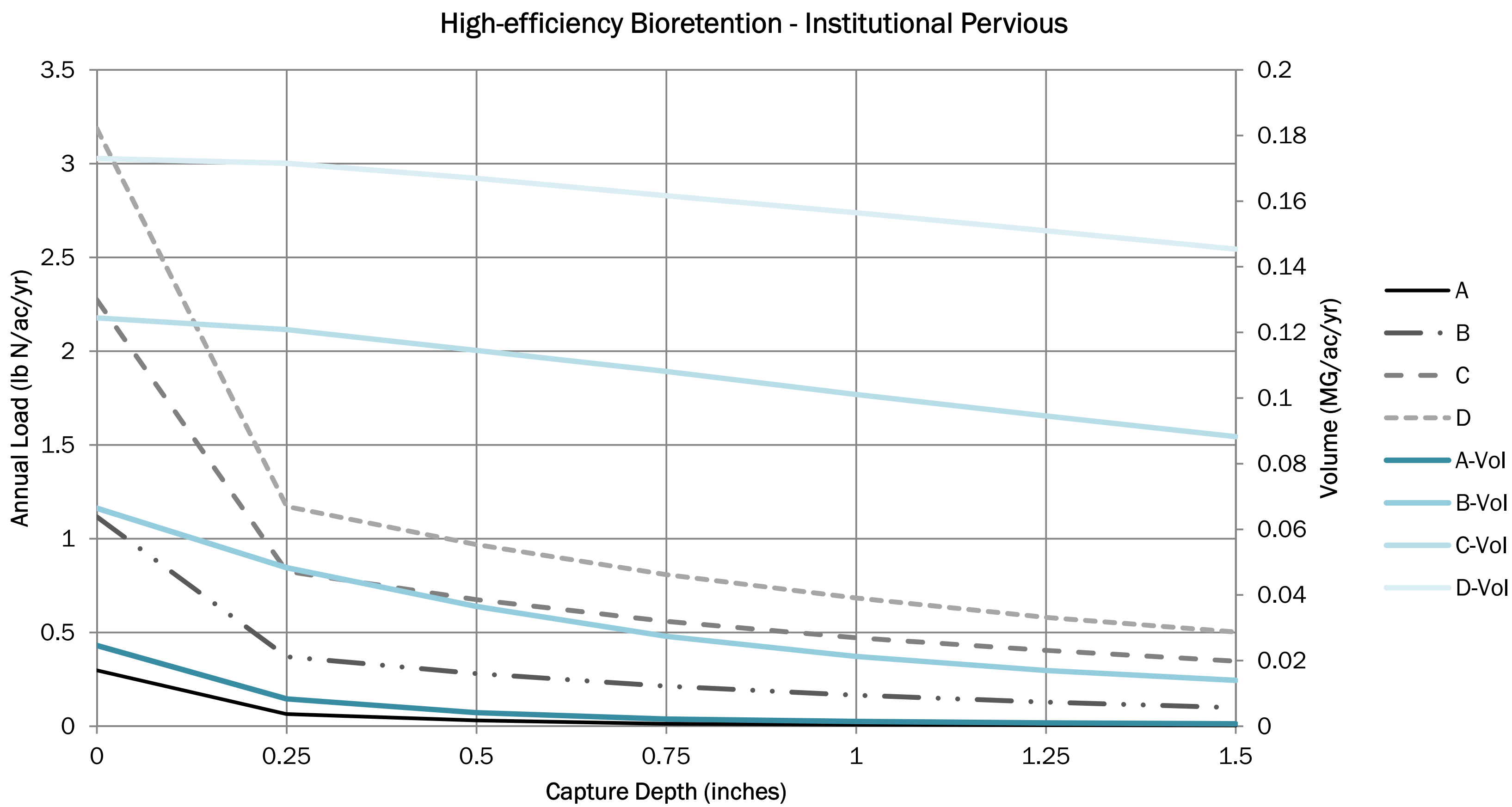
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



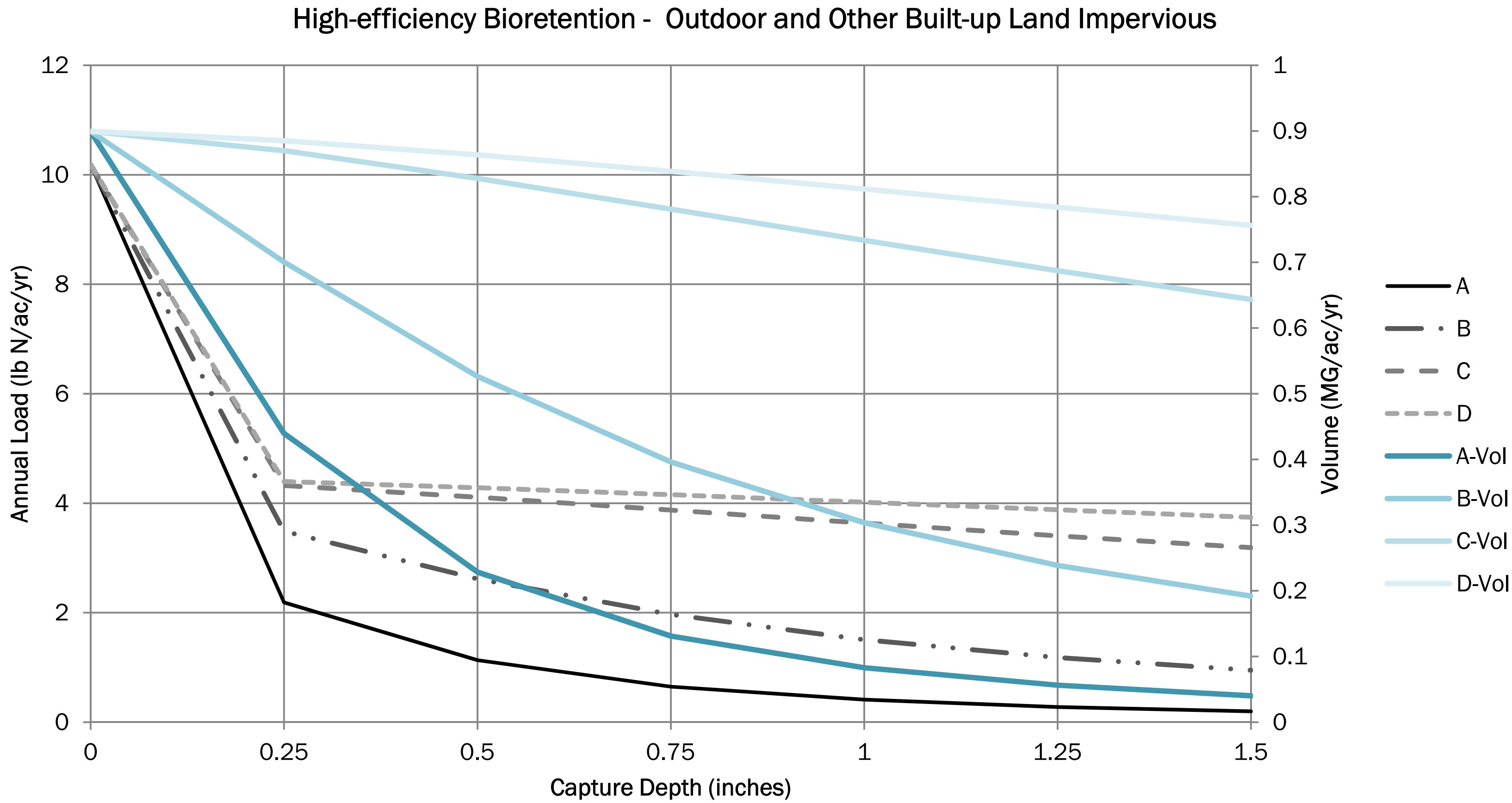
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



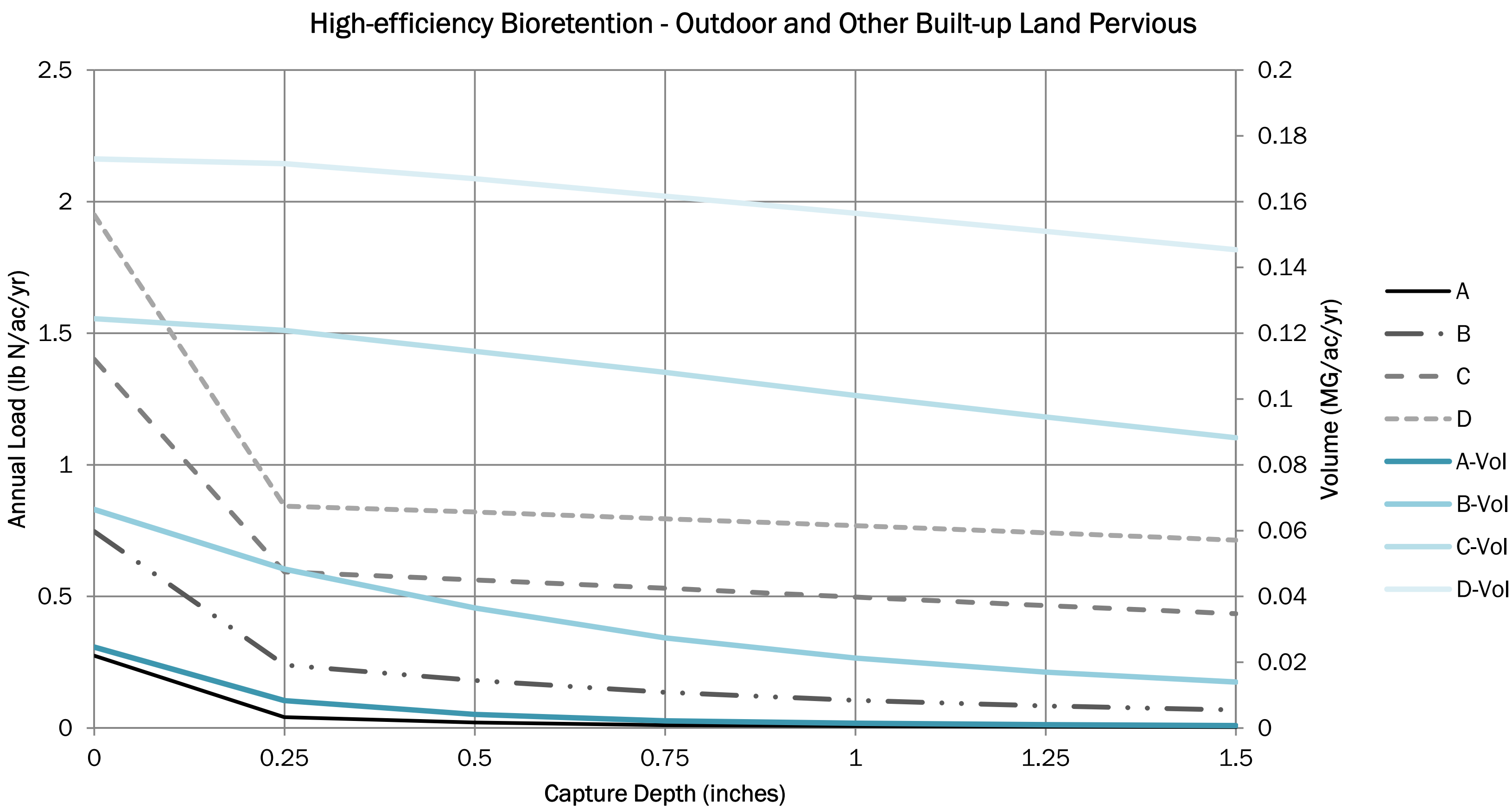
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



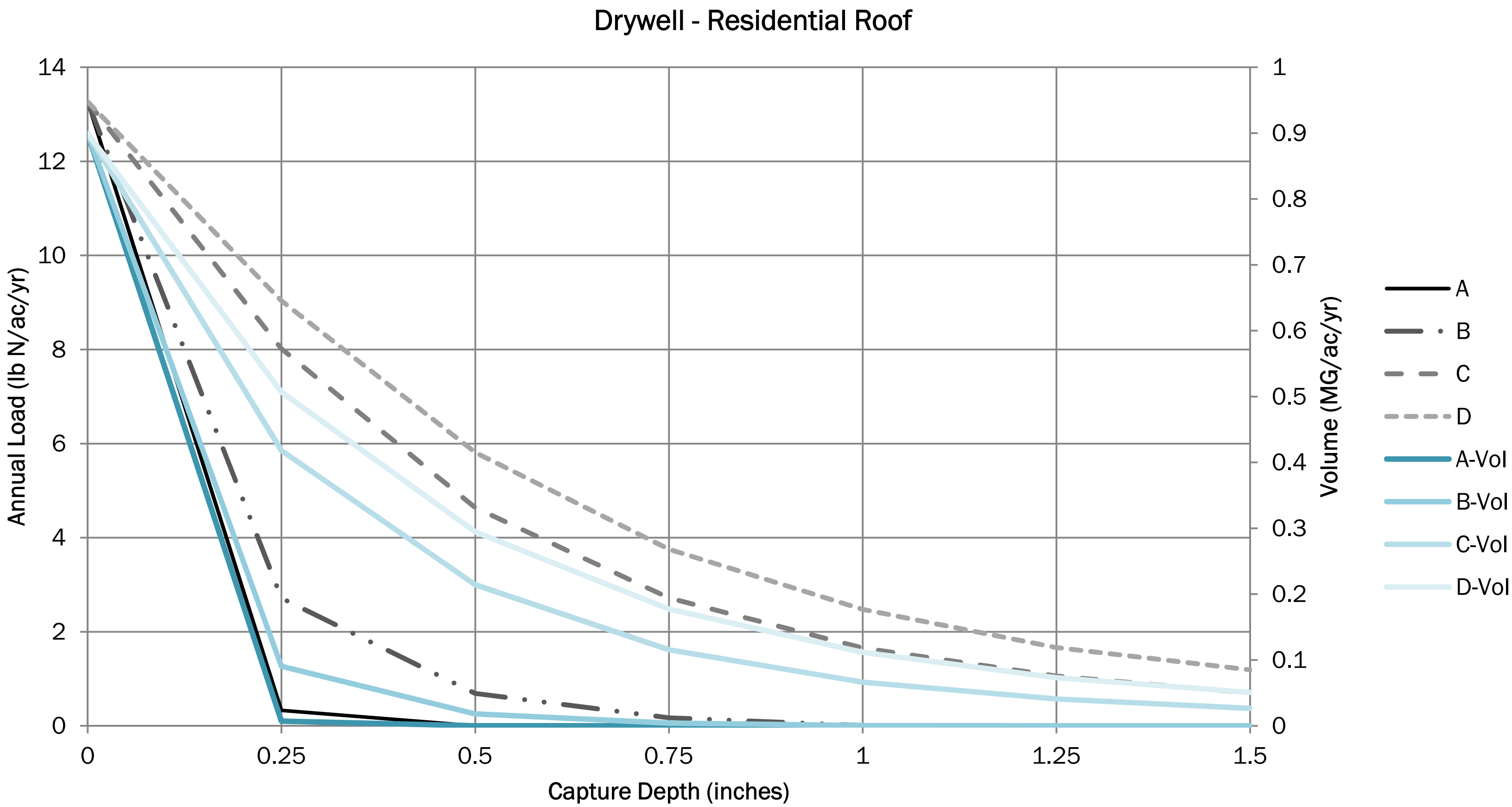
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



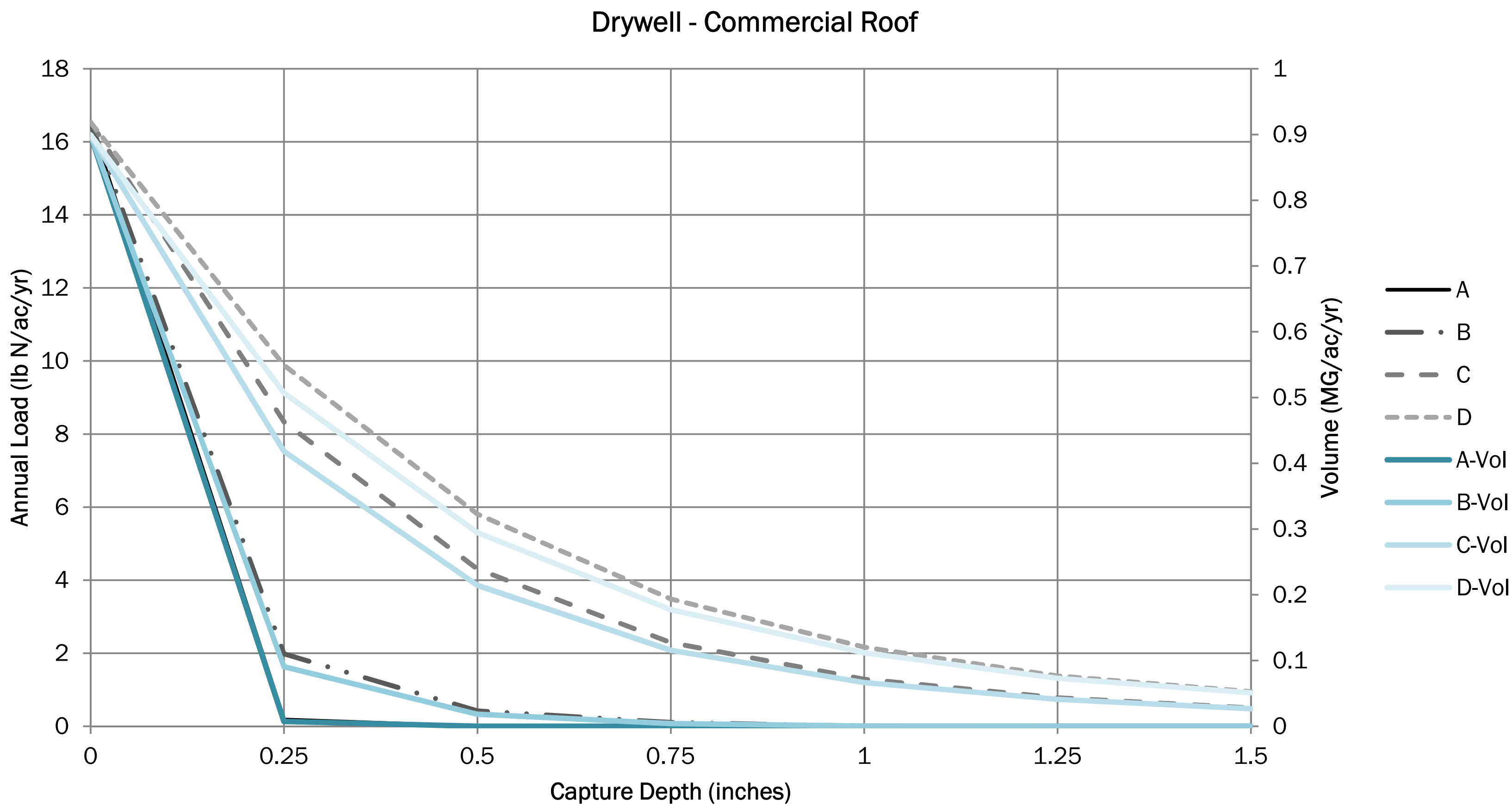
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



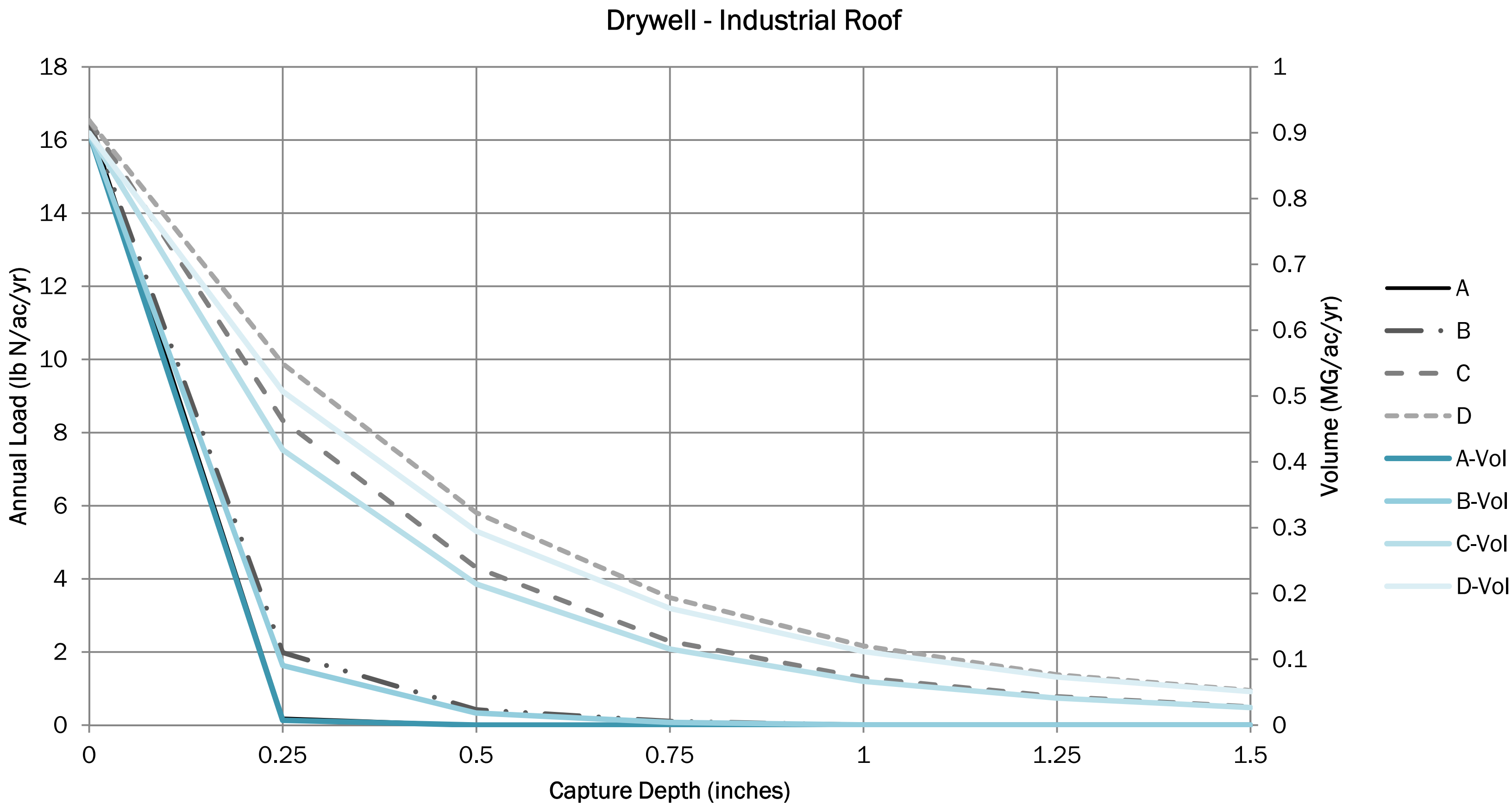
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



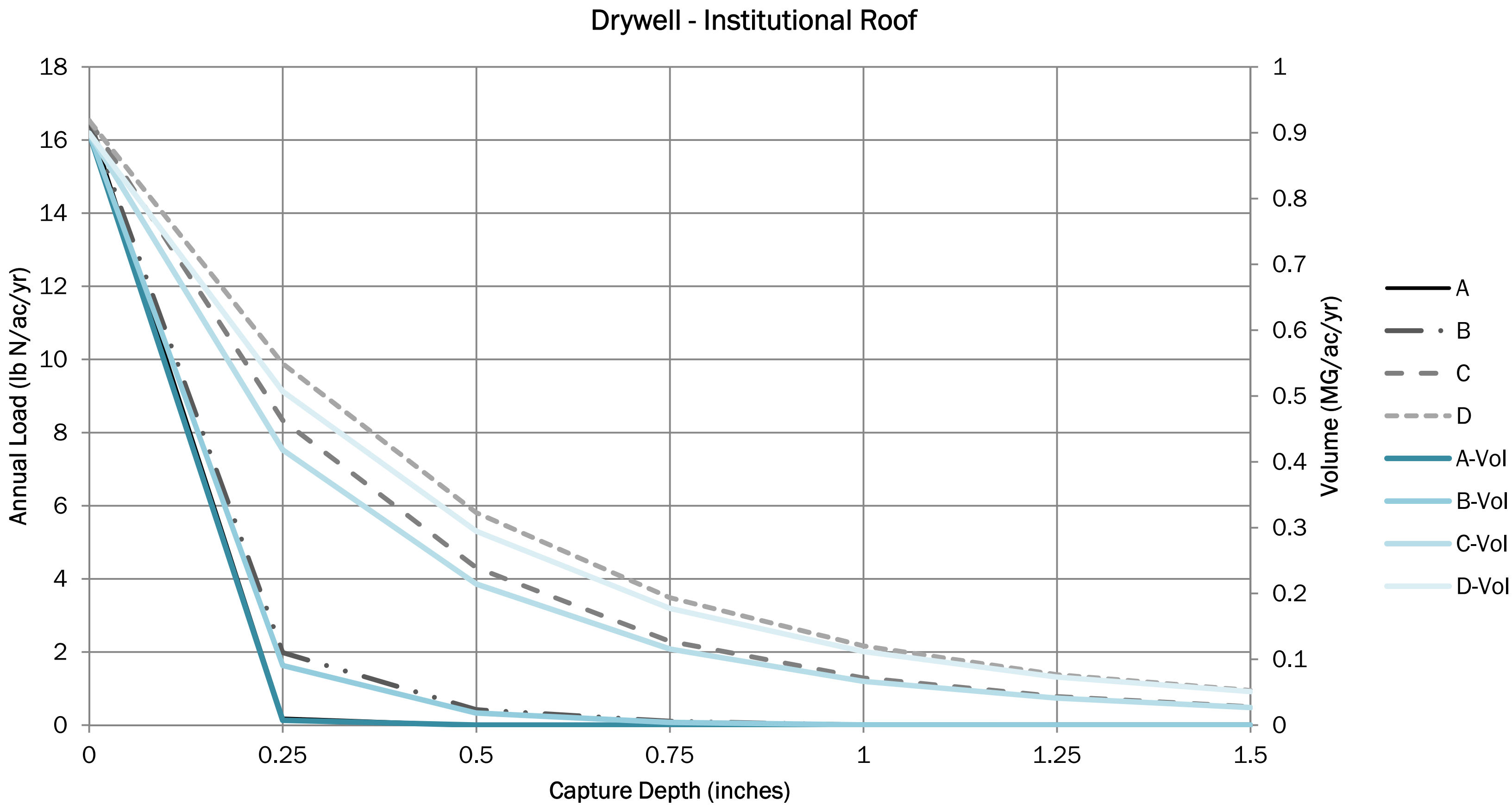
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



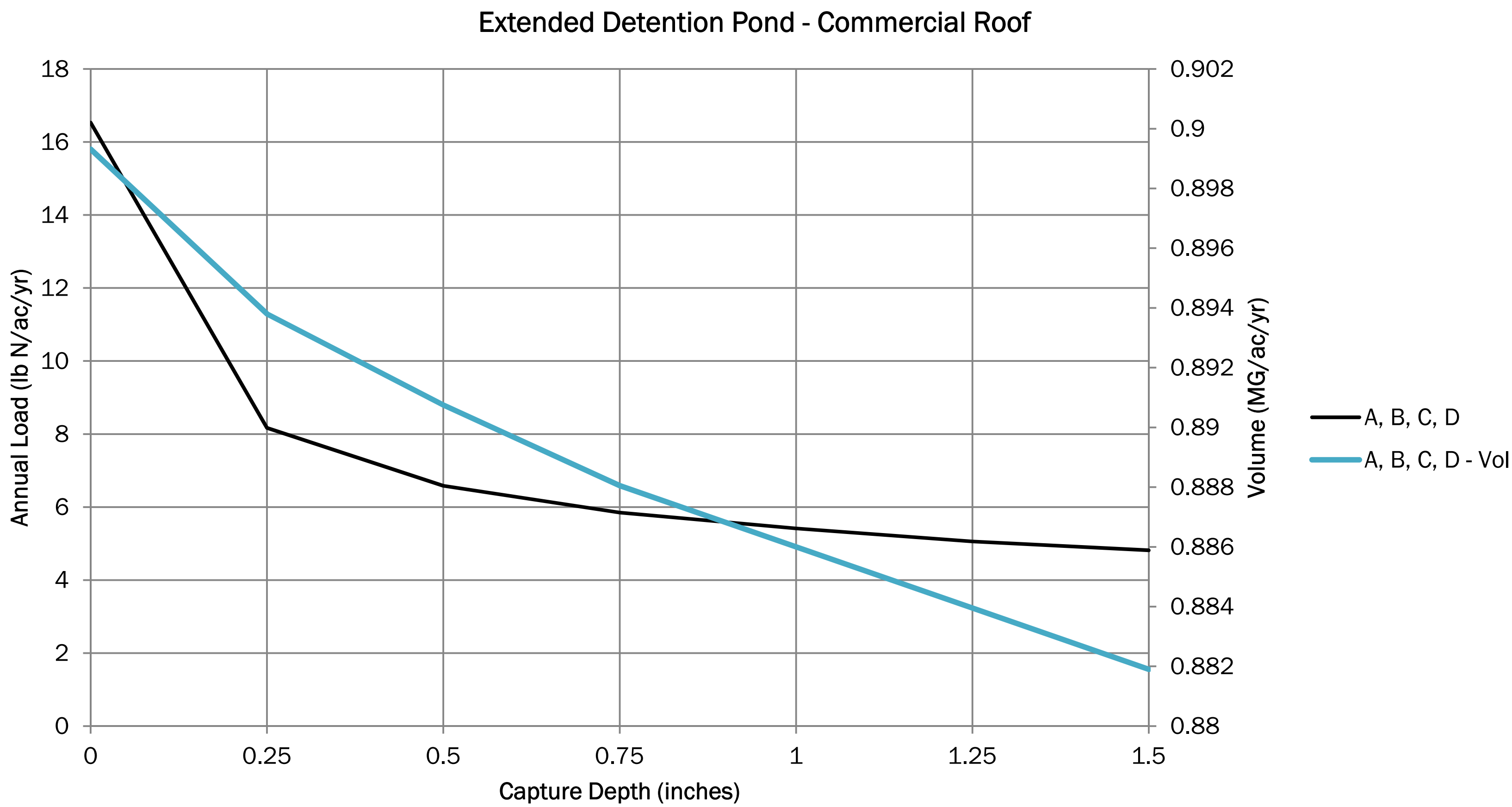
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



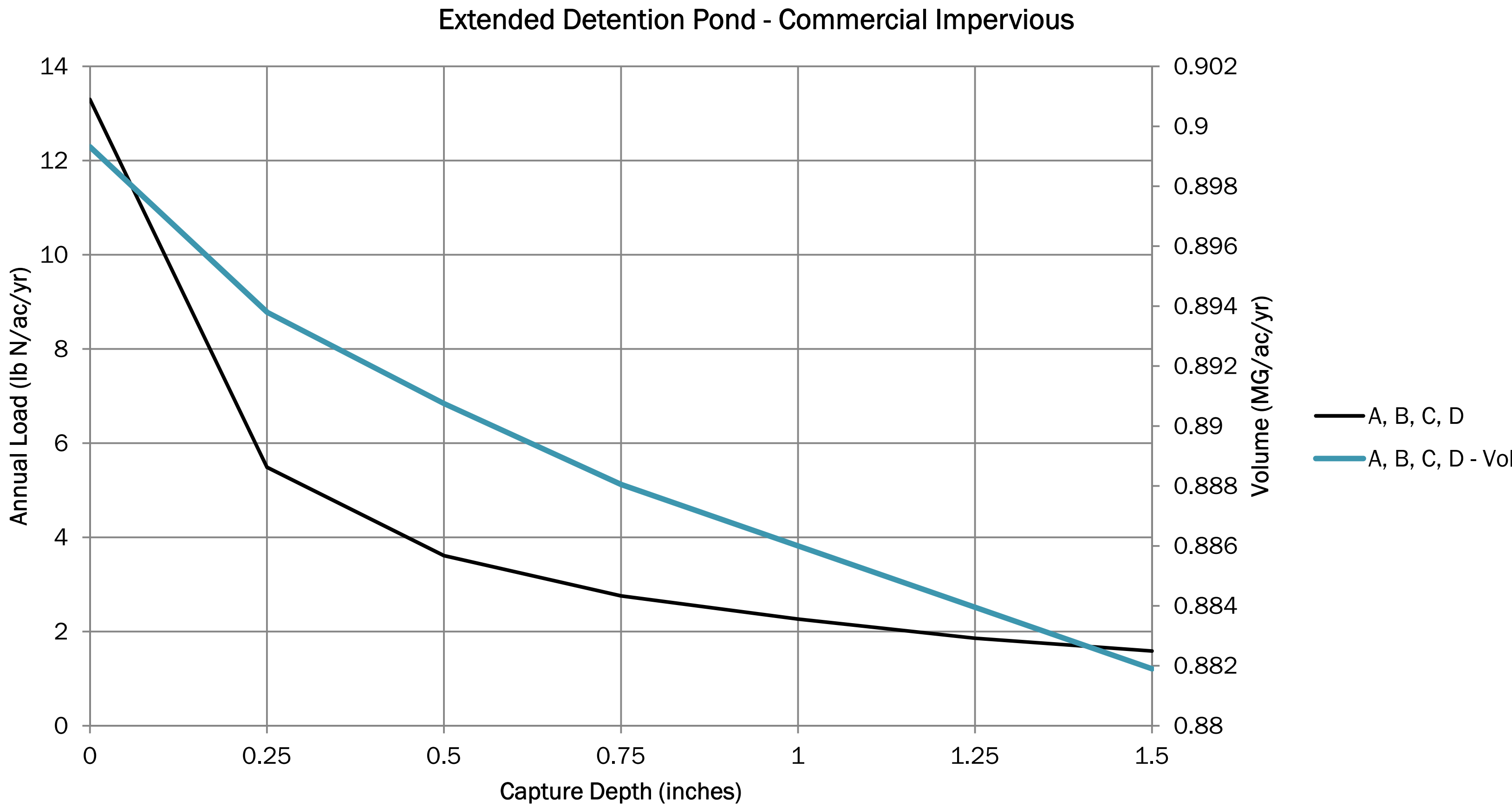
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



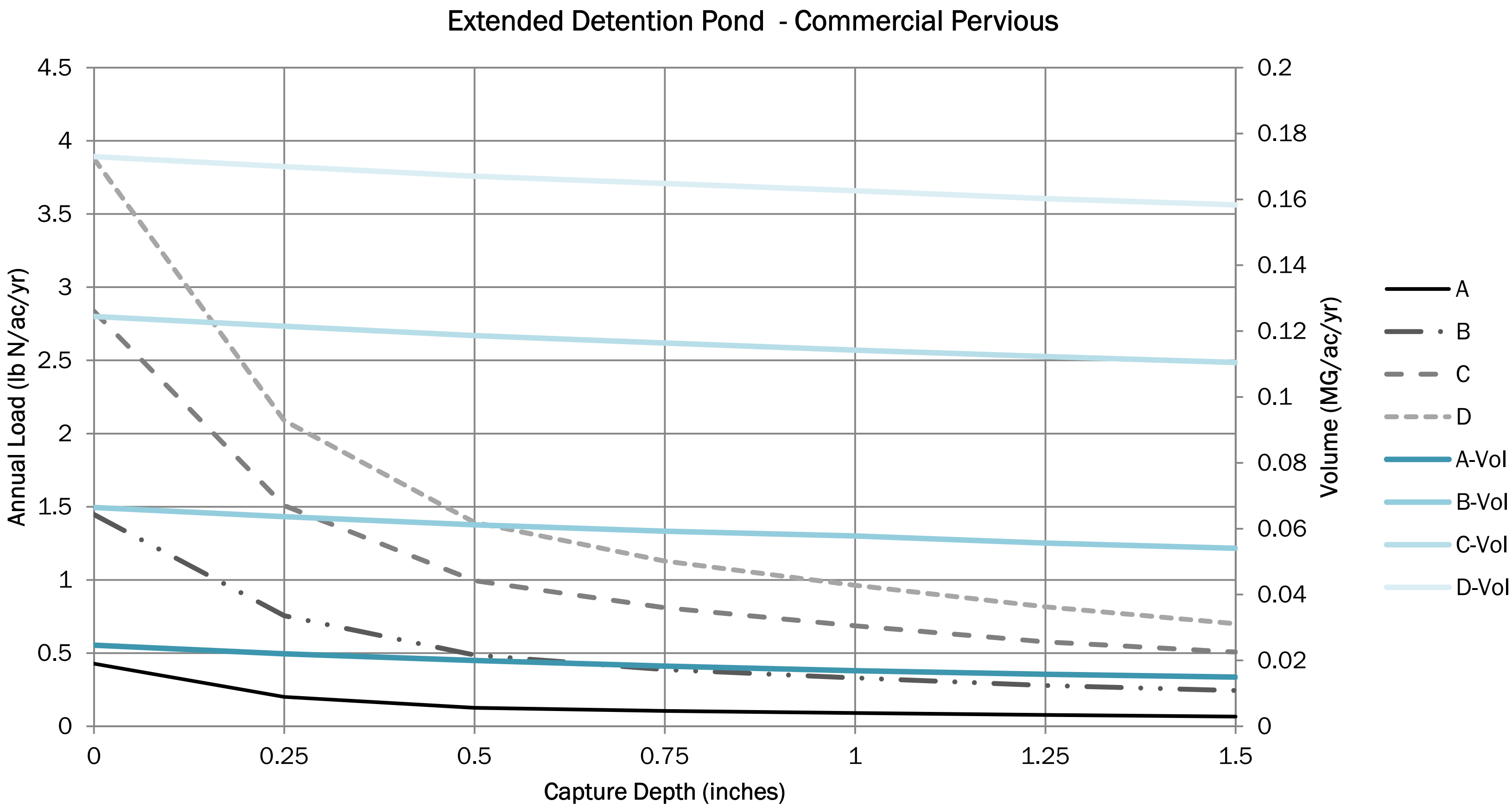
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



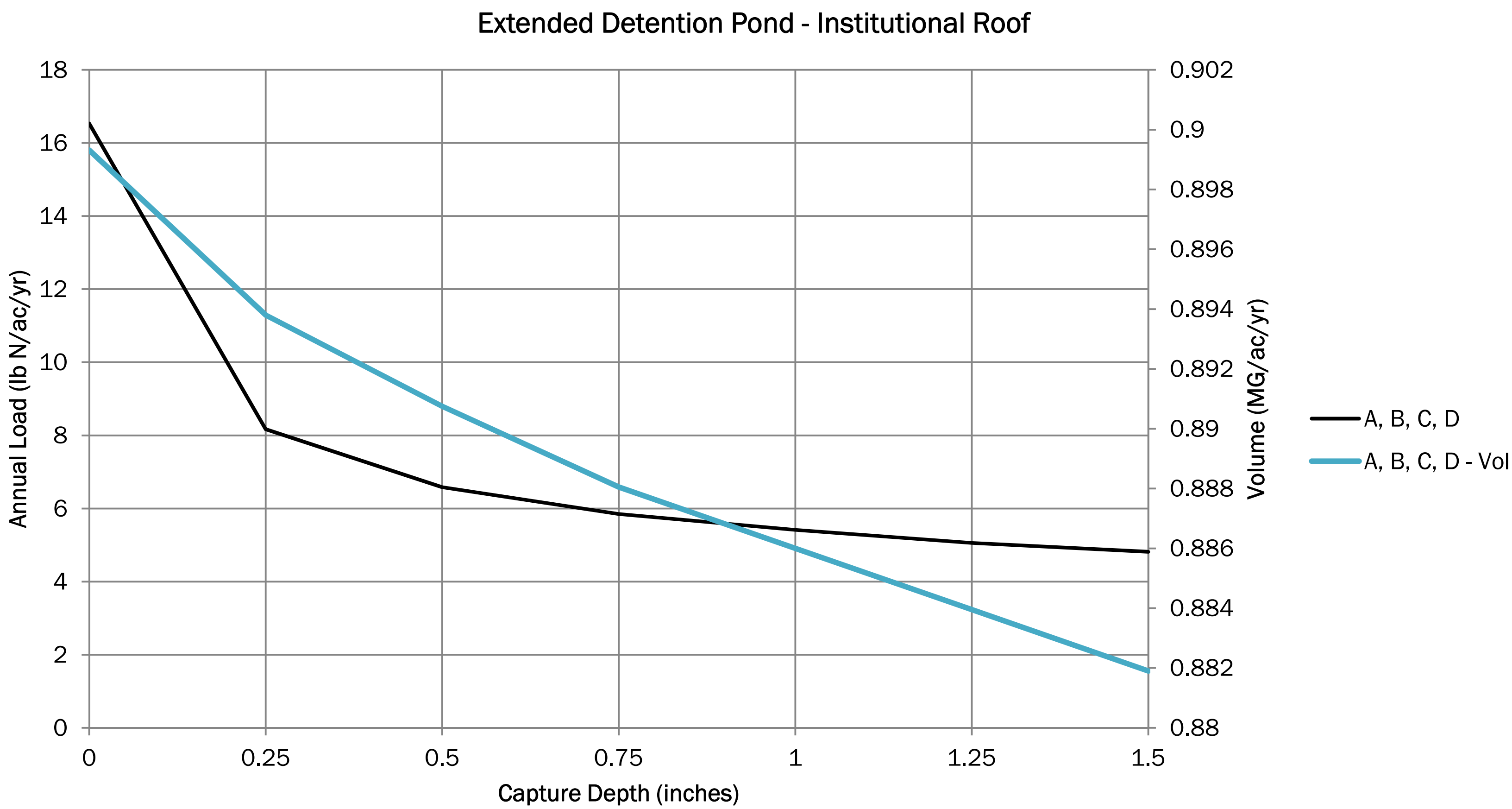
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



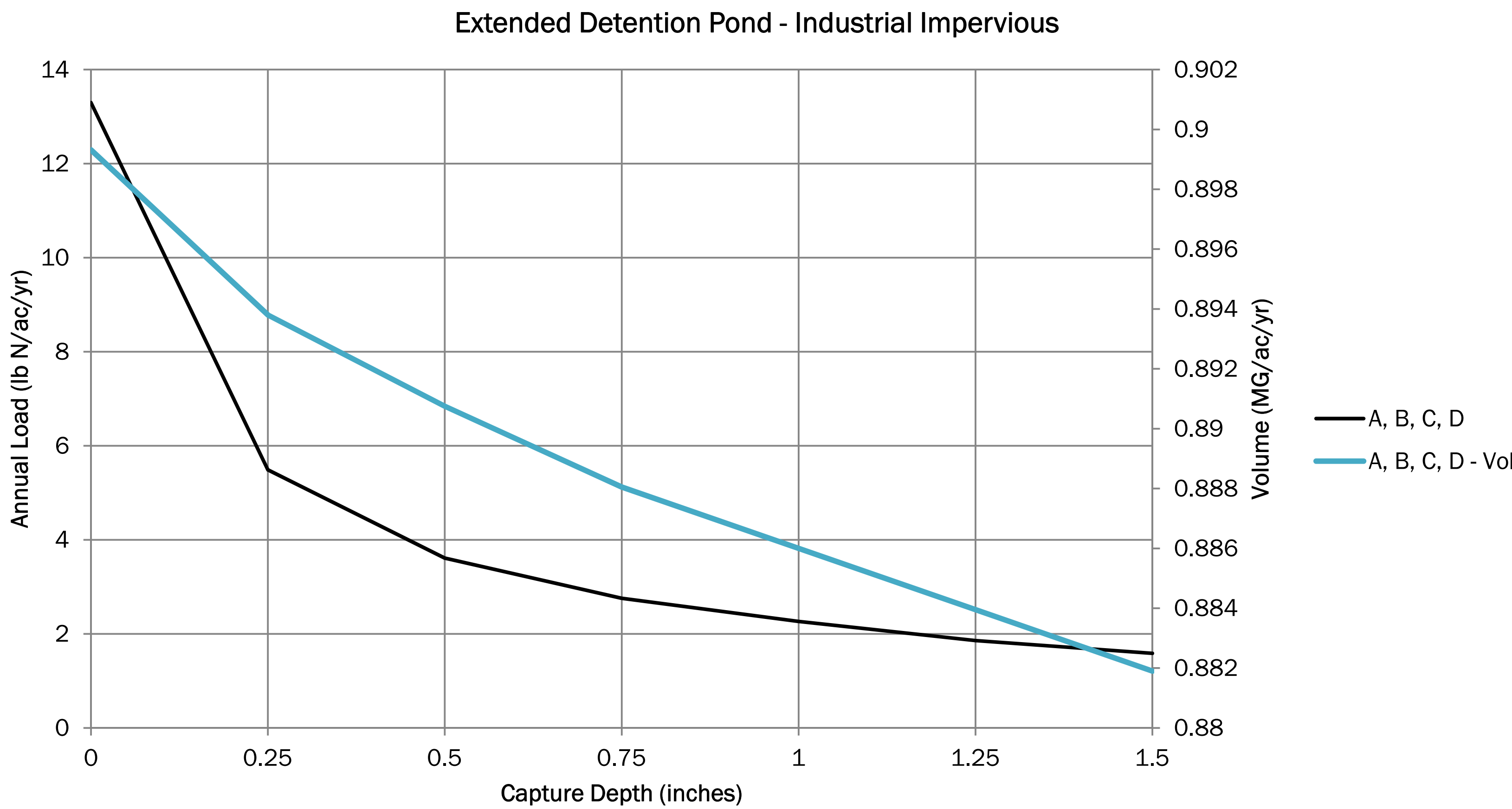
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



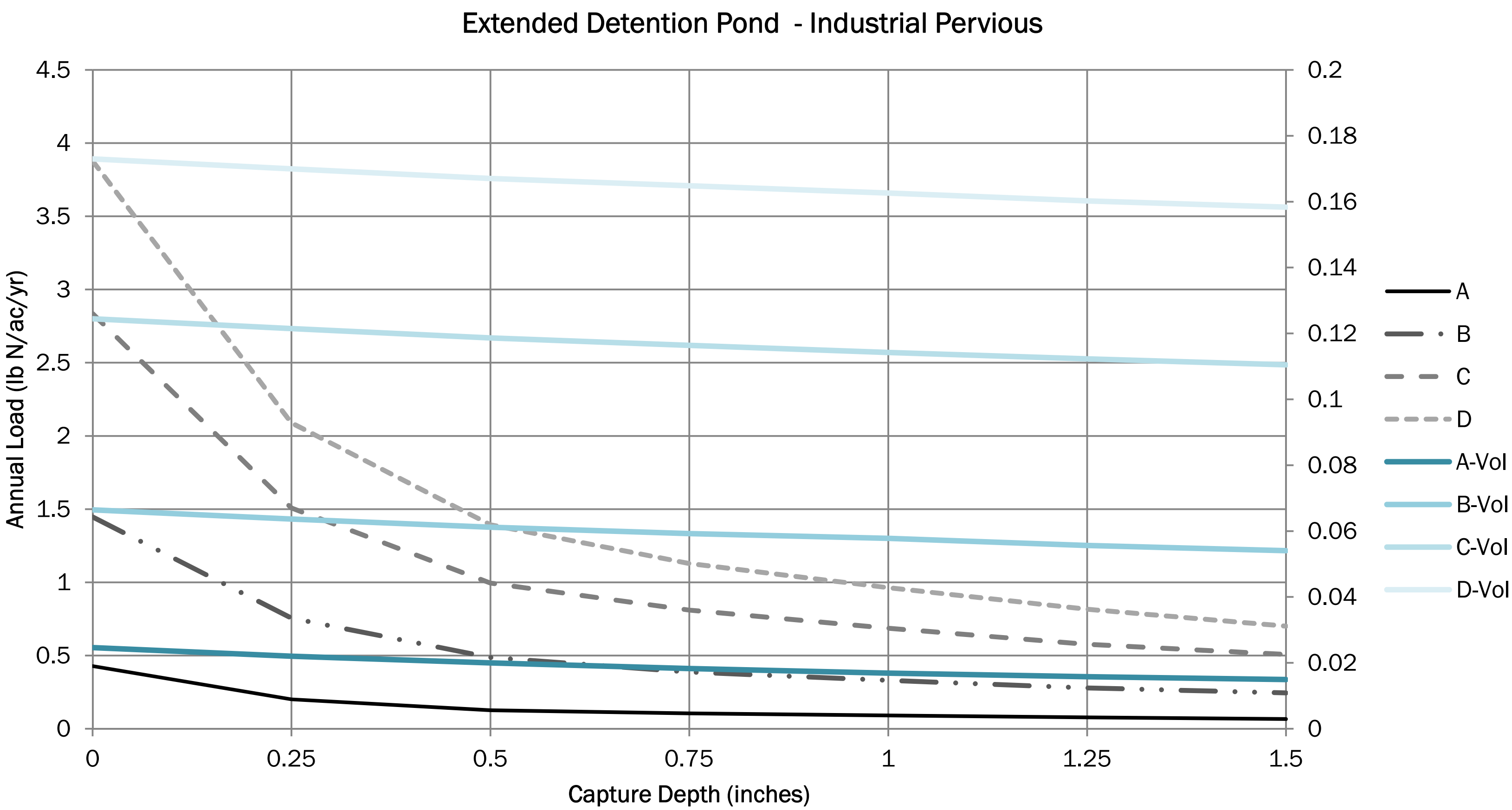
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



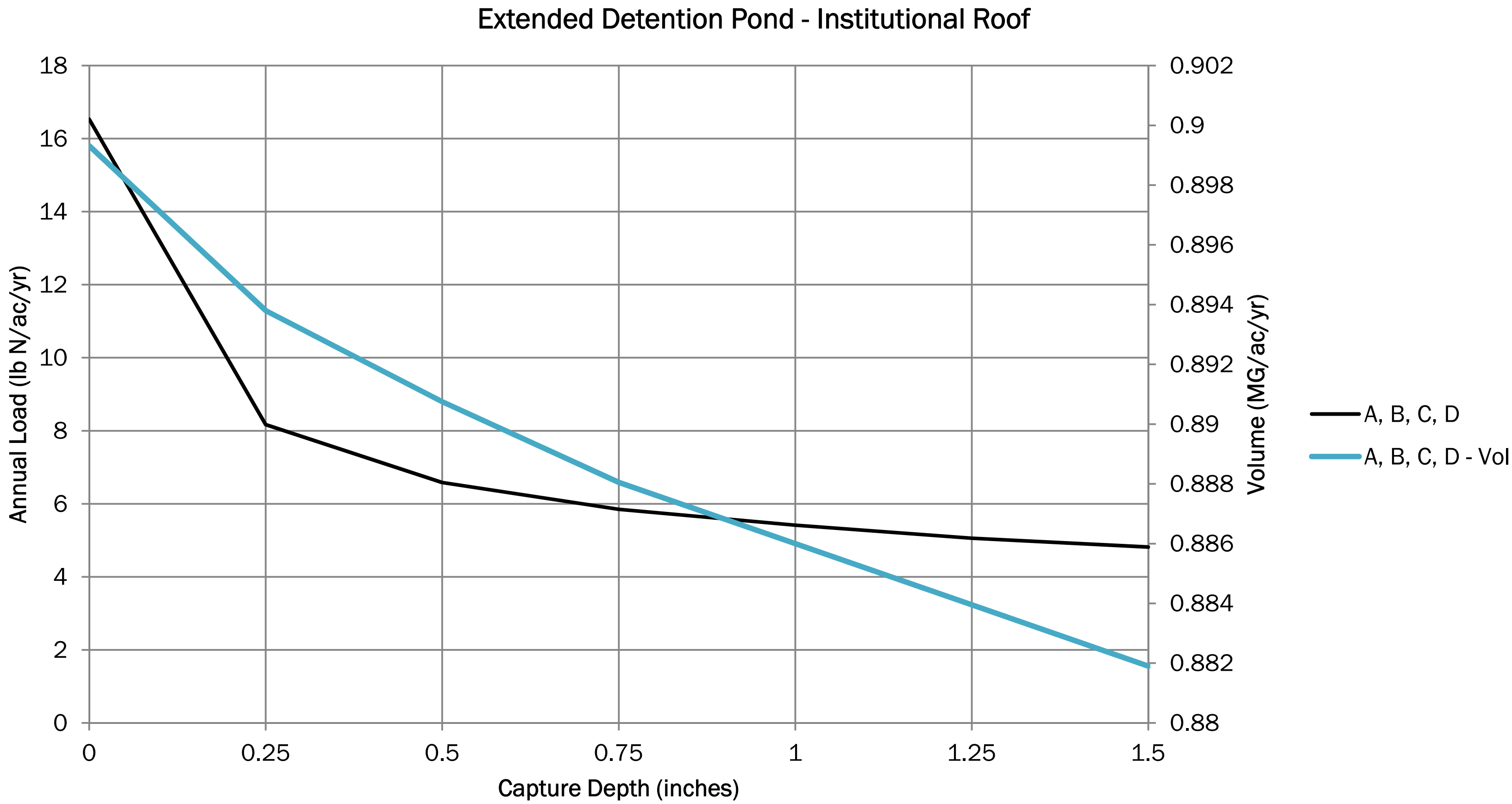
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



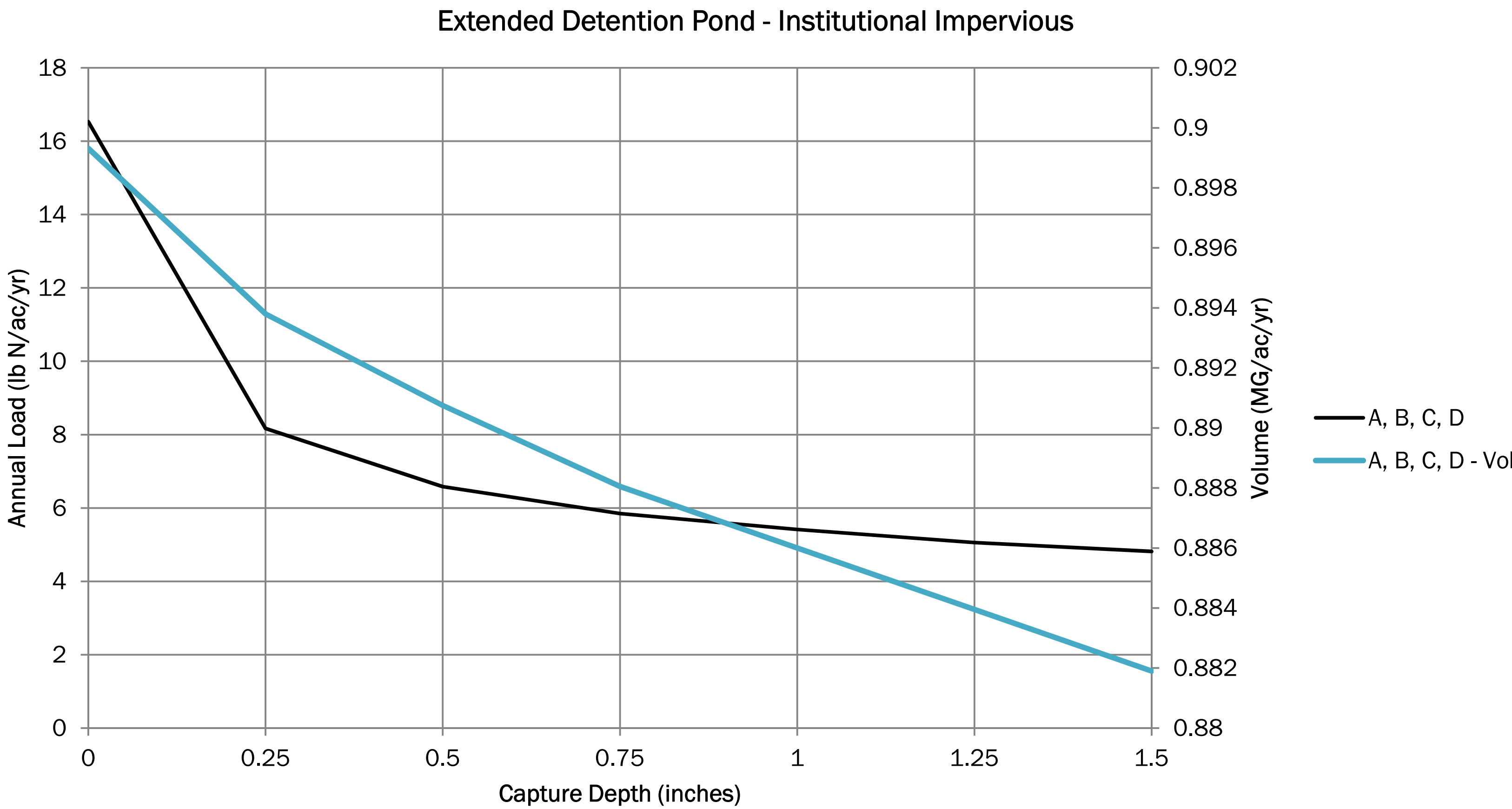
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



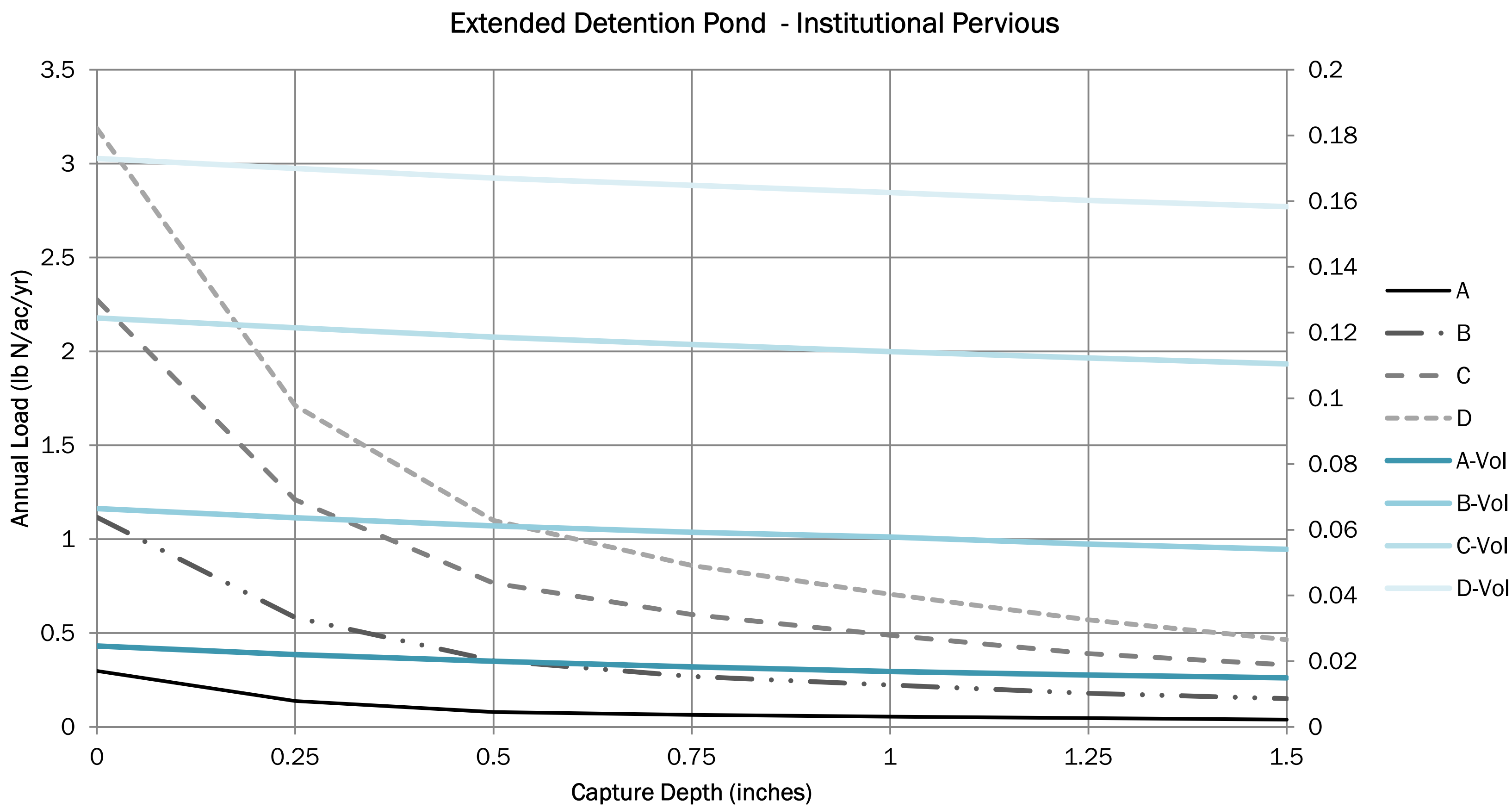
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



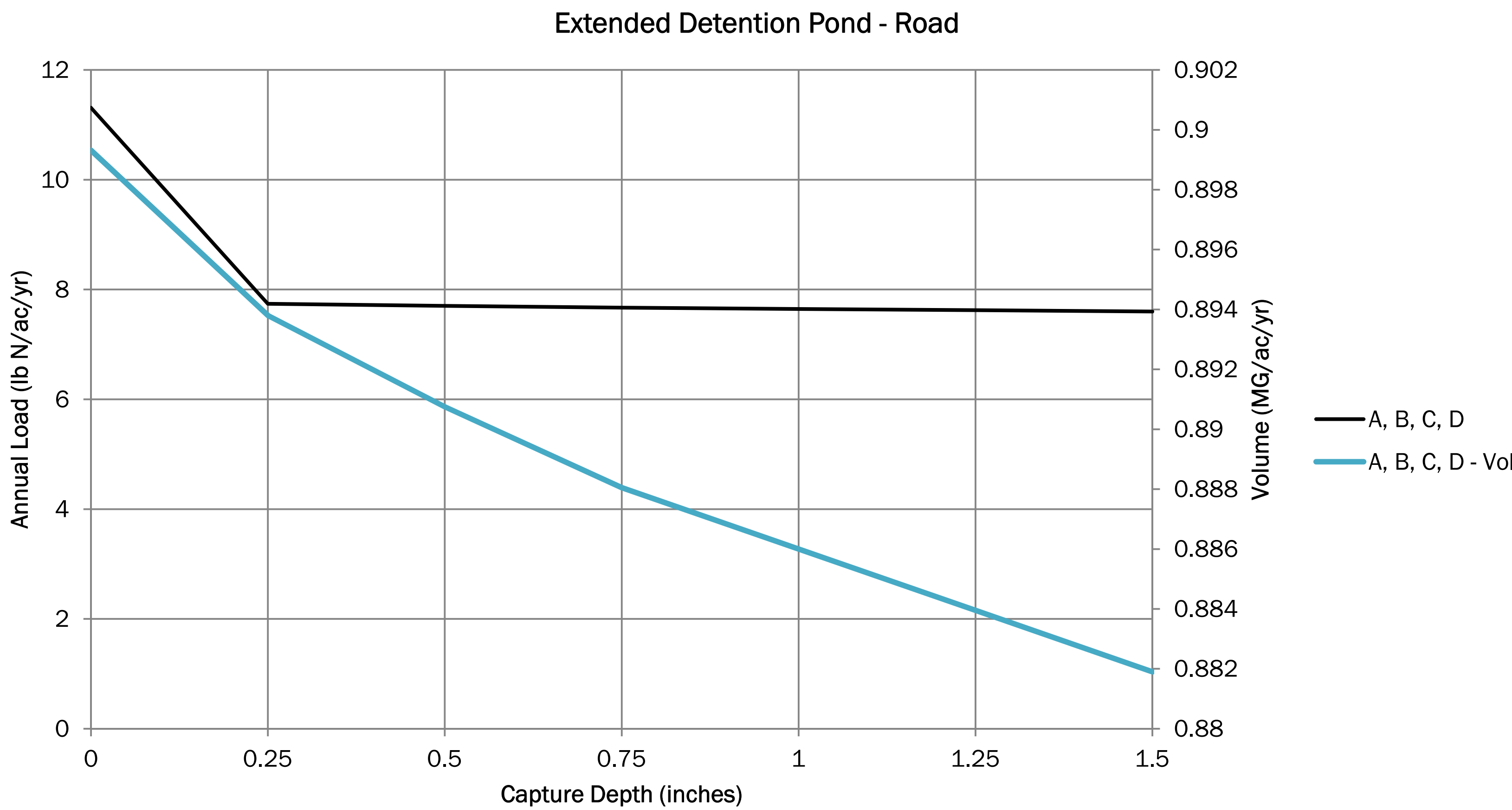
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



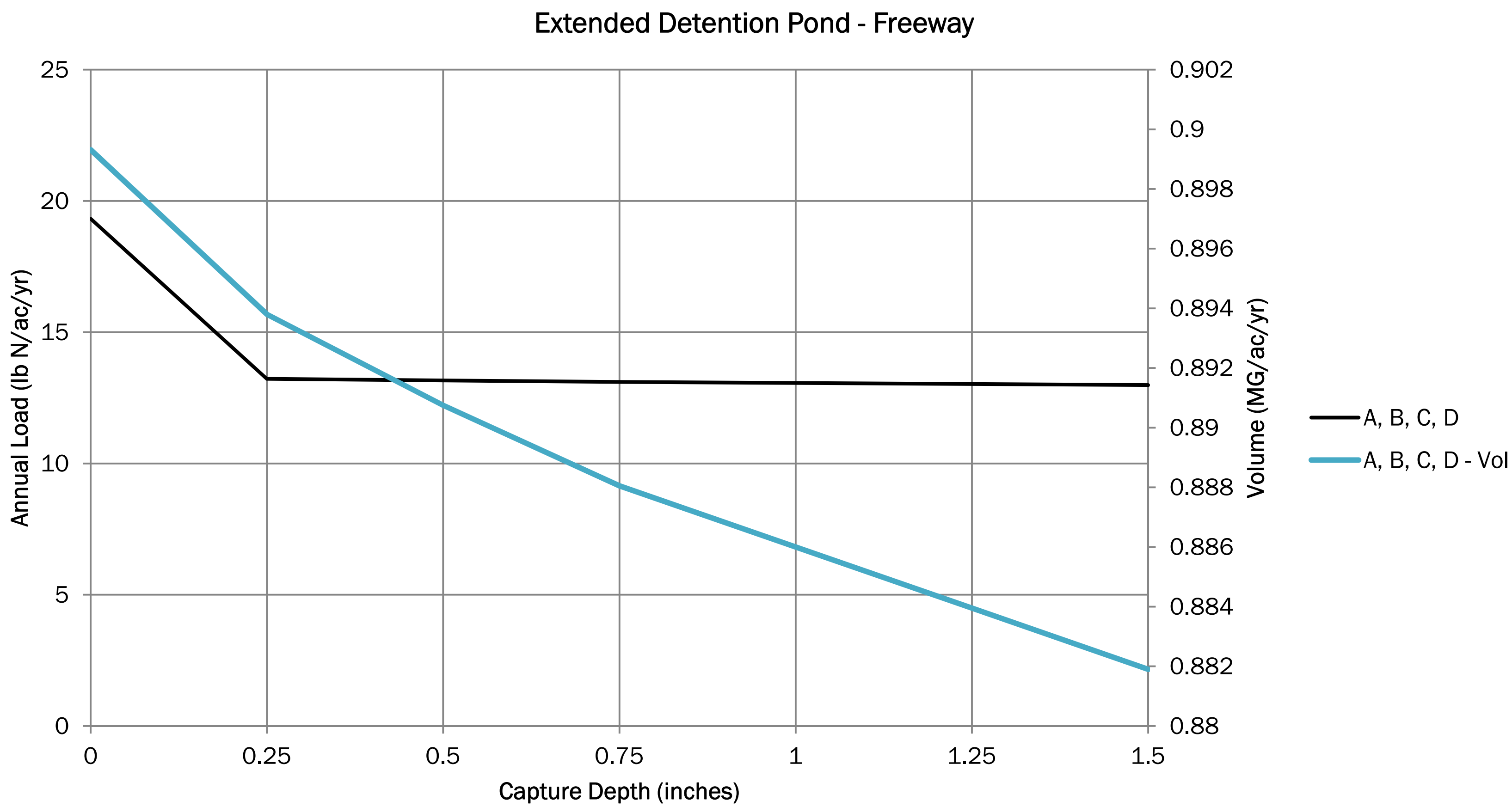
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



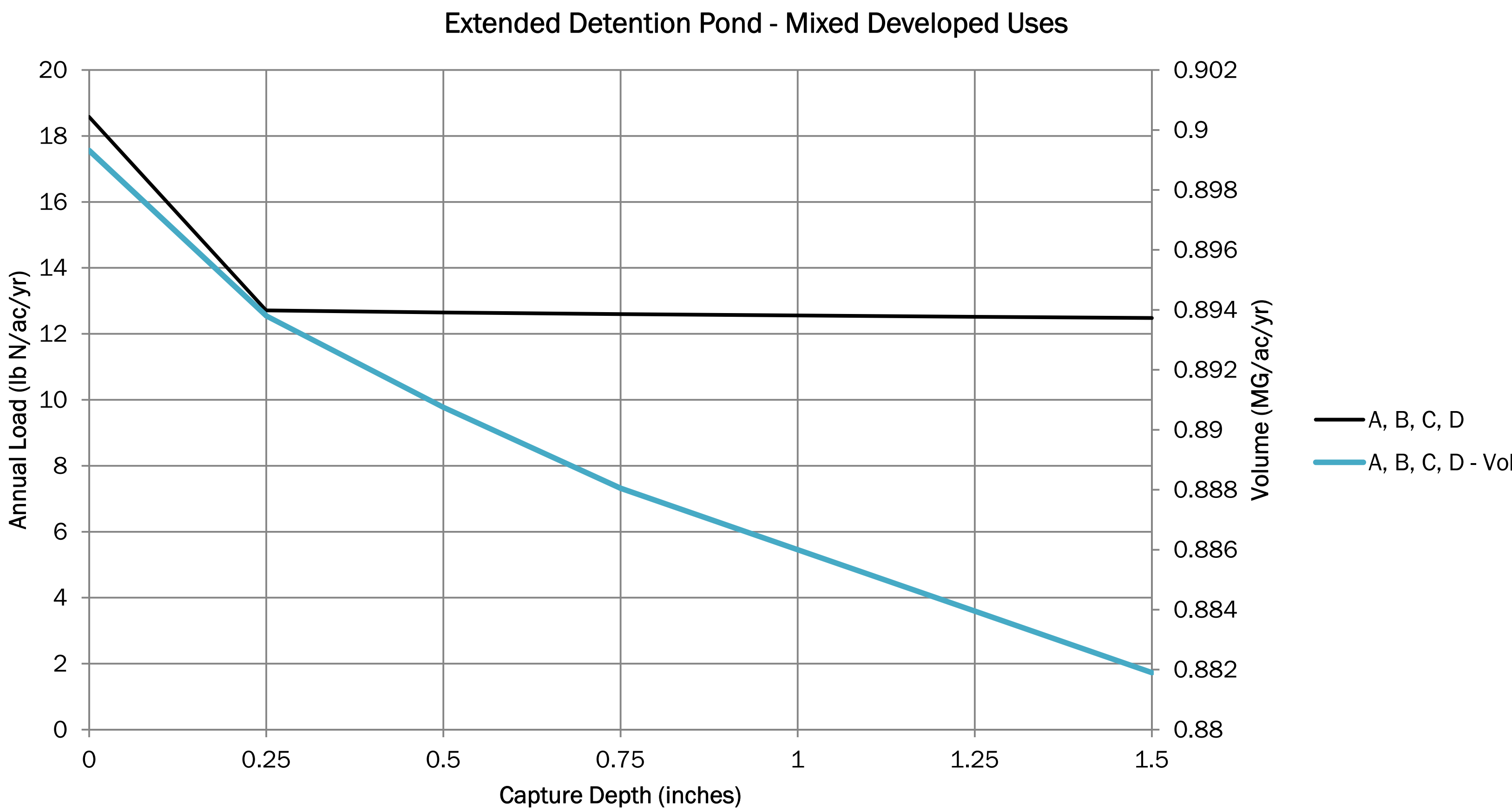
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



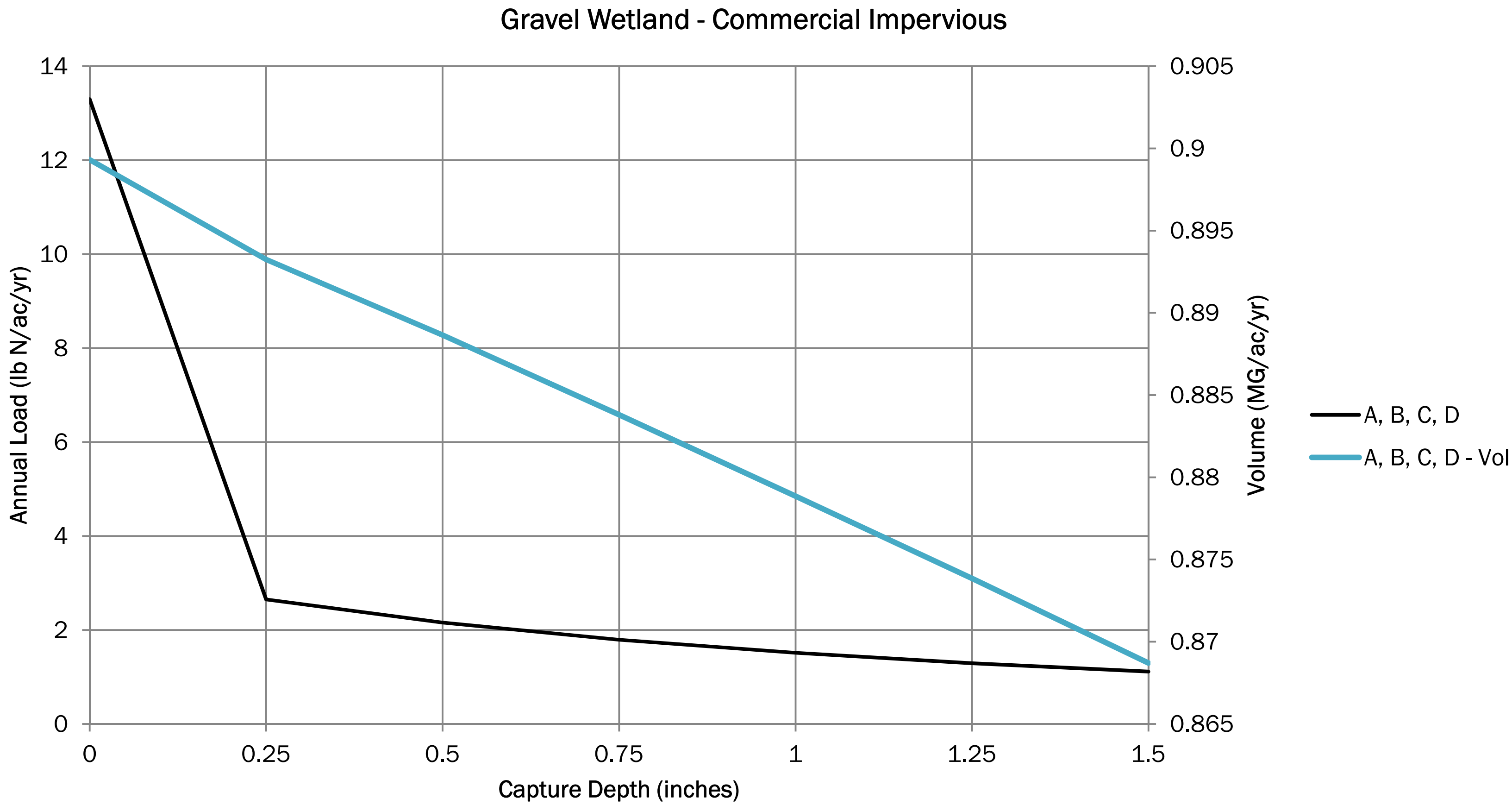
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



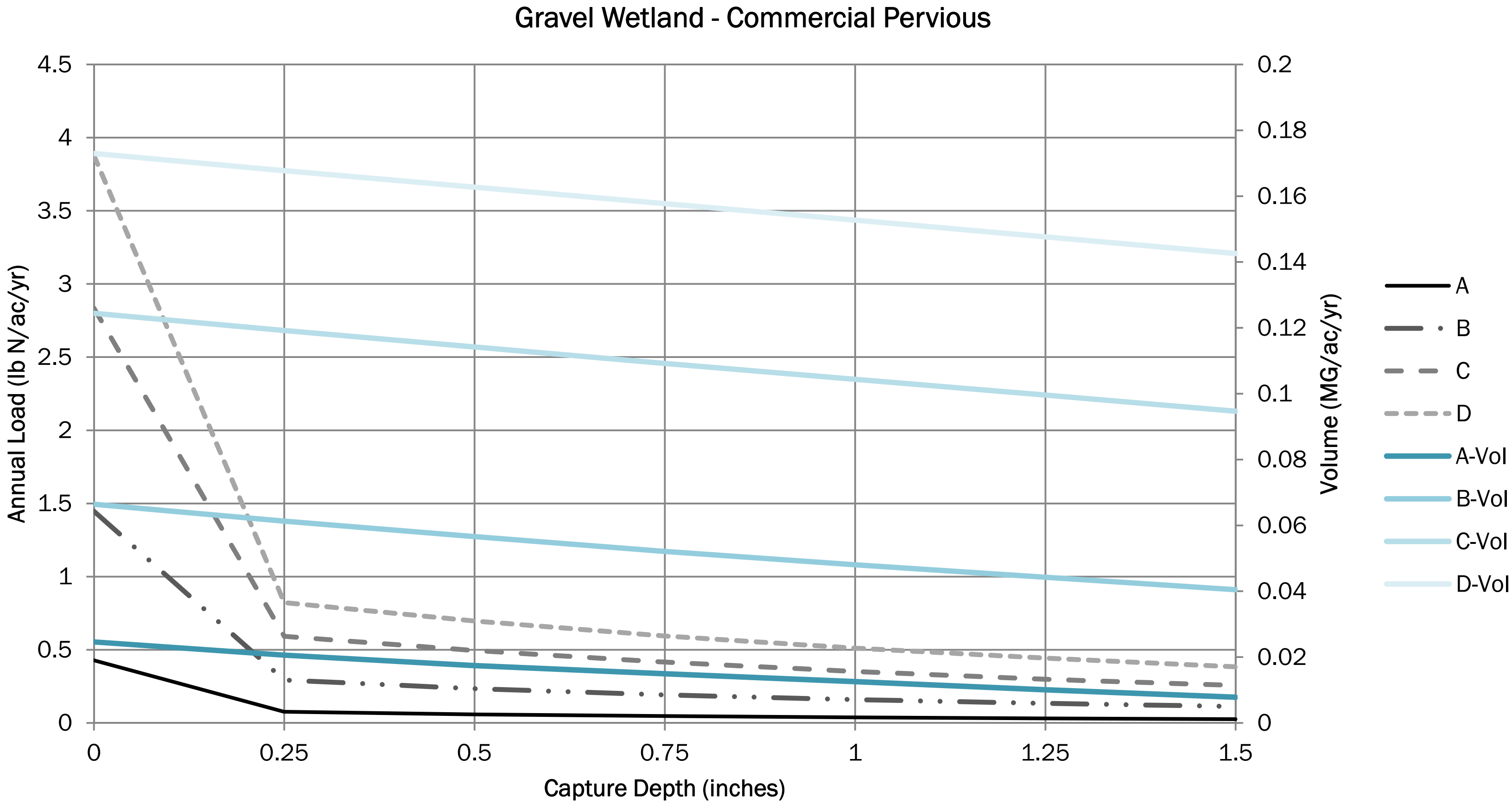
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



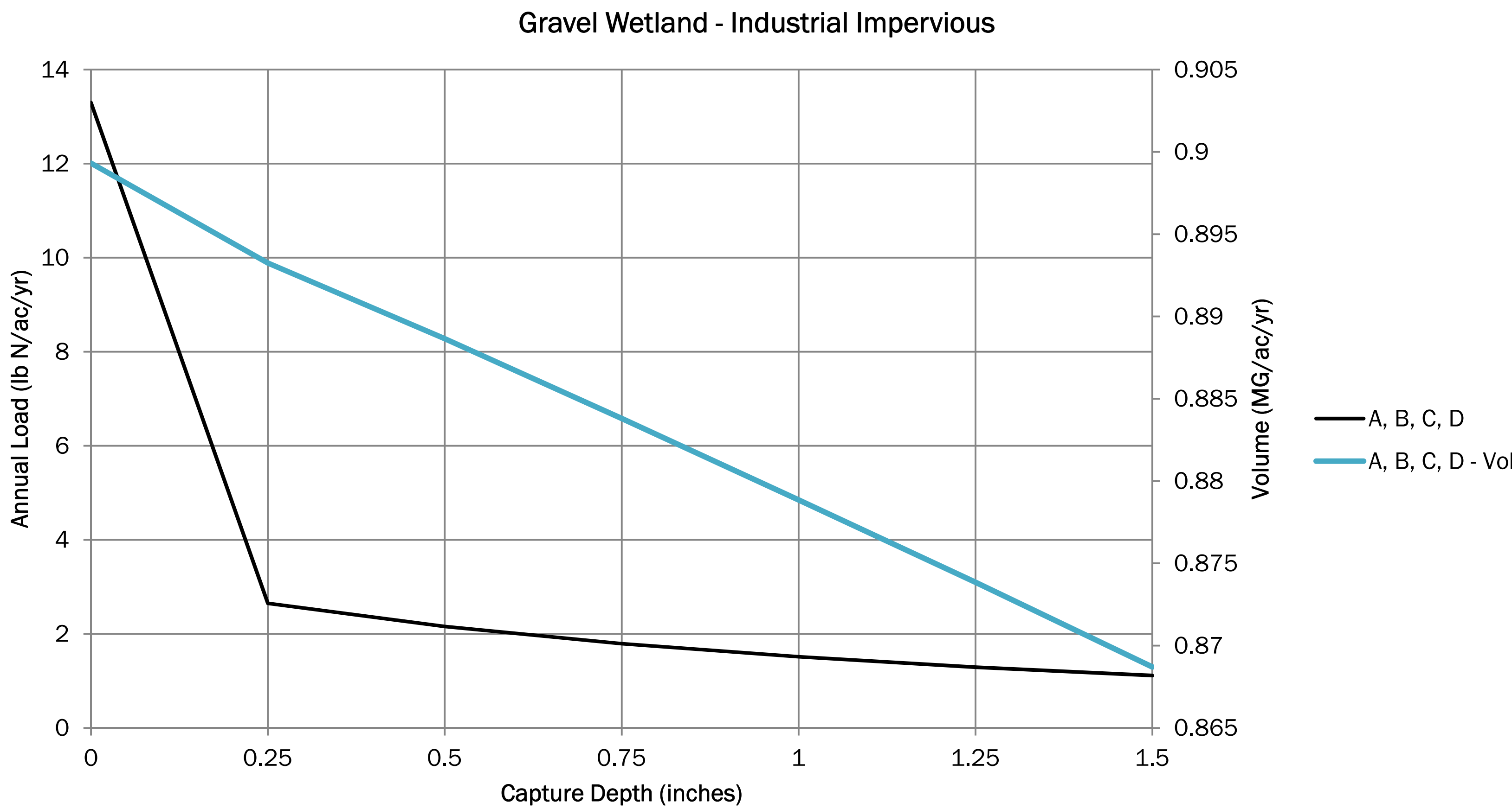
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



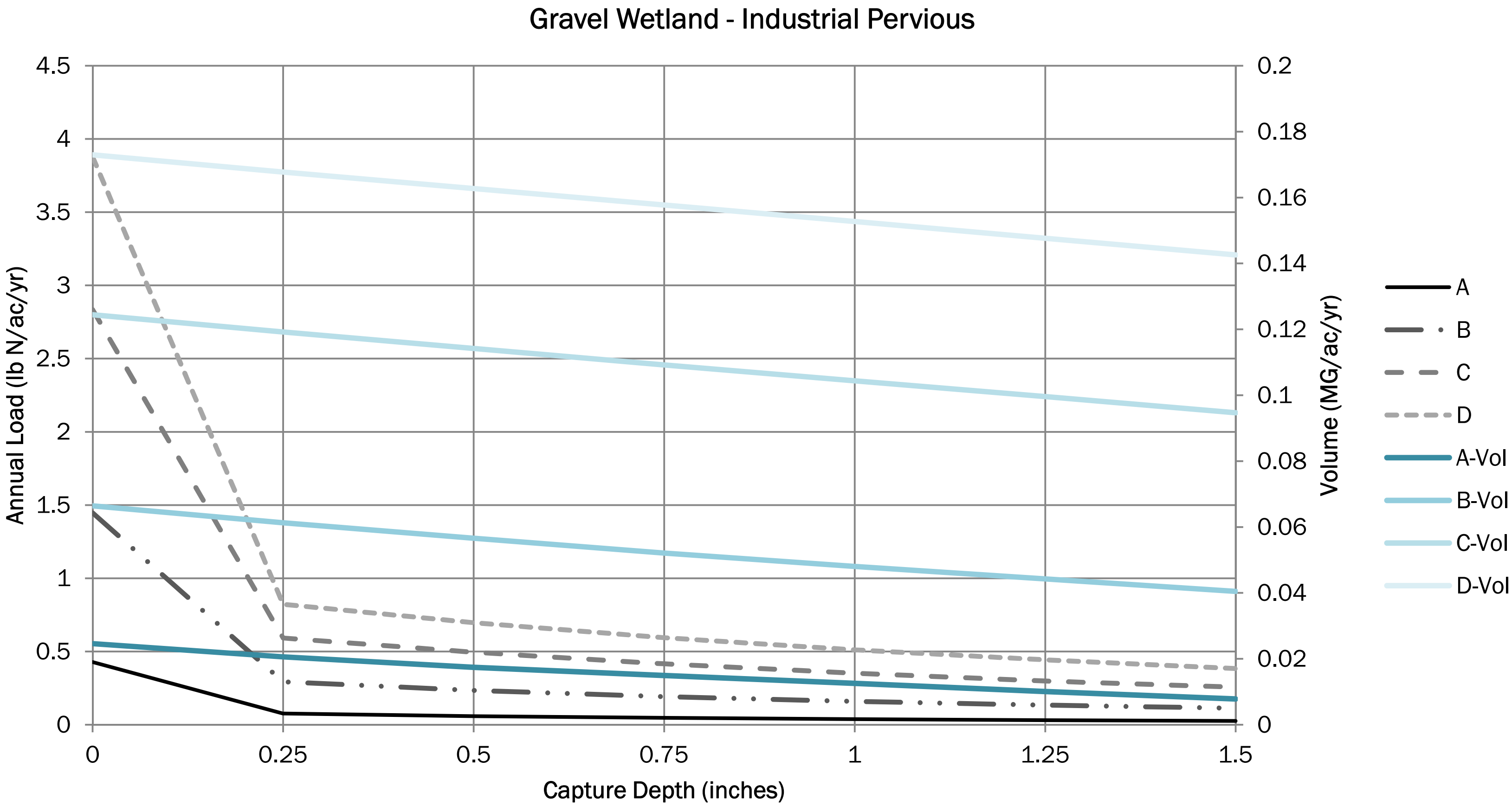
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



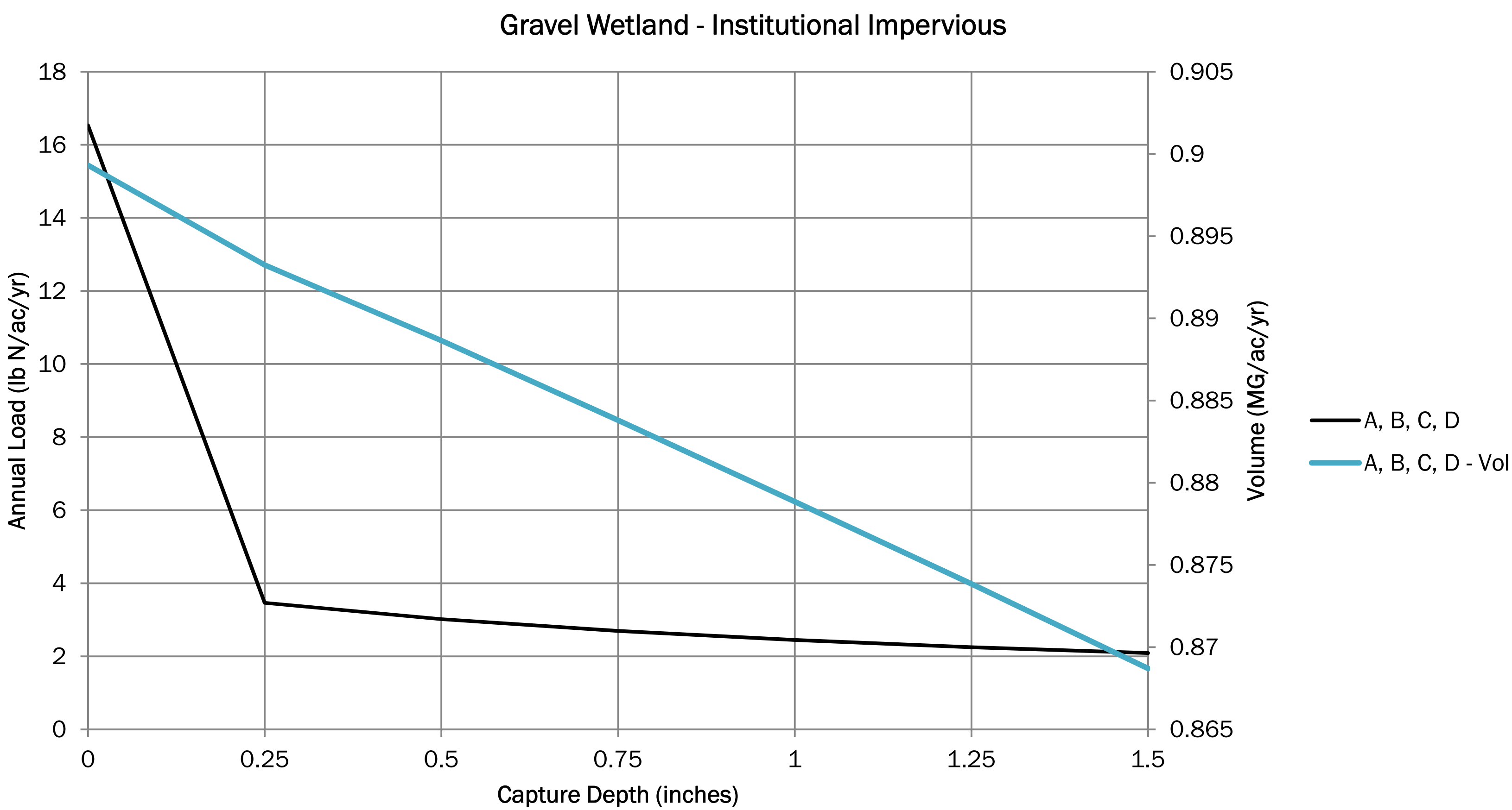
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



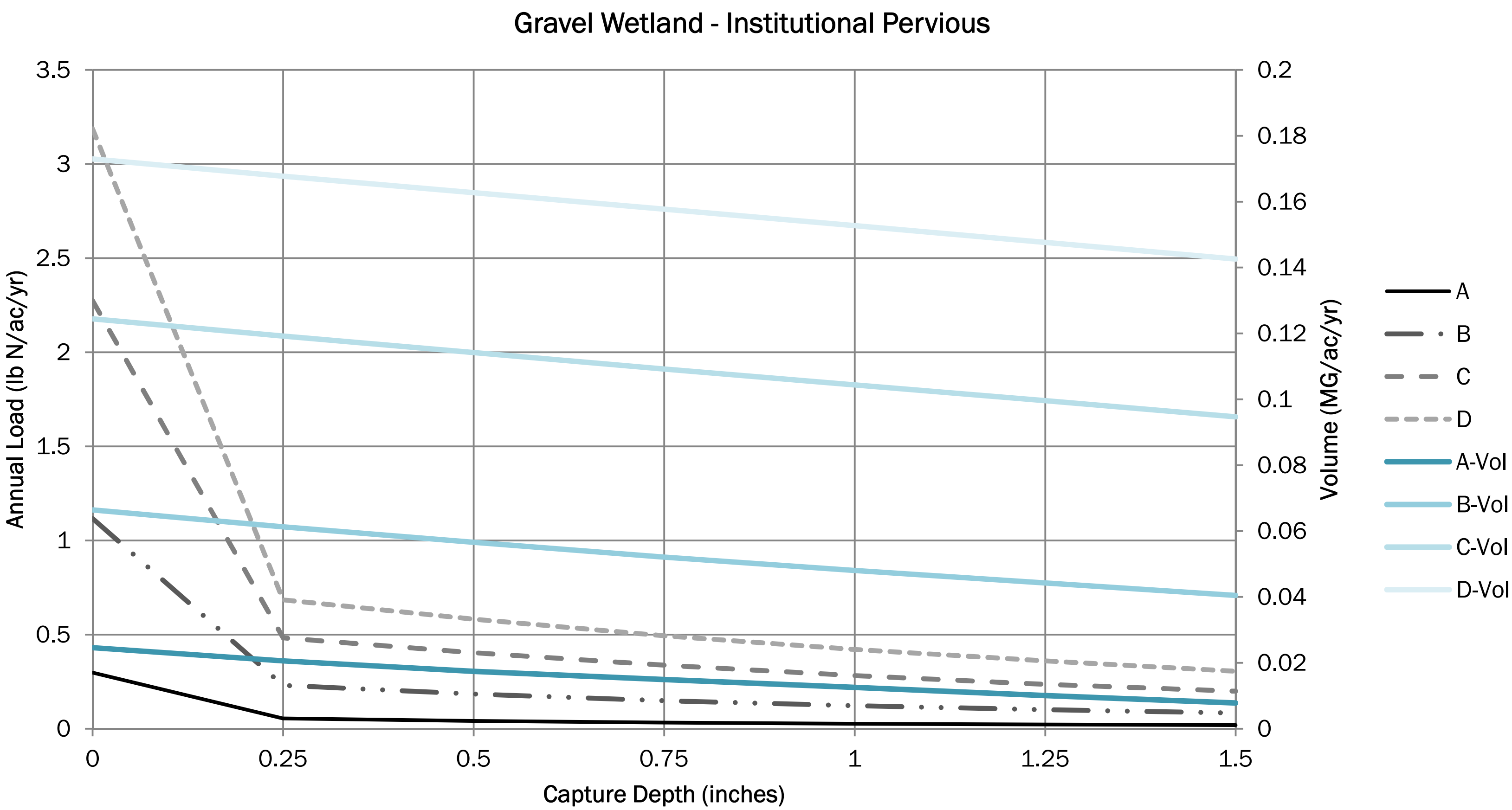
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



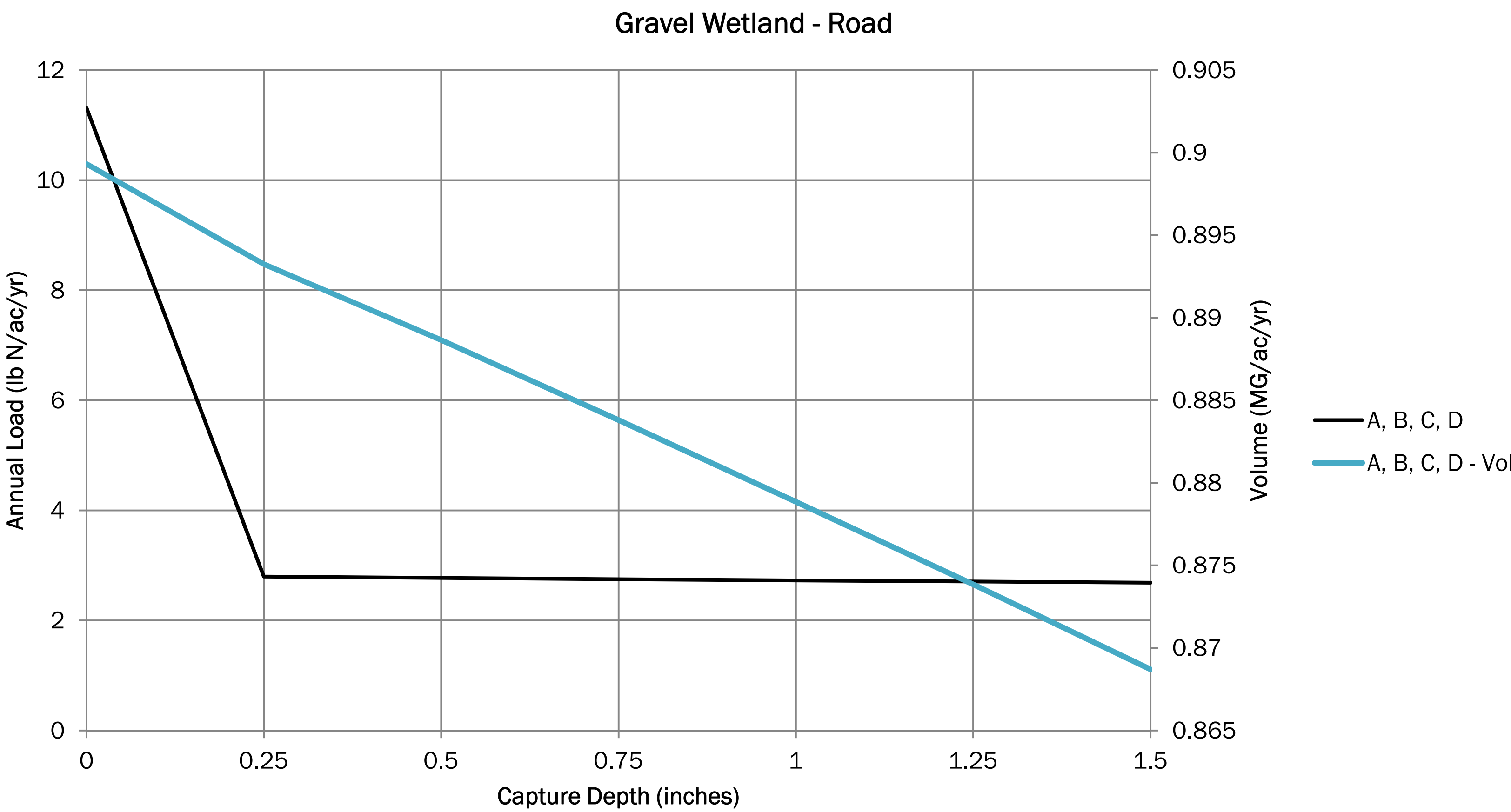
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



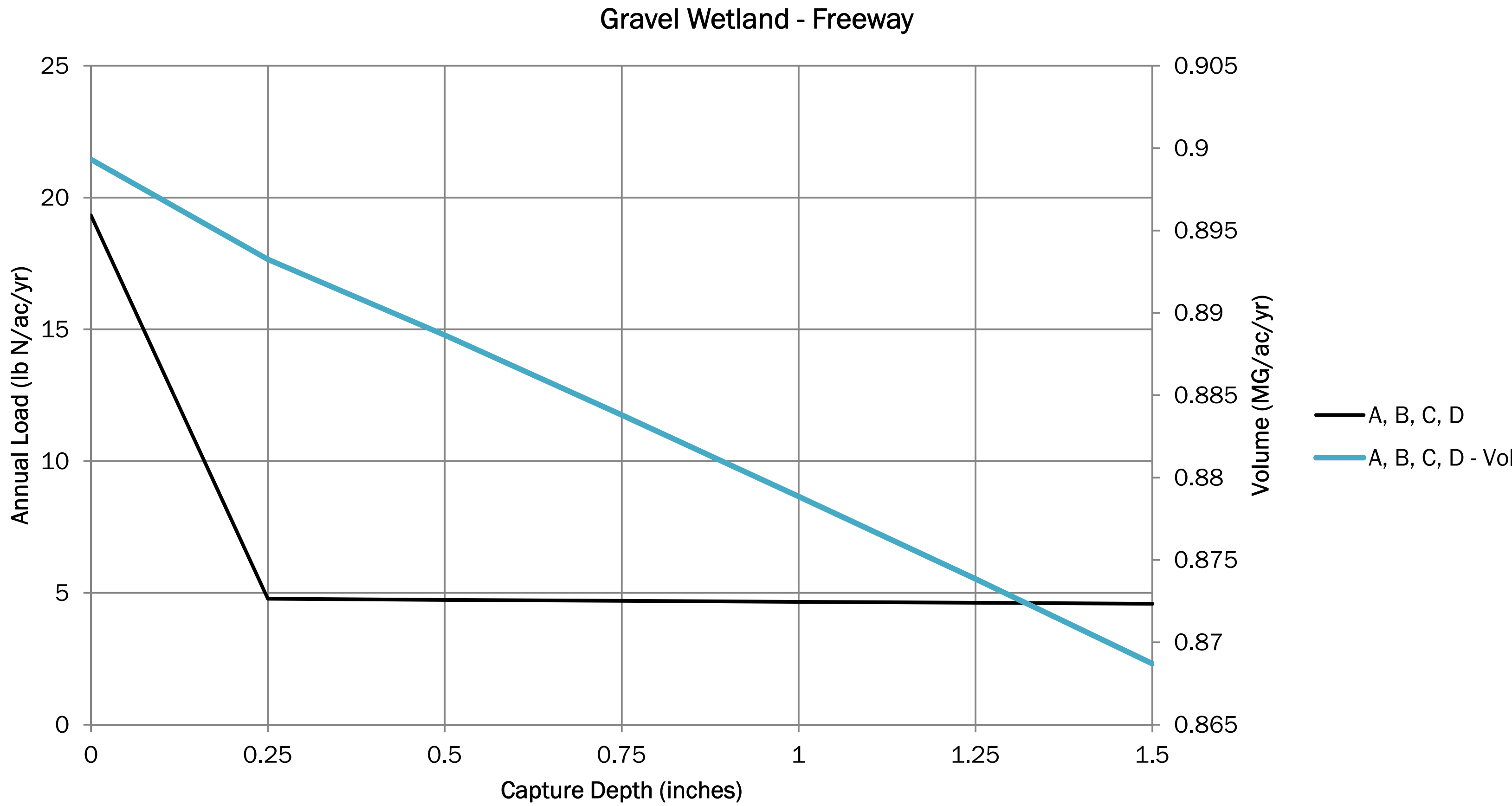
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



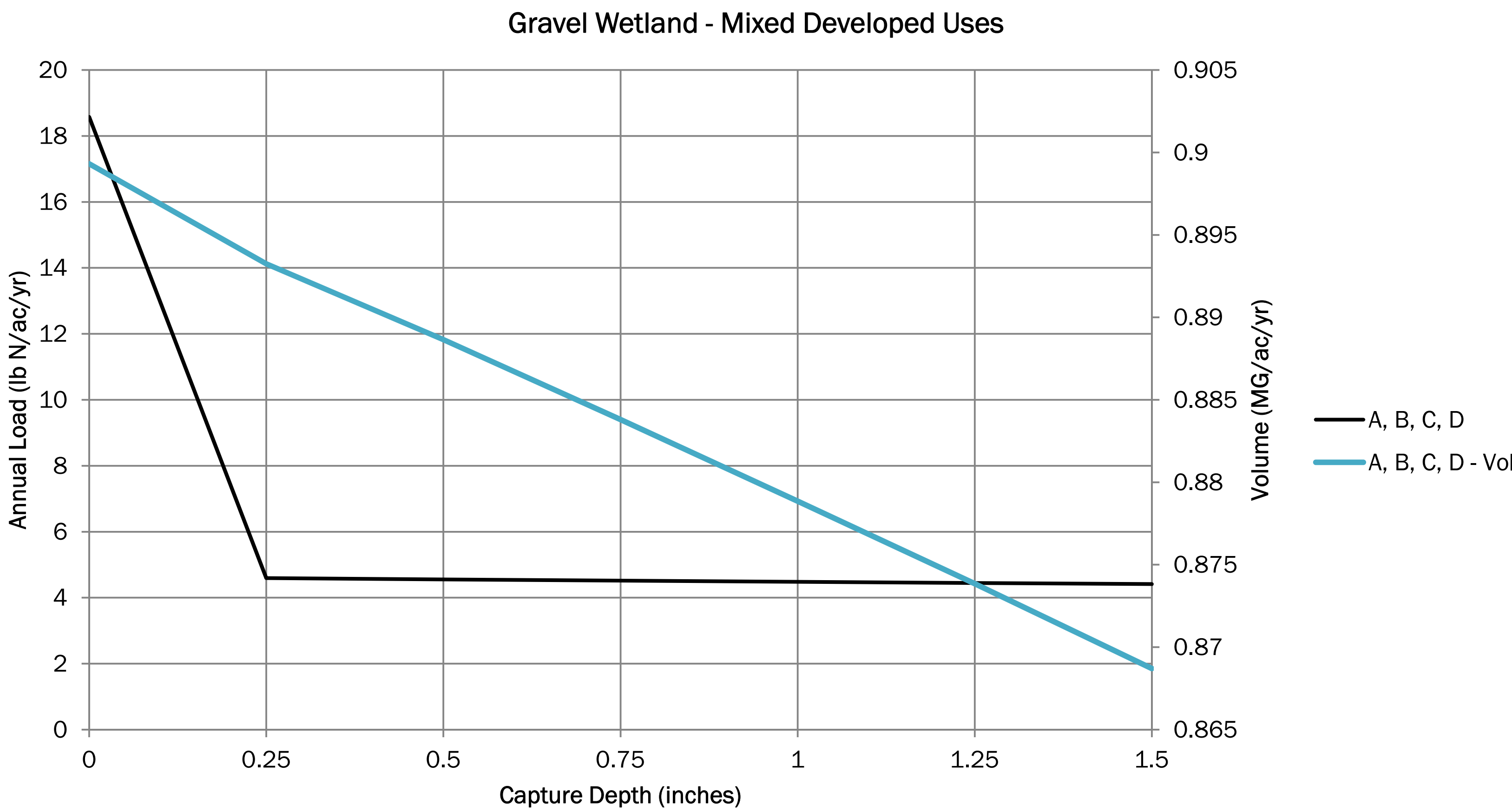
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



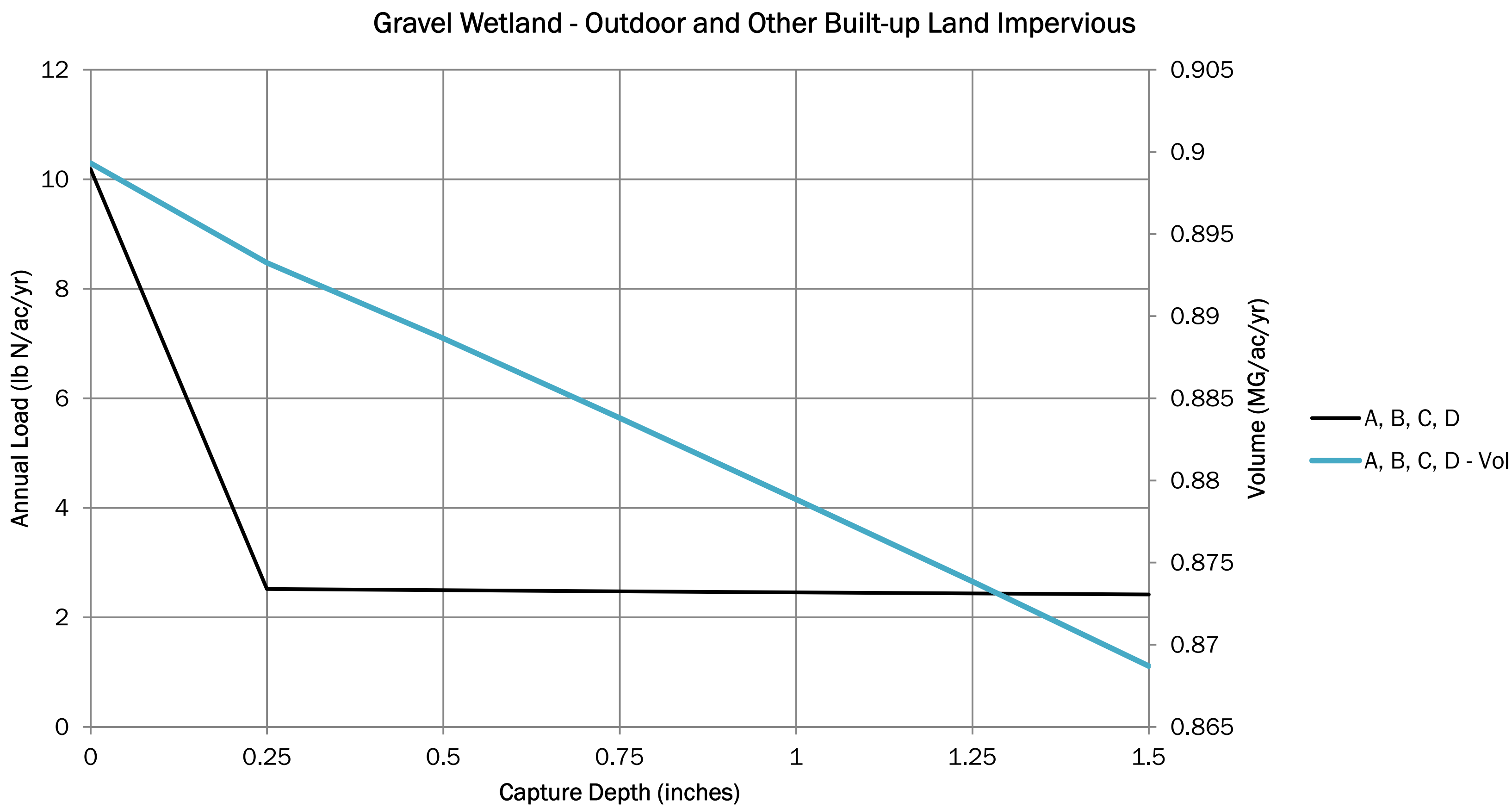
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



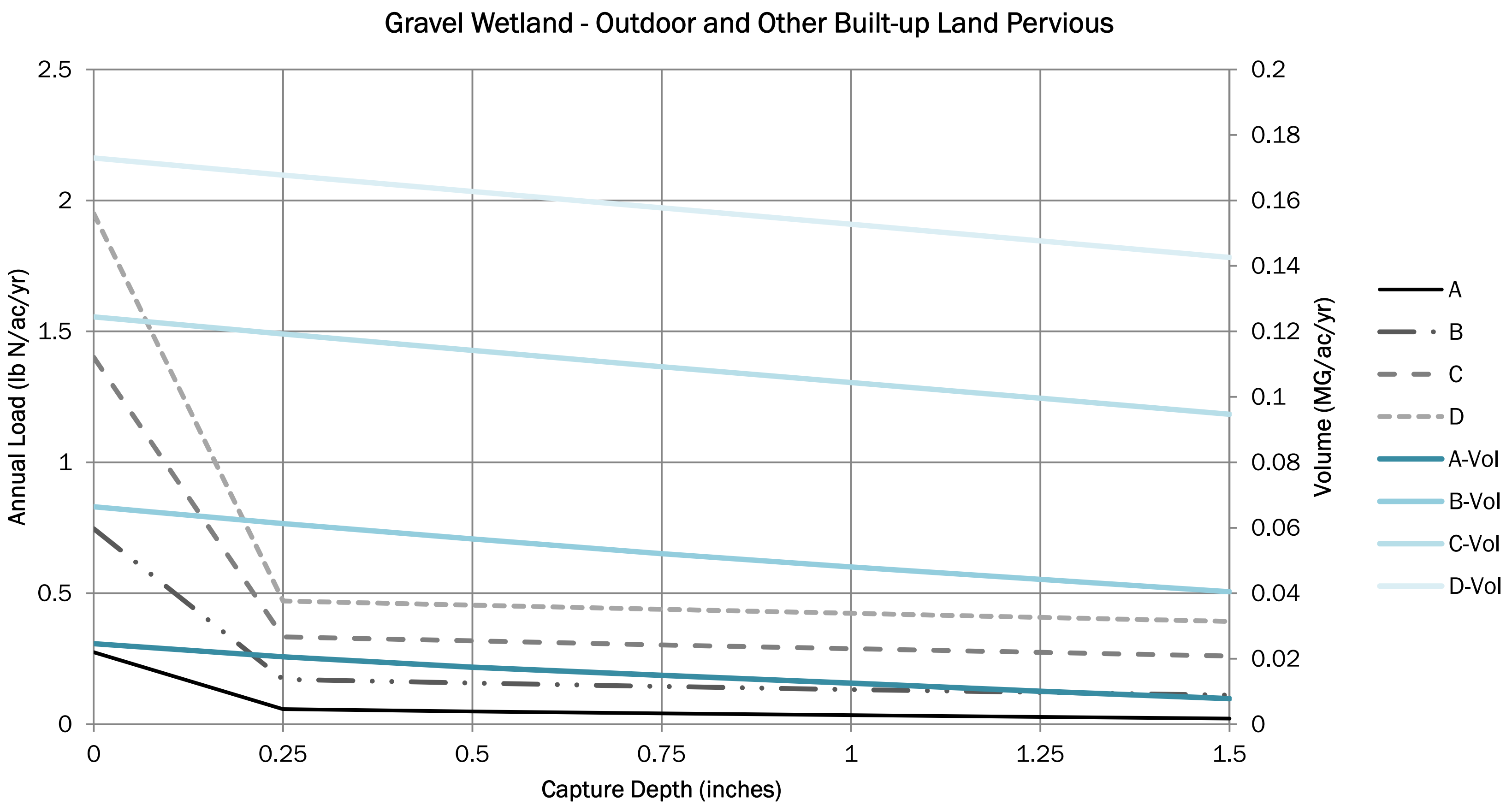
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



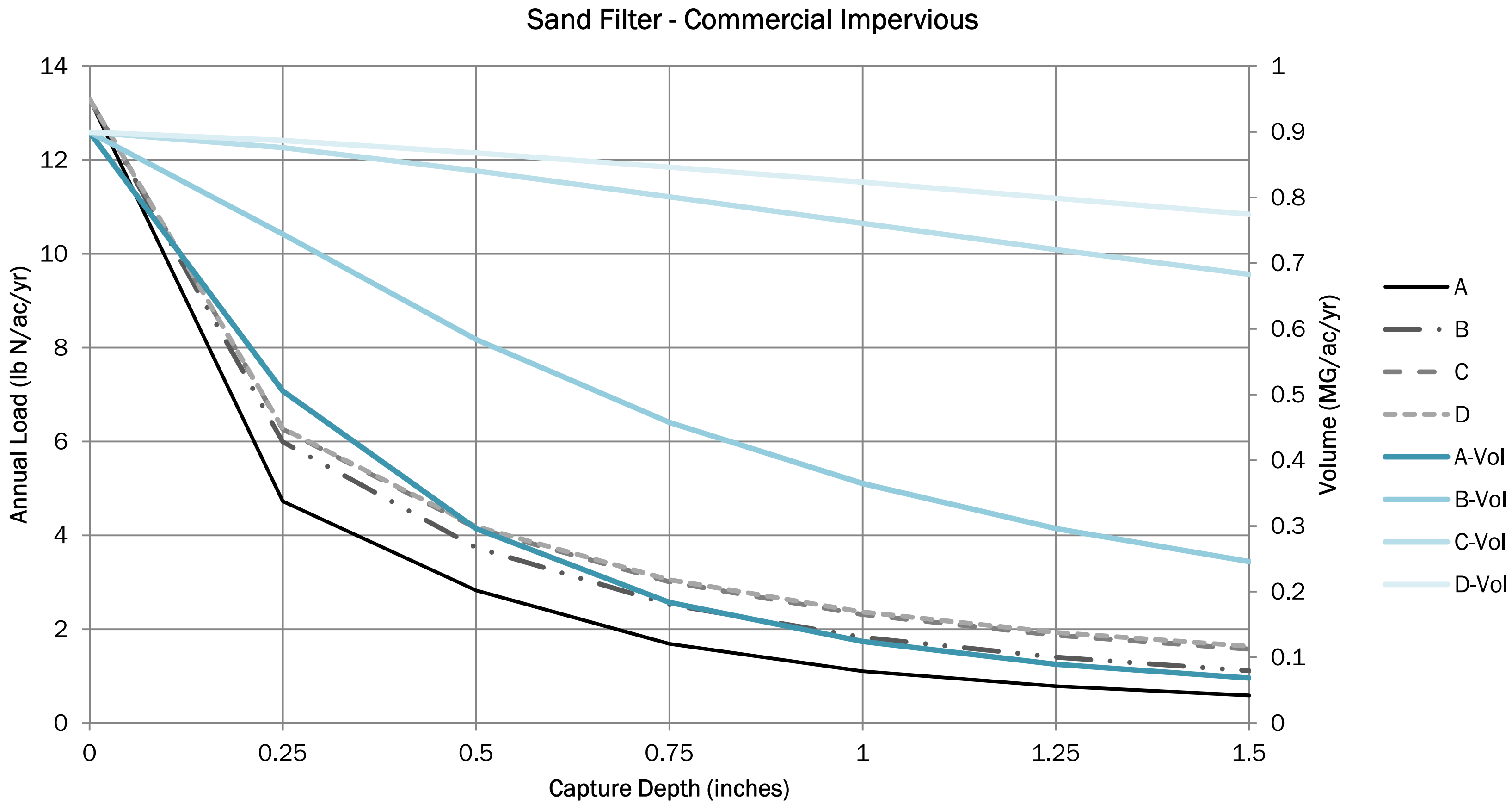
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



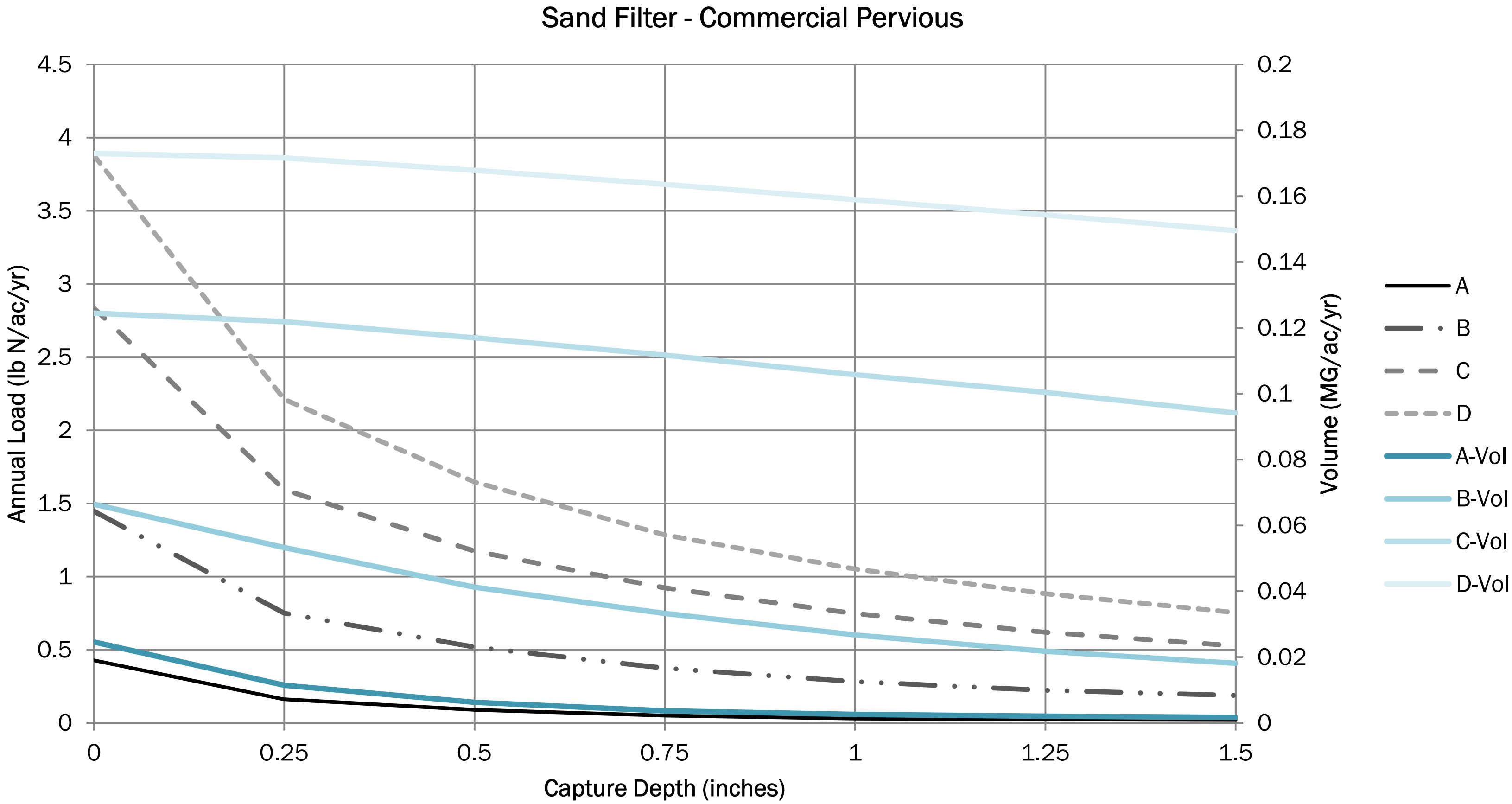
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



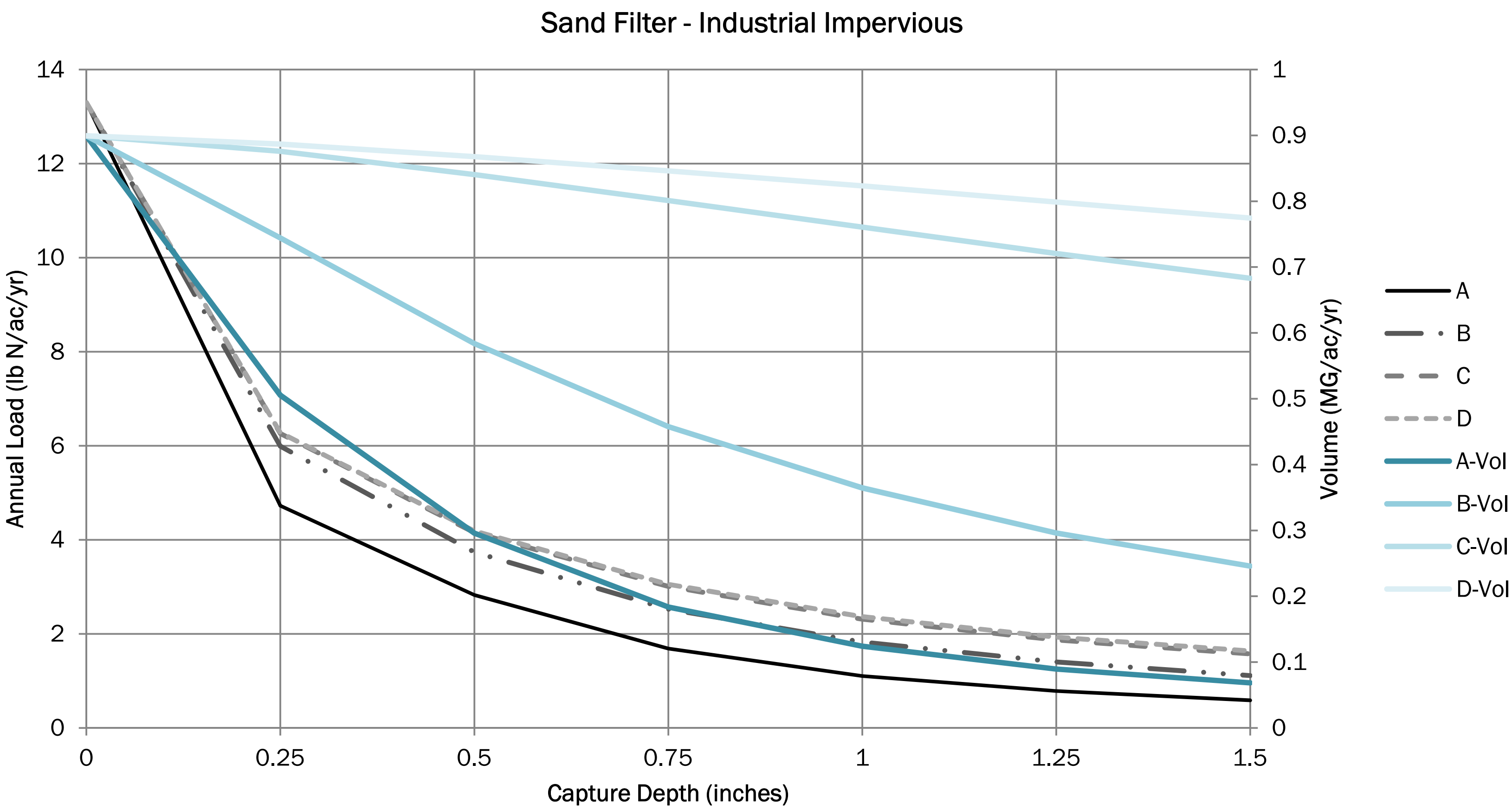
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



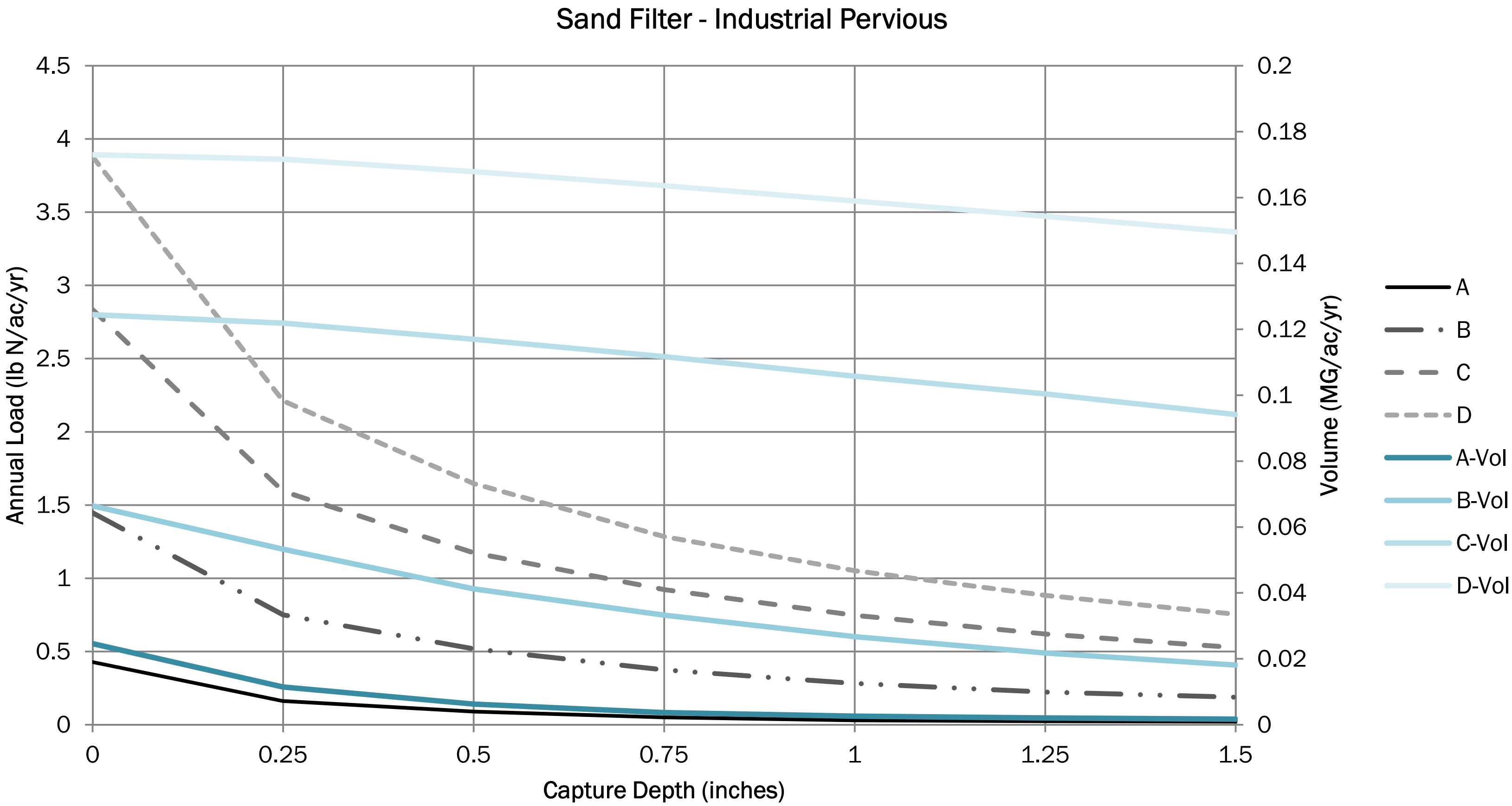
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



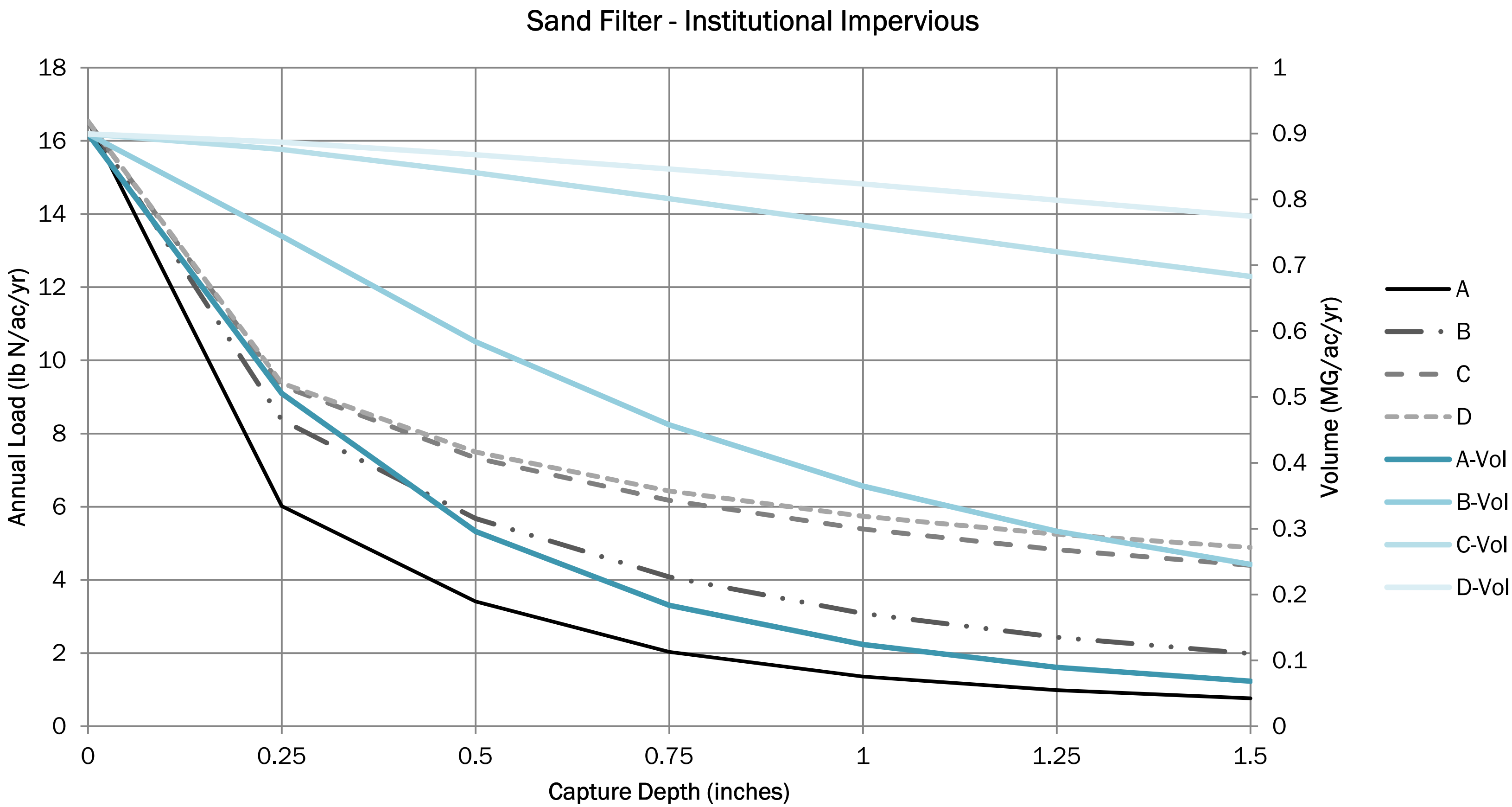
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



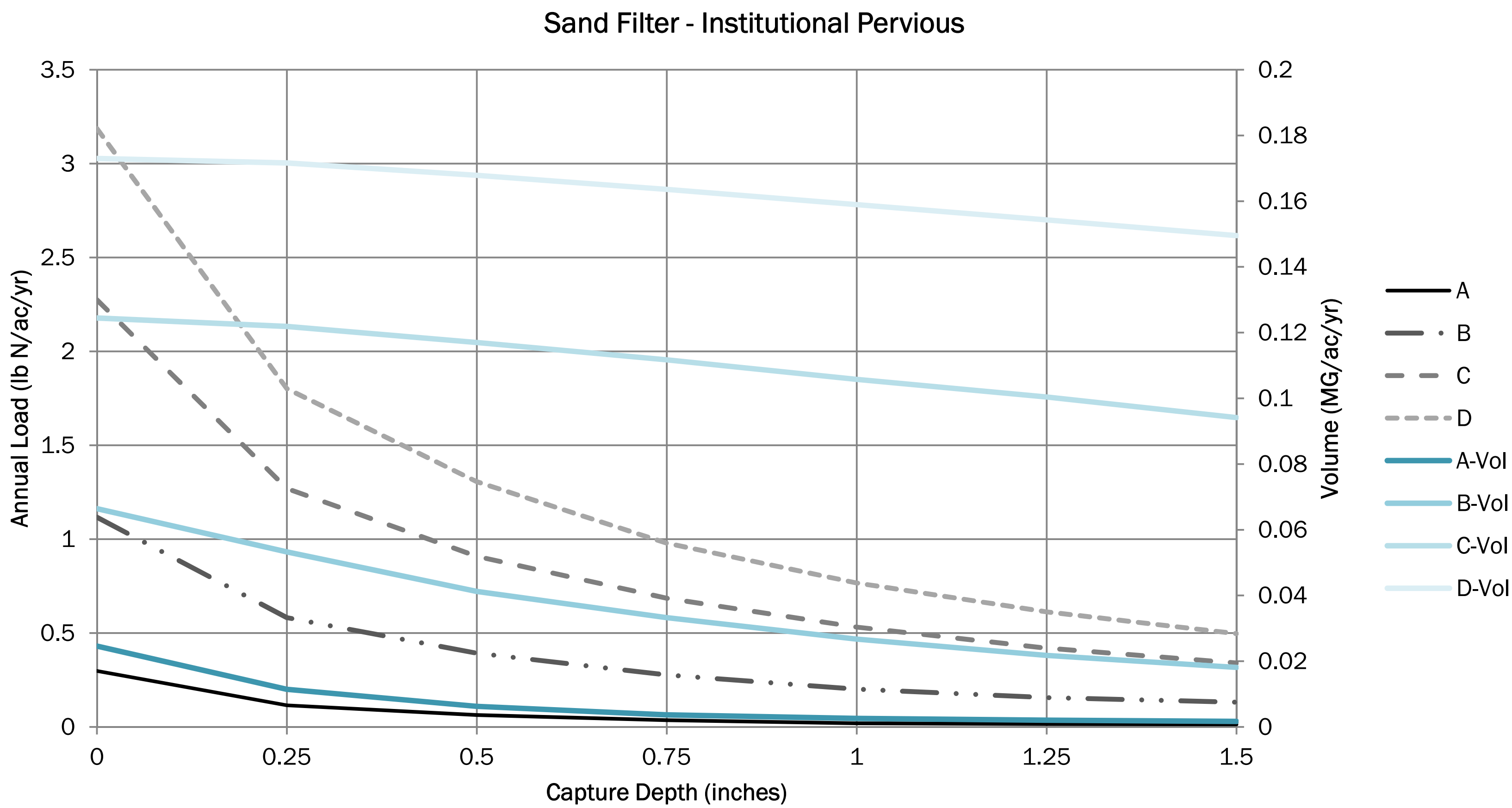
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



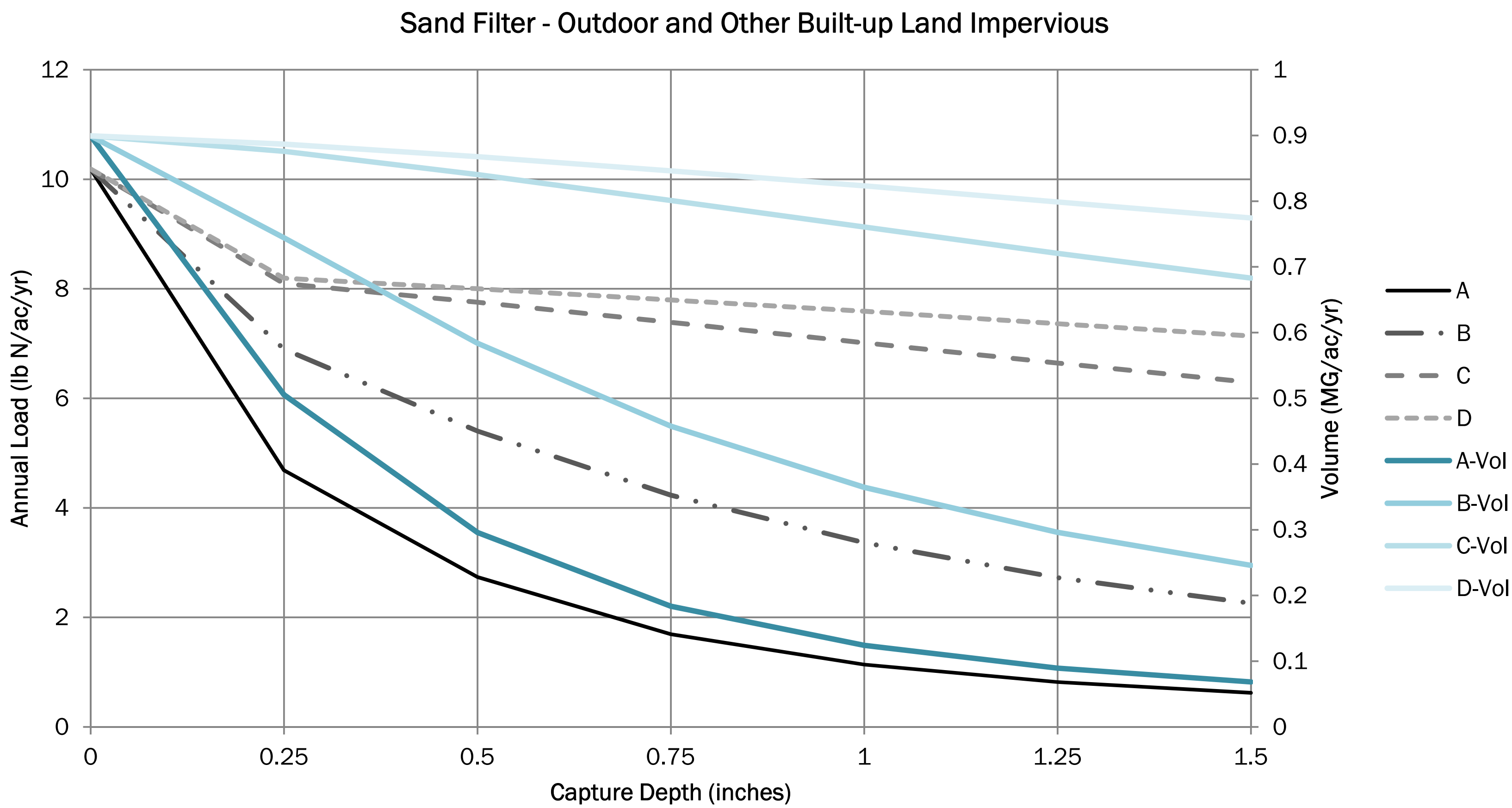
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



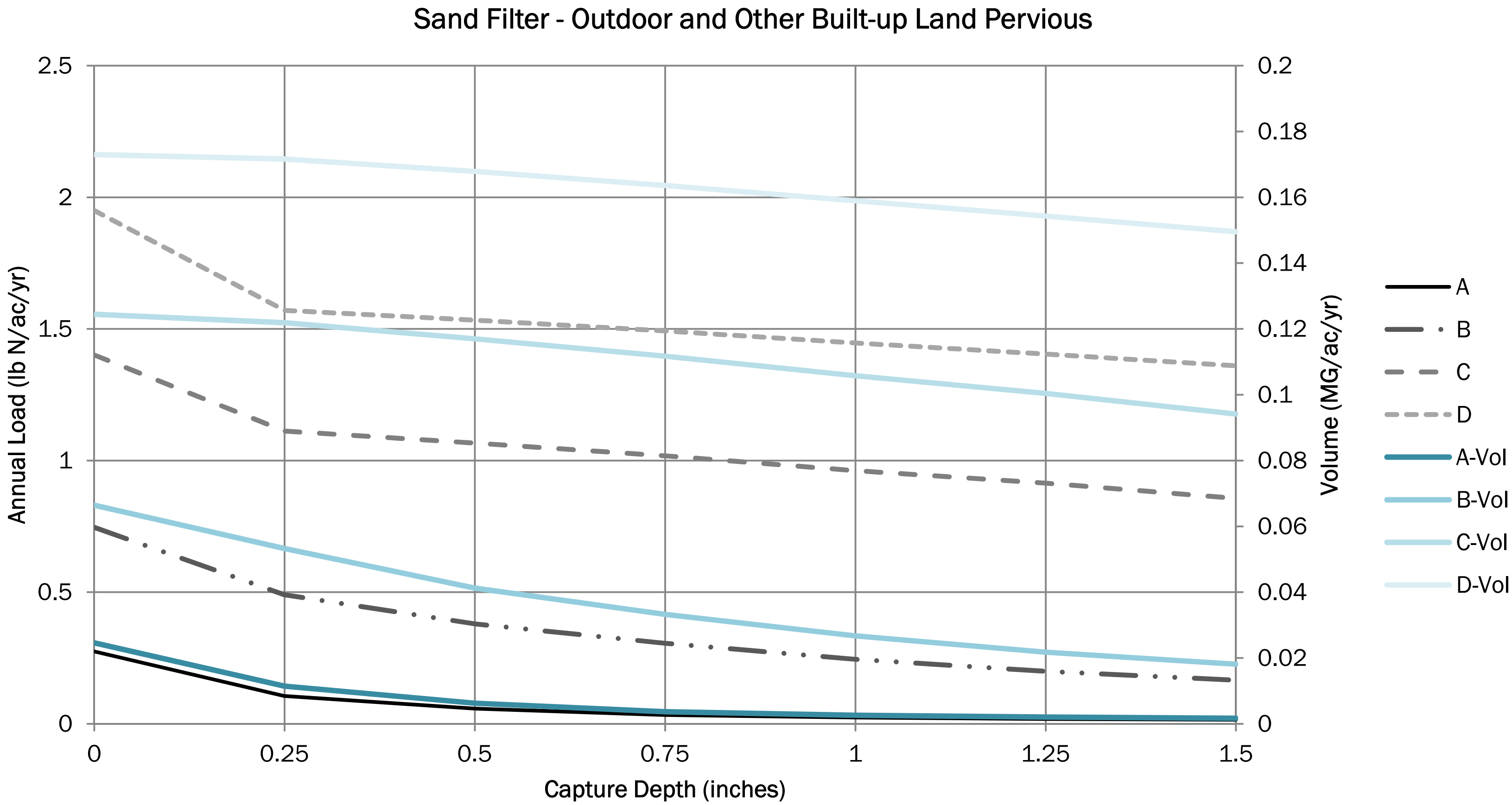
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



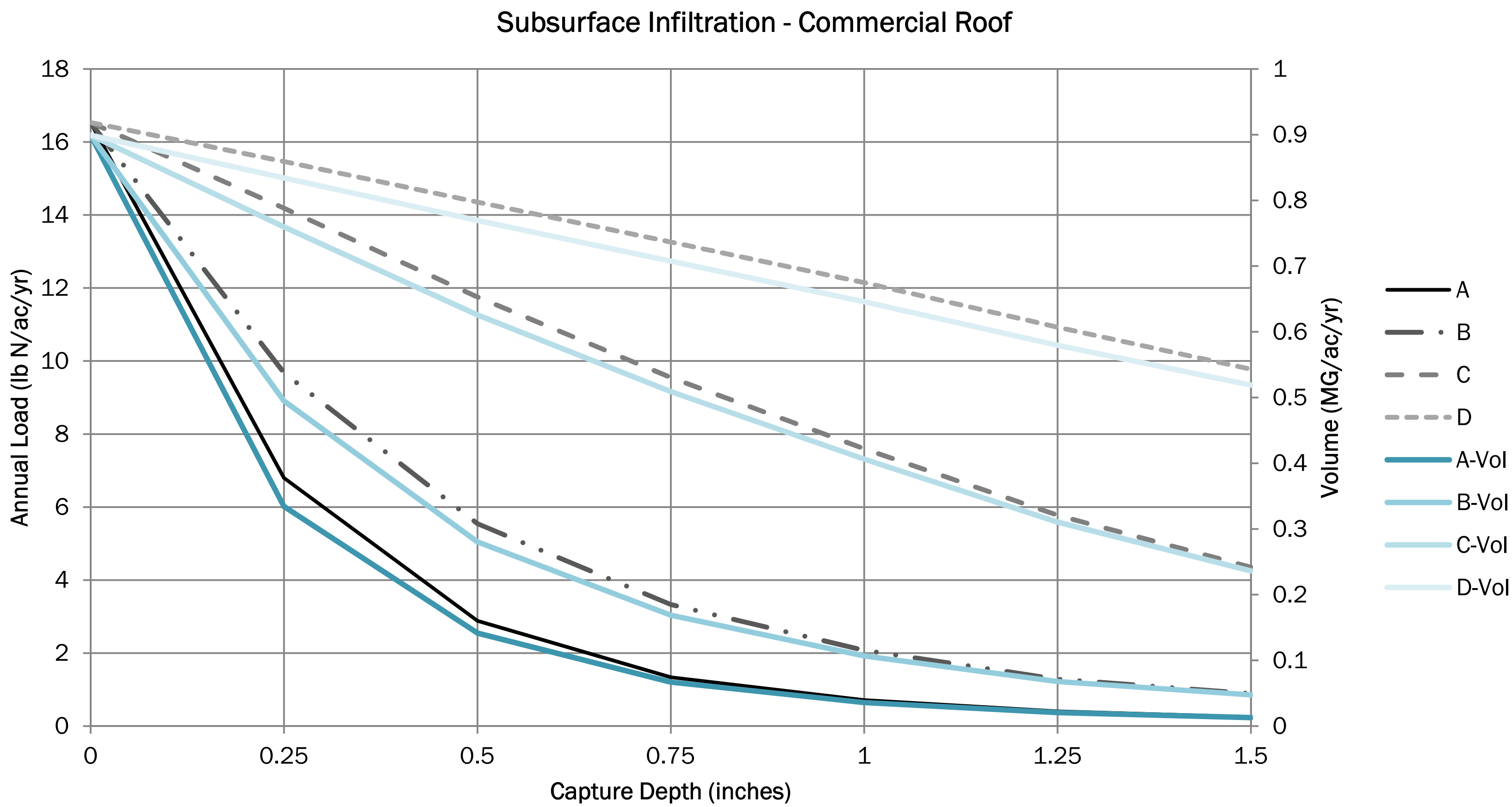
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



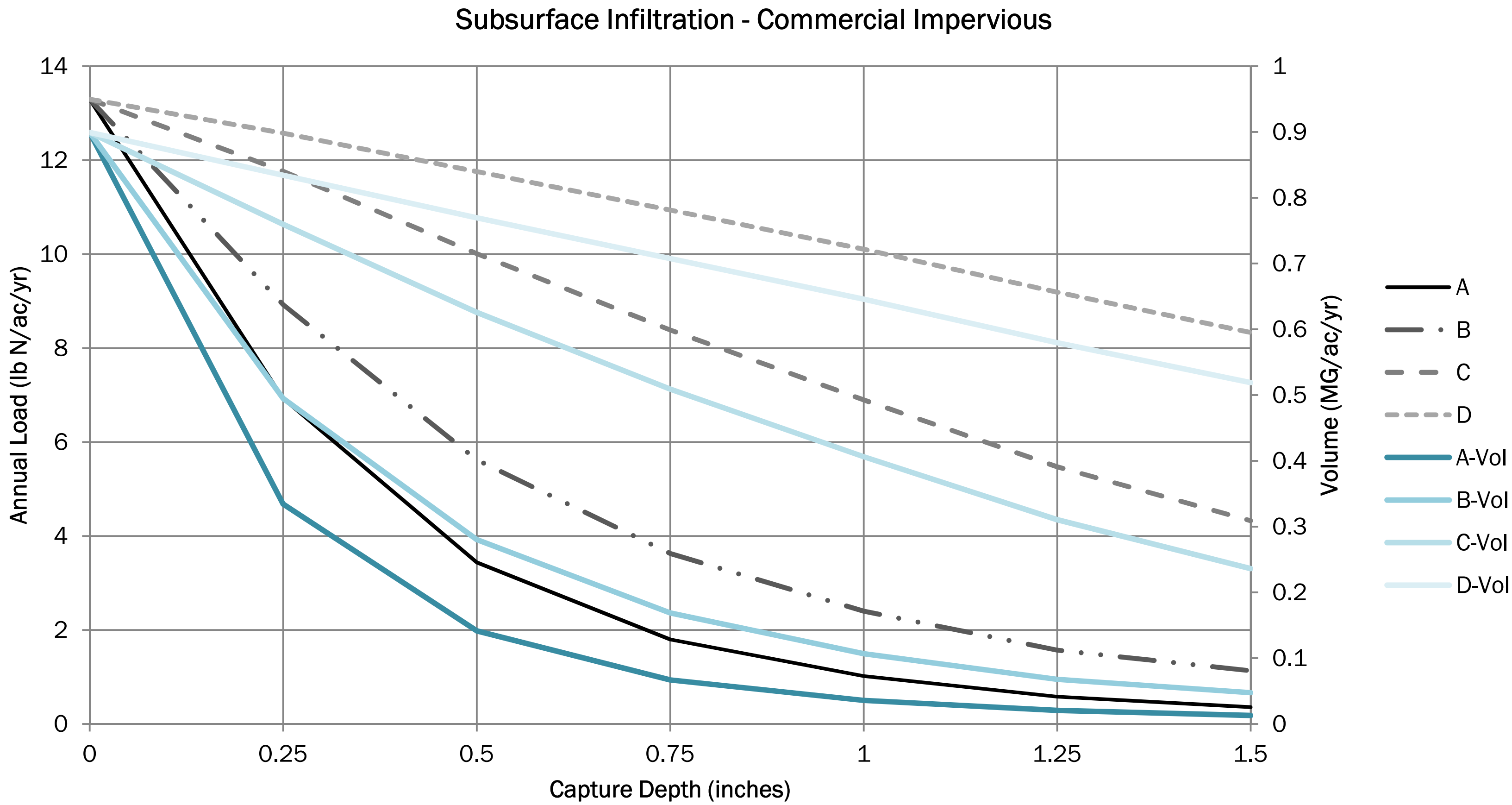
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



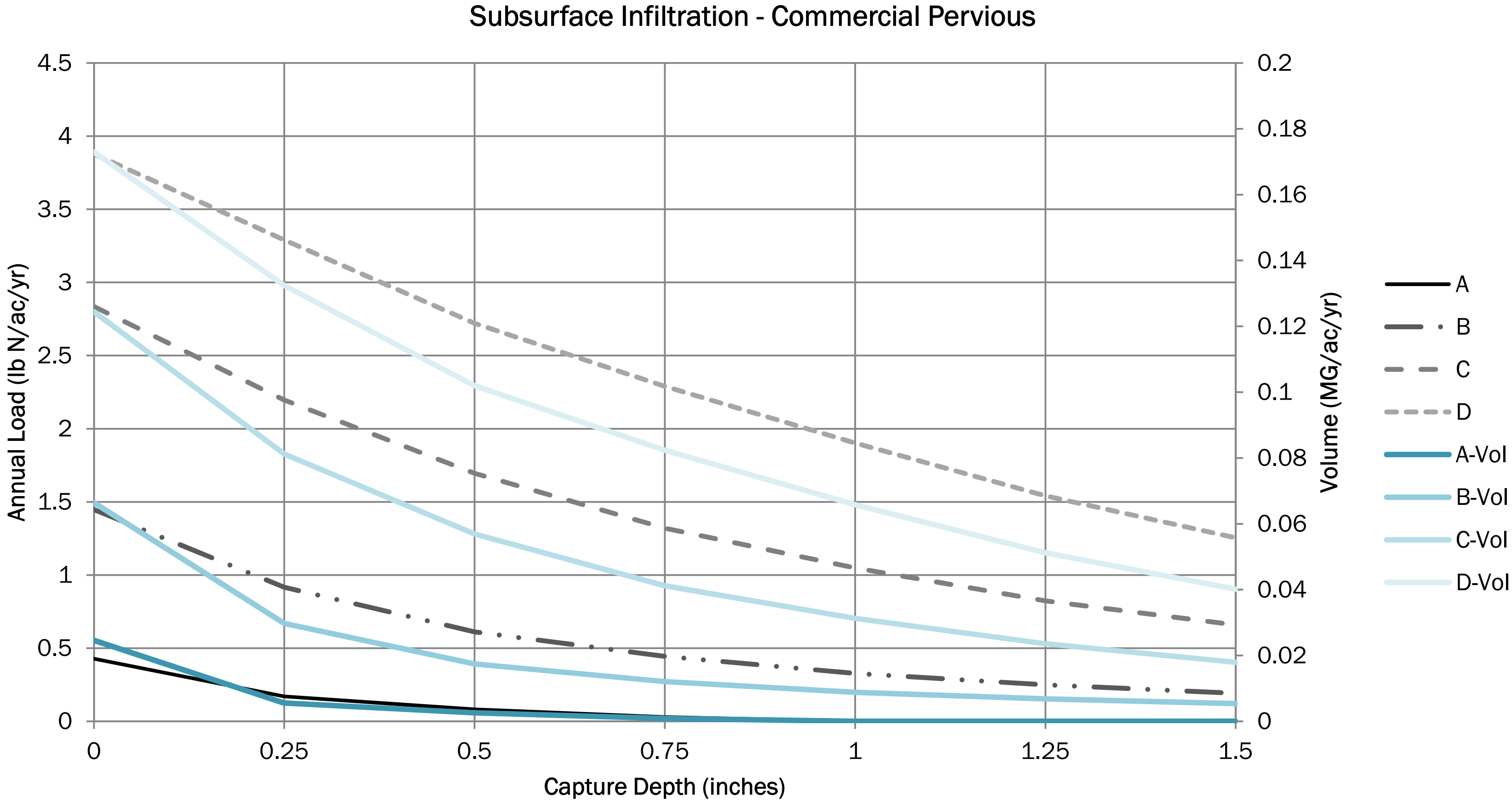
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



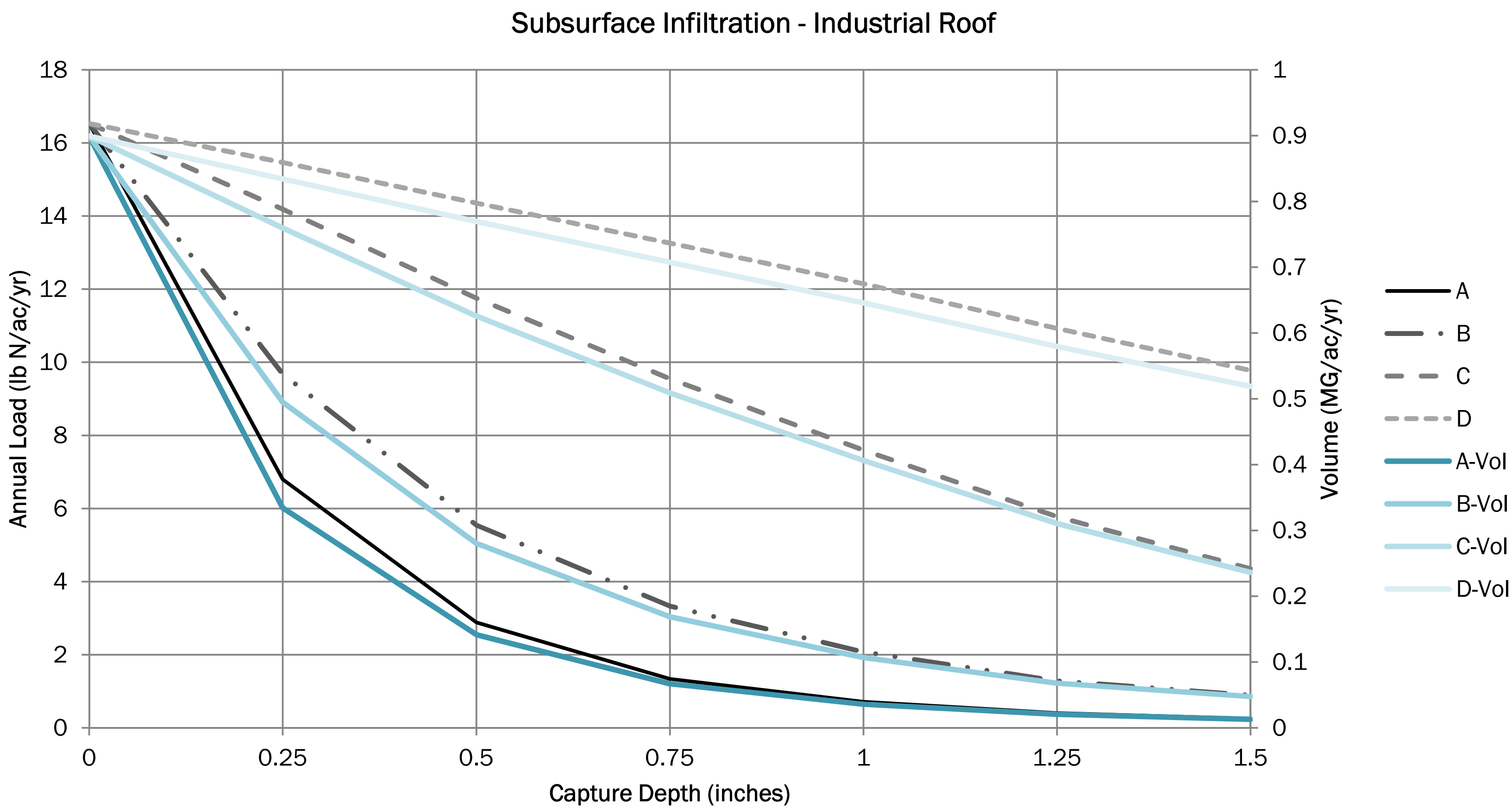
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



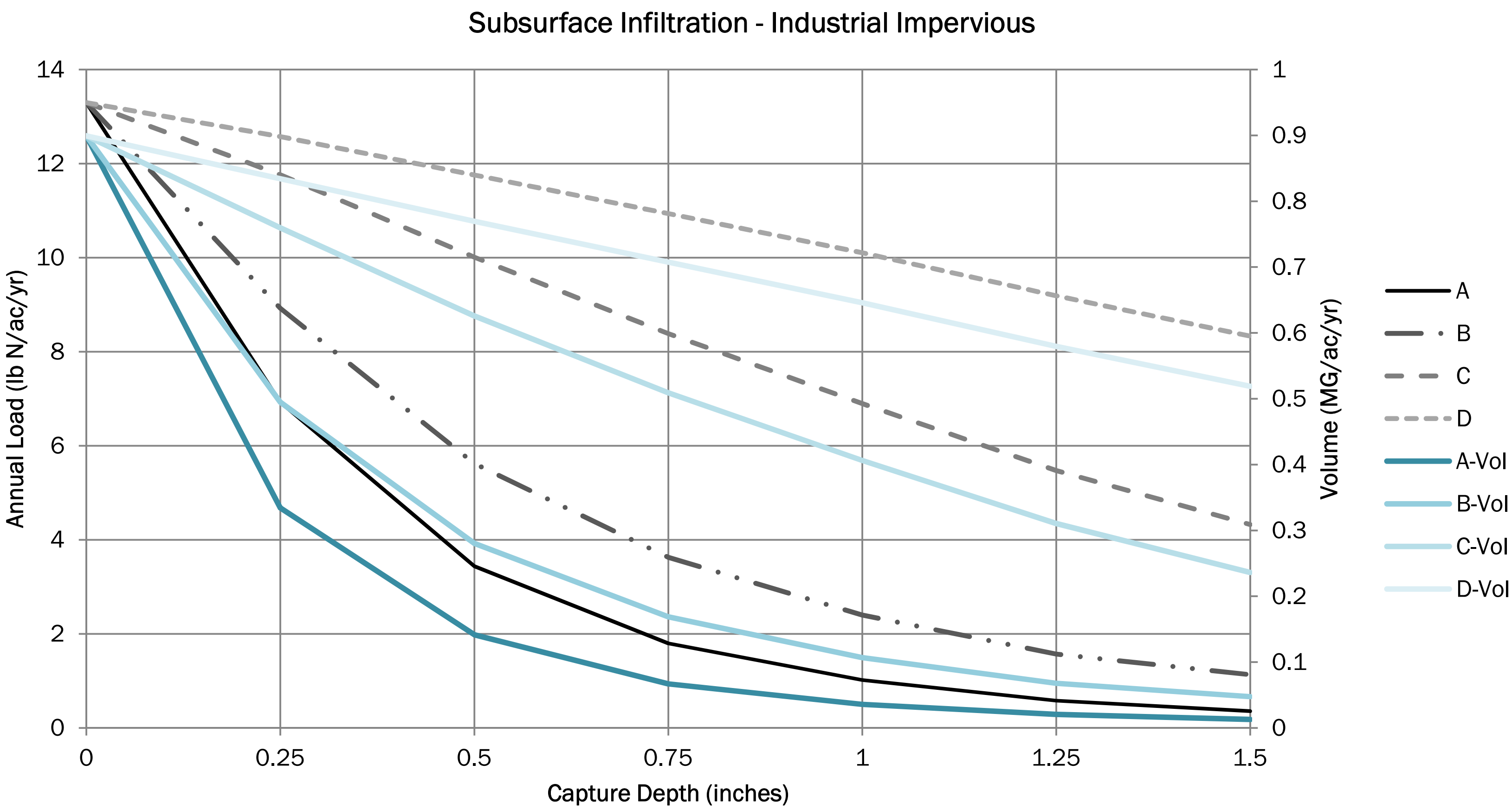
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



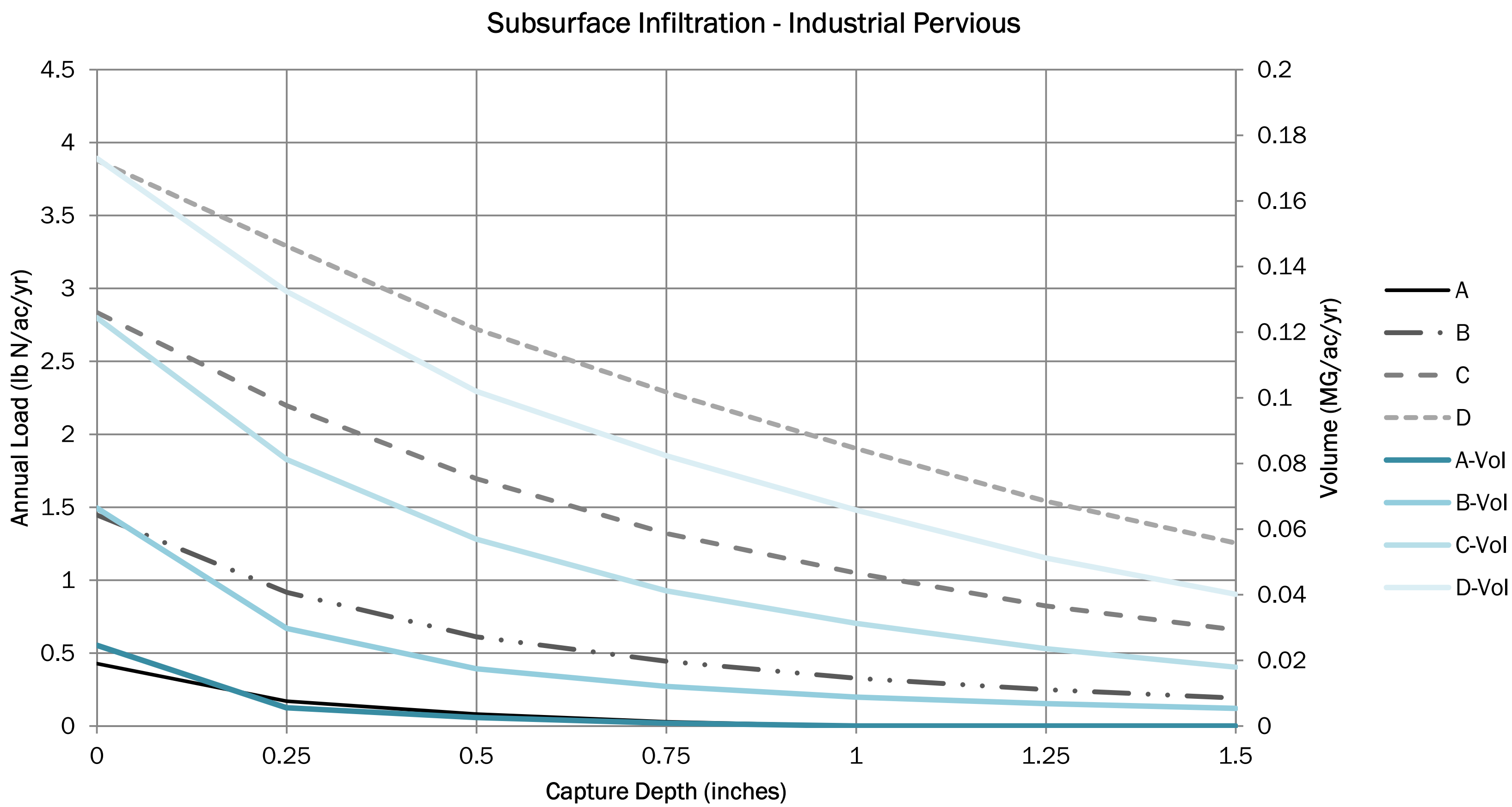
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



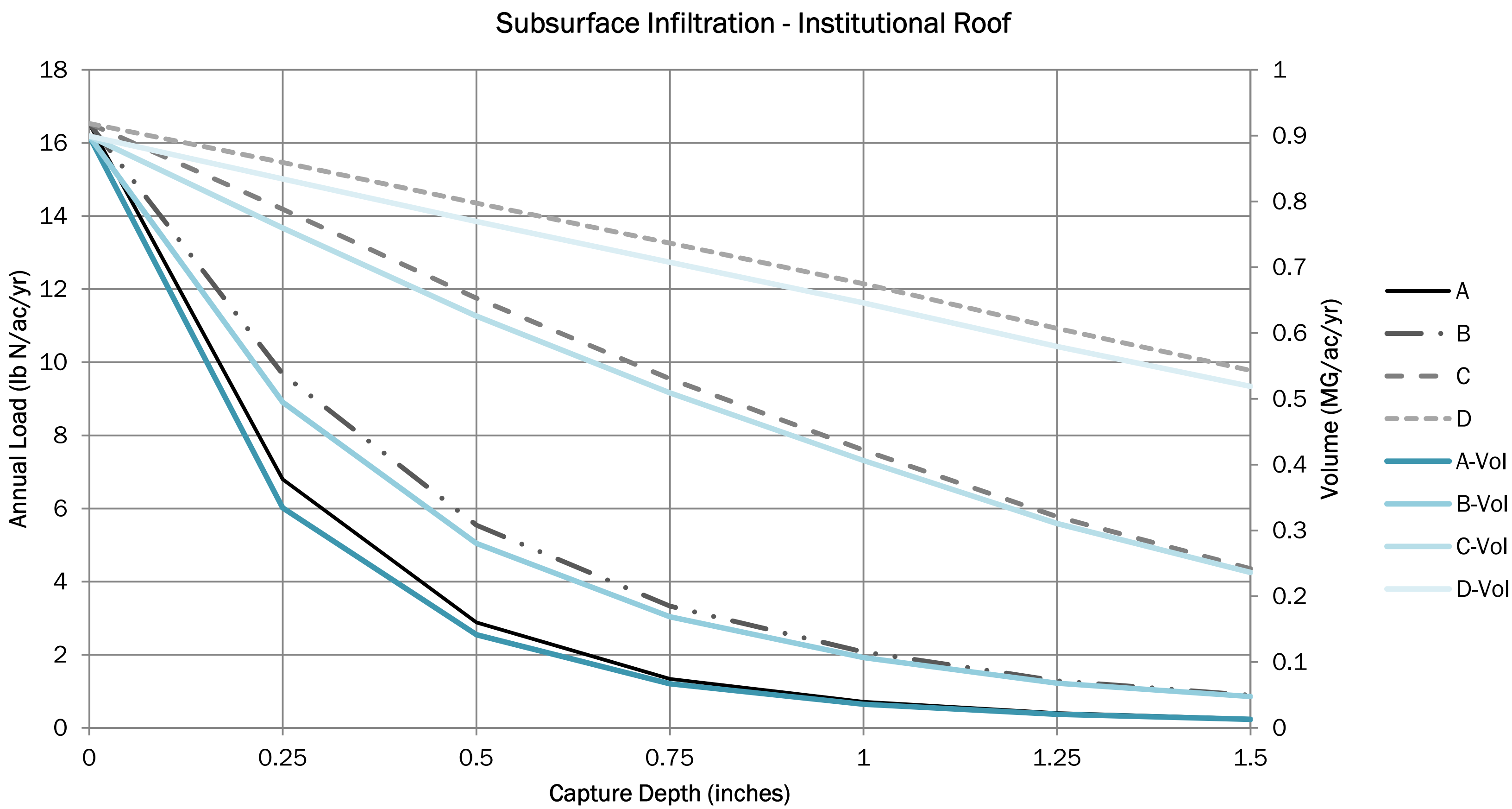
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



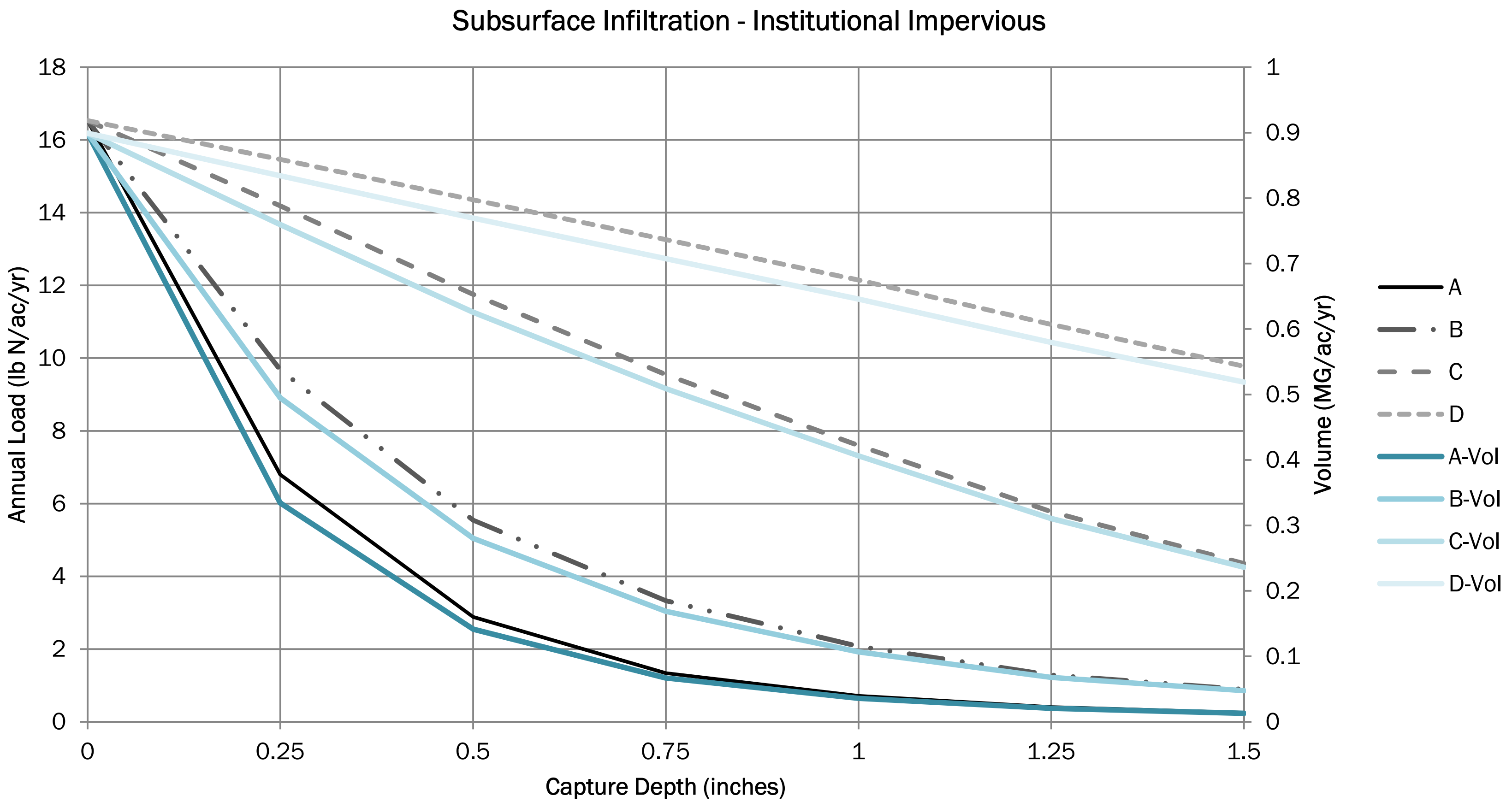
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



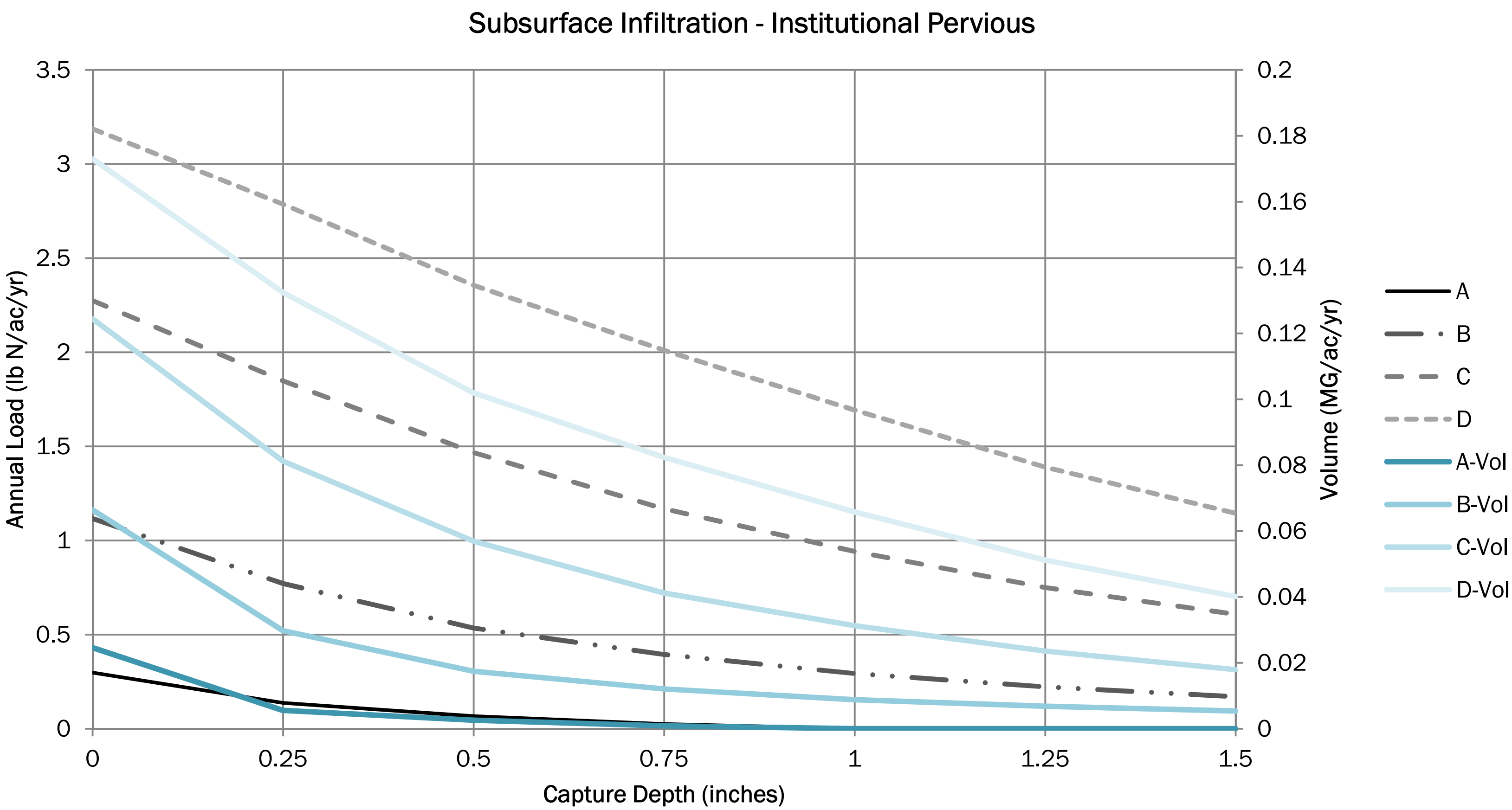
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



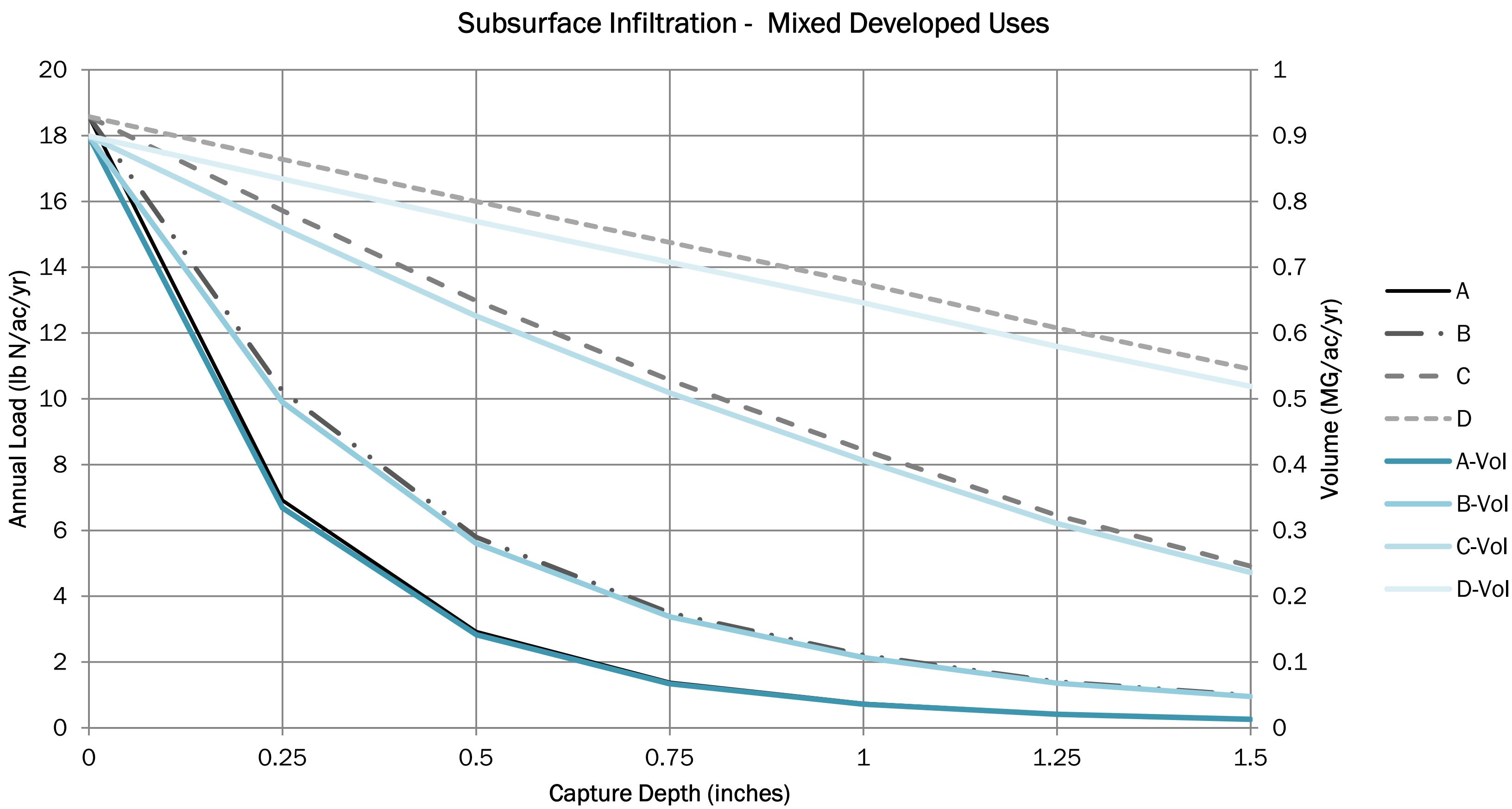
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



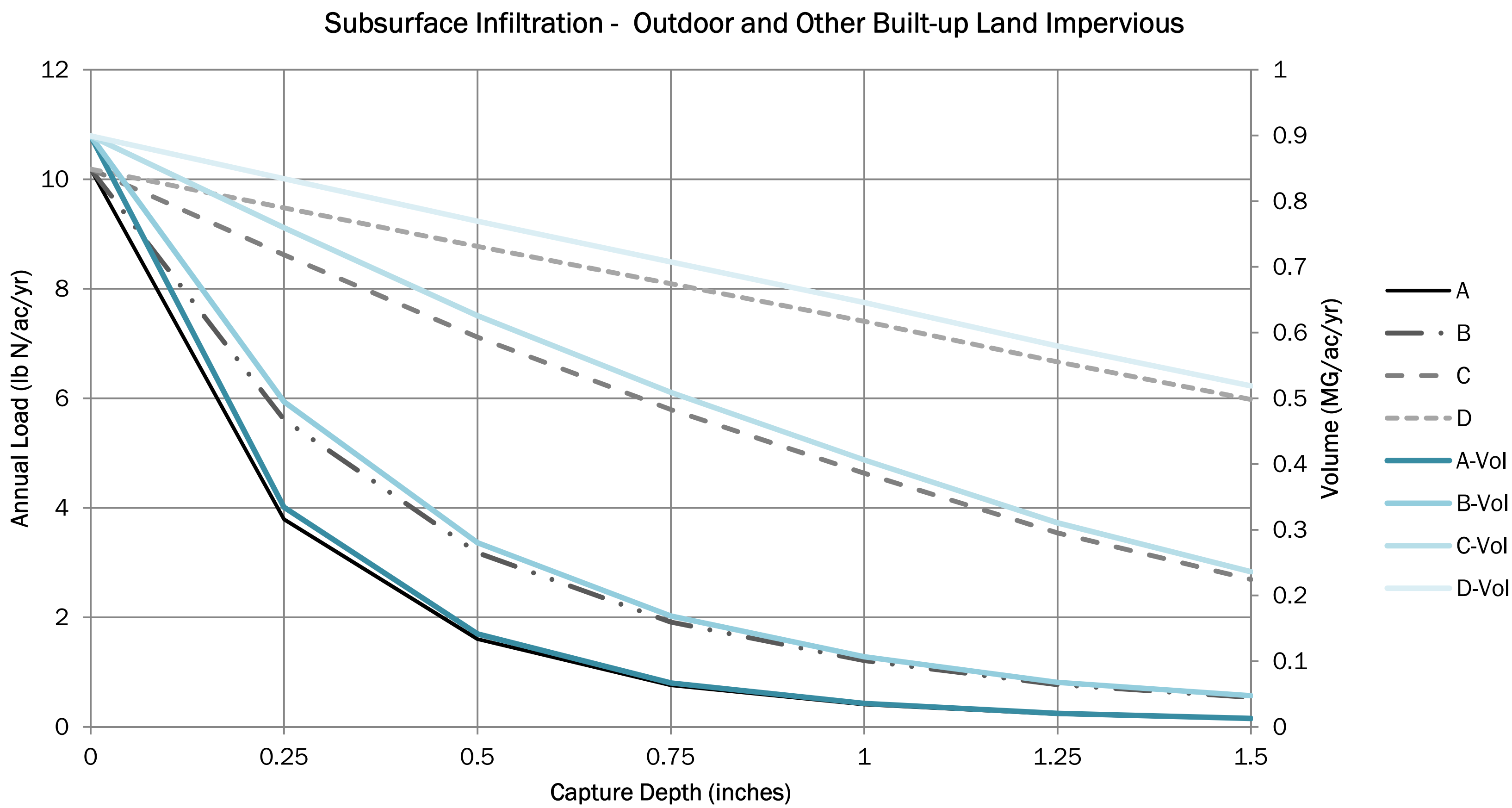
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



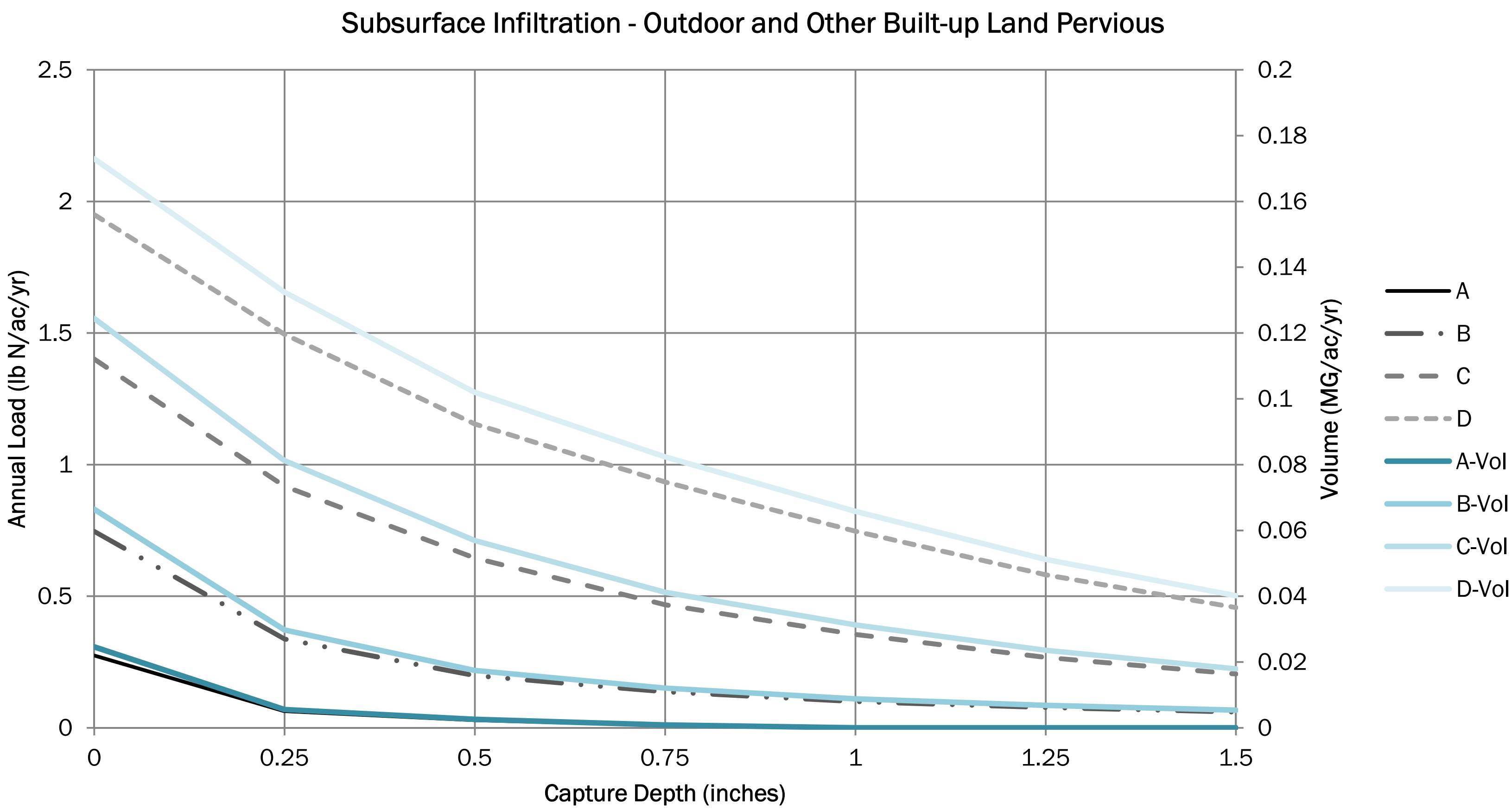
The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.



The above chart depicts the pollutant load export rates (PLERs) from the stated land use with and without the installation of the stated BMP. The PLER of the land use before treatment can be read at the capture depth of 0 inches (i.e. no BMP present). The modified PLER, after treatment from the BMP has occured, is read by reading up from the BMP's capture depth until it intersects the curve.

The four lines on the chart indicate the differing rates of treatment according to the soil in which the BMP is installed (hydrologic soil groups A-D). These lines will differ if the BMP includes an infiltration component, and will overlap if the BMP does not infiltrate.

Appendix D:
Water Quality Monitoring Plan

WISE MONITORING PROGRAM

MONITORING PROGRAM

INTRODUCTION

This monitoring program is a recommended strategy to meet the goals and requirements outlined in the WISE Integrated Plan. The monitoring will meet regulatory requirements for the current Exeter Administrative Order of Consent (AOC) - *Administrative Order on Consent for Exeter, NH*, June 24, 2013 and pending Municipal Separate Storm Sewer System (MS4) permits (*2013 Draft NH Small MS4 General Permit*) for Exeter and Stratham. Additional monitoring is recommended to meet specific goals related to tracking of management measures, load allocation, and targeted locations of interest to residents and managers. The plan includes monitoring of causal nutrient concentration (for nitrogen) and biological response indicators (e.g., algae) along a gradient of anthropogenic stress. Monitoring measures current conditions, and assesses progress towards goals. The monitoring program must have enough resolution to detect changes in water quality and ecosystem indicators, while effectively prioritizing funds and resources to guide cost effective management of restoration and response.

GOALS AND OBJECTIVES

The goal of this monitoring plan is to provide accurate and informative data at spatial and temporal scales that meet regulatory requirements, assure management goals are being attained, evaluate ecosystem condition, and equitably allocate pollutant loads.

Specific objectives are:

- Meet existing and expected regulatory requirements associated with discharge from wastewater treatment plants, and expected requirements under a draft MS4 permit.
- Estimate loads from existing sources to prioritize management strategies, allocate responsibility and validate model.
- Support and improve integrated watershed understanding of human –caused ecosystem impacts and their solutions in the Exeter and Squamscott Rivers and Great Bay.
- Support adaptive management opportunities that help ensure cost-effective and productive management strategies and accountability.
- Support interactive tracking and assessment and potentially provide a framework for “trading” of reduction credits.

MONITORING PROGRAM PLANNING AND DESIGN

RECOMMENDED MONITORING

This Monitoring Program is broken into four main elements:

Element	Management Objective	Permit requirement?
A. MS4 Outfall Monitoring	Identify illicit discharges	MS4
B. WWTF Outfall Monitoring	Determine load from WWTF	Exeter AOC
C. Watershed & Receiving Waters	Measure progress, target management measures	Exeter AOC
D. Ecosystem Indicators	Improve ecosystem understanding	No

Although each element is addressed separately, many of these components overlap; for instance, measuring concentrations in outfalls also guides targeted management measures. Monitoring ecosystem indicators such as macroalgae in Great Bay documents improvements, but also improves our understanding of the ecosystem as a whole.

ELEMENT A. MS4 MONITORING REQUIREMENTS FOR SEWER OUTFALLS

Outfall Monitoring shall be conducted, through sampling and testing, at the frequency and locations required by the Illicit Discharge Detection and Elimination (IDDE) Program. A summary of the sampling guidelines is included here, and a more detailed description of the IDDE program is included in Appendix B.

IDDE screening shall include collection of grab samples and analysis of said samples for E. coli (for freshwater receiving waters) or enterococcus (for saline or brackish receiving waters). Bacteria analysis shall be conducted using the analytical methods found in 40 CFR §136, or alternative methods approved by EPA in accordance with the procedures in 40 CFR §136. Other IDDE screening parameters shall be considered field screening and are not subject to 40 CFR §136 requirements.

If the discharge is directly into impaired water, or if the discharge is subject to a waste load allocation in an approved Total Maximum Daily Load (TMDL) as indicated in Appendix F of the Draft NH Small MS4 General Permit, grab samples shall be collected concurrently and analyzed for the pollutants identified as the cause of the impairment. The required pollutant analyses in connection with causes of impairment are provided in Appendix G of the Draft NH Small MS4 General Permit.

All monitoring results shall be documented each year in the annual report. The report shall include the date, outfall or interconnection identifier, location, weather conditions at time of sampling, precipitation in previous 48 hours, field screening parameter results, and results of all analyses. The annual report shall include this information as well as data for the current reporting period and for the entire permit period.

Results from any other stormwater or receiving water quality monitoring, or studies conducted during the reporting period, shall also be included in the annual report. If such monitoring or studies were conducted on behalf of the permittee, or if monitoring or studies conducted by other entities were reported to the permittee, a brief description of the type of information gathered or received shall be included in the annual report(s) covering the time period(s) the information was received.

MS4 OUTFALL AND INTERCONNECTION SCREENING AND SAMPLING

The Draft MS4 Permit requires stormwater outfall monitoring under an Illicit Discharge Detection and Elimination (IDDE) program. The IDDE program must include a written procedure for screening and sampling of outfalls and interconnections from the MS4 in dry and wet weather for evidence of illicit discharges and sanitary sewer overflows (SSOs). This screening procedure shall be used for:

- Baseline outfall and interconnection screening
- Confirmatory screenings
- Follow-up screening

Dry weather screening and sampling shall be conducted at every MS4 outfall and interconnection when no more than 0.1 inches of rainfall has occurred in the previous 24-hour period. When a flow is observed, a sample of the flow shall be collected and analyzed, at a minimum, for ammonia, chlorine, conductivity, salinity, *E. coli* (freshwater receiving water) or enterococcus (saline or brackish receiving water), surfactants (such as MBAS), temperature. All analyses with the exception of indicator bacteria can be performed with field test kits or field instrumentation. In addition, where the discharge is directly into an impaired water or is subject to an approved TMDL as indicated in Appendix F of the *Draft NH Small MS4 General Permit*, the sample shall be analyzed for the pollutants identified as the cause of the impairment as specified in Appendix G of the *Draft NH Small MS4 General Permit.*

Wet weather screening and sampling shall proceed during or after a storm event of sufficient depth or intensity to produce a stormwater discharge but only during the spring (March to June) when groundwater levels are relatively high. The permit does not require a minimum rainfall event prior to wet weather screening. However, the purpose of wet weather screening and sampling under the IDDE program is to identify illicit discharges that may activate or become evident during wet weather. Permittees may incorporate provisions that assist in targeting such discharges, including avoiding sampling during the initial period of discharge ("first flush") and/or identifying minimum storm event intensities likely to trigger sanitary sewer interconnections.

Catchments sampling shall be conducted where there is relevant information indicating sewer input to the MS4 or sampling results where ammonia ≥ 0.5 mg/l, surfactants ≥ 0.25 mg/l, and bacteria levels greater than the water quality criteria applicable to the receiving water (or alternatively, ammonia ≥ 0.5 mg/l, surfactants ≥ 0.25 mg/l, and detectable levels of chlorine) shall be considered highly likely to contain illicit discharges from sanitary sources, and such catchments shall be ranked at the top of the High Priority Catchments category for investigation.

Confirmatory Screenings. When the source of an illicit discharge or SSO is identified and confirmed, the permittee shall exercise its authority as necessary to require its removal. Within one year of removal of all identified illicit discharge and SSO sources, confirmatory outfall or interconnection screening shall be conducted. The confirmatory screening shall be conducted in dry weather unless System Vulnerability Factors have been identified in the catchment in which case both dry weather and wet weather confirmatory screening shall be conducted.

Follow up Screening. Upon completion of catchment investigation and illicit discharge removal and confirmation (if necessary), the catchment outfall or interconnection shall be scheduled for follow-up screening within five years, or sooner as determined by the permittee based on the catchment's illicit discharge priority. Follow-up screening shall consist of dry weather screening. Wet weather screening and sampling may also be required (see Catchment Investigation Procedure).

ELEMENT B. EFFLUENT MONITORING REQUIREMENTS FOR THE EXETER WASTEWATER TREATMENT FACILITY

The permit contains specific requirements for effluent monitoring, and broader requirements for demonstrating progress towards water quality goals. Effluent monitoring is ongoing over the life of the permit, and contains clearly defined discharge criteria. Demonstration of progress will require a combination of monitoring and tracking as discussed under Element C.

Effluent monitoring shall be conducted from March 1, 2013 until June 30, 2019 or until 12 months after substantial completion of the Exeter Wastewater Treatment Facility (WWTF) (whichever is sooner), the Town of Exeter must comply with the interim total nitrogen effluent limitations and monitoring requirements outlined in Table 1. Table 1 requires weekly sampling, but does not specify a maximum concentration. After June 30, 2019 (or 12 months after completion of construction), the average monthly effluent concentrations may not exceed 8mg/l between April 1 and October 31 as outlined in Table 2.

The interim effluent limit of 8mg/l will remain in effect until either the Town submits an engineering evaluation justifying continuation of the interim or an alternate limit, OR until the EPA determines that milestones set forth in the AOC are not being met.

Table 1: Interim Effluent Limits and Monitoring Requirements from 3/1/2013 until 6/30/2019

	Mass		**Concentration**			
	Average Monthly (lbs/day)	Daily Max (lbs/day)	Average Monthly (mg/l)	Daily Max (mg/l)	Frequency	Type
Total Nitrogen*	Report	Report	Report	Report	1/week	24-hour composite

** Total Nitrogen shall be calculated by adding the total kjeldahl nitrogen (TKN) to the total nitrate (N03-N) and nitrite (N02-N).*

Table 2: Interim Effluent Limits and Monitoring Requirements after 6/30/2019

	Mass		**Concentration**			
	Average Monthly (lbs/day)	Daily Max (lbs/day)	Average Monthly (mg/l)	Daily Max (mg/l)	Frequency	Type
Total Nitrogen* Nov - March	Report	Report	Report	Report	1/week	24-hour composite
Total Nitrogen* April - October	Report	Report	8 mg/l**	Report	1/week	24-hour composite

**Total Nitrogen shall be calculated by adding the total kjeldahl nitrogen (TKN) to the total nitrate (N03-N) and nitrite (N02-N). The operation of the treatment facility for the removal of total nitrogen shall be optimized during the period but not requiring methanol or other carbon addition. **Calculated on a 214 day seasonal rolling average.*

ELEMENT C. WATERSHED AND RECEIVING WATERS

This element includes Exeter AOC Monitoring Requirements to document progress. The Town must evaluate and document progress towards water quality goals and non-point source reduction. Non-point source reduction will be documented, and may be monitored at key locations to demonstrate the success of management measures (e.g. stormwater control, septic upgrades, buffer implementation etc.). Water quality improvement in the tidal Squamscott and the downstream waters of the Great Bay will be monitored in the River, and as part of a collaborative monitoring program with other Great Bay communities.

By December 31, 2023, the Town must submit an engineering evaluation that includes recommendations for the implementation of any additional measures necessary to achieve compliance with the NPDES Permit, or a justification for leaving the interim discharge limit at 8mg/l, or justify an effluent limit at a level between 8mg/l and 3.0 mg/l. Such justification shall analyze whether:

a) Total nitrogen concentrations in the Squamscott River and downstream waters are trending towards nitrogen targets;
b) Significant improvements in dissolved oxygen, chlorophyll a, and macroalgae levels have been documented; and
c) Non-point source and storm water point source reductions achieved are trending towards allocation targets and appropriate mechanisms are in place to ensure continued progress.

Criteria (c) 'Non-point source and storm water point source reductions' will primarily be documented through tracking, but should be confirmed with monitoring at appropriate checkpoint stations on a subwatershed or catchment scale (Table 3a), while criteria (a) and (b) require monitoring in the Squamscott River and Great Bay. The AOC does not specify locations or frequency for monitoring, but documentation of progress will require baseline measurements prior to WWTF construction. The following table summarizes recommended minimum monitoring to establish baseline conditions and measure progress in the Squamscott River and the Great Bay.

REGIONAL MONITORING COLLABORATIVE

The recommended monitoring approach encompasses a range of scales, methods and equipment, and effective implementation will require trained personnel and adequate resources. Much of this monitoring could be completed under a regional program, which would deliver reliable and consistent data for communities, agencies and other stakeholders in the region. The Piscataqua Region Monitoring Collaborative will allow communities, agencies, and organizations to combine their resources for the collaborative monitoring of the region. Dozens of communities surrounding the Piscataqua Region estuaries have a common interest in the health of their estuaries and watersheds. These shared questions are best answered with a shared monitoring program. Benefits of participating in a regional monitoring program approach include:

- Take advantage of cost sharing between local, state, and federal agencies.
- Have a role in deciding monitoring priorities and methods.
- Establish a baseline now to show progress in the future.
- Sharing trained personnel and resources

The costs estimated in Table 3 have been developed assuming participation in a Piscataqua Region Monitoring Collaborative. The Collaborative will build on existing monitoring programs, and will leverage existing funds and resources from NH Department of Environmental Services (NHDES), the Piscataqua Region Estuaries Project (PREP), Great Bay National Estuarine Research reserve (NERR), University of New Hampshire (UNH), US Environmental Protection Agency (EPA) and others. A more detailed description of the Great Bay Collaborative Monitoring Program is included in Appendix A. Monthly water quality monitoring would be coordinated with the existing Volunteer Rivers Monitoring Assessment Program (VRAP) and UNH Water Resources Research Center.

At the end of each year, all data collected by the Monitoring Collaborative programs will be quality assured by PREP or NHDES, using a standardized process, and reported to the partners in a data report.

The monitoring data will be interpreted by PREP every three years in the State of Our Estuaries report. If partners require more detailed assessments of the data, they may establish a contract with PREP or another contractor for those additional services.

The DES Environmental Monitoring Database will be the central repository for all water quality measurements and observations. Geospatial data such as maps of eelgrass and salt marsh will be shared through the NH GRANIT GIS Clearinghouse. The Monitoring Collaborative partners may also chose to fund the development of a “Great Bay Data” portal to facilitate data access by partners and the public.

All programs operating under the Monitoring Collaborative will follow standardized methods that are documented in a Quality Assurance Project Plan or equivalent document. UNH laboratories will be used for water quality analyses, whenever possible, in order to maintain data continuity and consistency.

Table 3a: Recommended monitoring stations and analyses to meet AOC requirements in the River and Watershed

Focus Area	Management Question(s)	Location	Annual Cost[1]	Cost by Population[2] Exeter 64%	Stratham 28%	Newfields 8%
I - Squamscott River	(a) Total Nitrogen concentrations in the **river** and downstream waters are trending toward nitrogen targets. (b) Significant improvements in dissolved **oxygen, chlorophyll-a**, and macroalgae levels have been documented.	1 station in the Squamscott below Exeter WWTF monitored 1 xMonth (falling tide) for nutrients, TSS, and chlorophyll-a[3]. 1 station in the Squamscott below Exeter WWTF discharge monitored continuously for dissolved oxygen with datasonde	**$29,000**	$18,560	$8,120	$2,320
II- Exeter/ Squamscott Watershed	(c) Non-point source and stormwater point source reductions achieved are trending towards allocation targets and appropriate mechanisms are in place to ensure continued progress.	3 stations in watershed monitored monthly for nutrients, TSS, and chlorophyll-a. 3 stations monitored continuously for water level.	**$12,000** **$1,500**	$7,680 $960	$3,360 $420	$960 $120
			$42,500	**$27,200**	**$11,900**	**$3,400**

Notes: [1]*All costs are estimated; actual costs will depend on details of the selected program including the number of samples collected, purchase price of equipment and selected subcontractor. Personnel and analytic costs are based on expanding existing UNH and NHDES programs. Costs assume that equipment purchase price will be amortized over 5 years (purchase price = $15,000 for Squamscott data sonde, $500 each for three watershed water level loggers).*

[2]*Population based on 2010 census data: Exeter has a population of 14,306; Stratham 6,533; Newfields 1,680.*

[3]*Grab sample analyses include nitrate (NO3), nitrite (NO2), ammonium (NH4), phosphate (PO4), silica (SiO2), total dissolved nitrogen (TDN), dissolved organic carbon (DOC), total dissolved nitrogen and organic carbon (TDN+DOC), particulate organic carbon and nitrogen (POC/PON), total suspended solids (TSS), and Chlorophyll-a.*

Table 3b: Recommended monitoring to meet AOC requirements in downstream waters (Great Bay)

Focus Area	Management Question(s)	Location	Annual Cost
III. Great Bay	(a) Total Nitrogen concentrations in the river and **downstream waters** are trending toward nitrogen targets. (b) Significant improvements in dissolved oxygen, chlorophyll-a, and macroalgae levels have been documented.	Town contribution to Piscataqua Region Monitoring Collaborative: eelgrass, macroalgae, saltmarsh, and water quality monitoring in Great Bay and Little Bay assuming multiple partners share the total cost ($50-$100,000).	Up to $10,000

The scope of services provided by the Piscataqua Region Monitoring Collaborative will depend on the amount of funding contributed by municipal partners. Contributing partners will work with the project partners (PREP and NHDES) to establish priorities based on available funding. The amount of funding communities contribute to this effort will depend on resources, level of interest, and regulatory requirements.

MONITORING LOCATIONS

Focus Area I. Squamscott River involves both monthly grab sampling and long-term installation of a datasonde in the Squamscott River. The recommended location is at the Route 101 bridge, just downstream of the WWTF. Previous monitoring at this location found high levels of chlorophyll-a, and fluctuating oxygen levels, apparently related to effluent discharge from the plant (Hydroqual, 2012). Monitoring here will establish the pre-upgrade baseline and document the anticipated improvements in water quality associated with upgrades to the facility. Monitoring at this location provides crucial information about the impact of the existing facility on the tidal river.

Focus Area II. Exeter/Squamscott Watershed requires measurements at selected locations within the watershed to meet management objectives. These objectives include tracking progress, as required in the AOC permit, but watershed scale improvements are unlikely to be detected in time frames of less than several years, and possibly decades. More immediate objectives are to quantify loads into the system, and identify opportunities for targeted management measures. Potential monitoring locations are listed in Table 4. These locations were selected by the WISE team, including municipal representatives, to meet permit requirements, or to answer specific management questions. Several of the identified sites are currently sampled under the VRAP program. VRAP sampling does not always include nutrients, but could be augmented for inclusion in this program. Recommended sampling locations and existing sampling programs are shown in Figure 1.

Table 4: Watershed Monitoring Locations – Recommended priority locations are in Bold.

Focus Area and Locations	Management Question - Unless otherwise noted, monitoring will provide data to 1) estimate loads from the target stream, and 2) provide baseline data to measure the effectiveness of management actions.
A. Newfields Stream	**Measure water quality and pollutant loads associated with DOT staging area and potentially high impact business on septic (day care and vet).**
B. Mill Brook (Stratham)	Water quality impacts/improvements associated with agriculture and BMPs
C. Parkman Brook (Stratham)	**Water quality impacts from Commercial on Septic**
D. Exeter Downtown Waterfront (outfalls)	Measure load from urban outfalls and runoff, detect hotspots, illicit sources
E. Watson/Norris Brook (Exeter)	**Commercial and residential development**
F. Deerborn Brook (Exeter)	Water quality entering, or in, drinking water reservoir
G. Great Brook (Exeter/Kensington)	Agricultural inputs
H. Brickyard Pond (Exeter)	Measure water quality in recreational pond, potential to measure improvements from localized non-point reduction
I. Pickpocket Dam (Upstream boundary)	**Measure loads entering the watershed. Augment existing VRAP sampling**

All of these locations would provide important information on pollutant loads and sources, and selected locations will be re-evaluated and adjusted as necessary. Priority locations include:

- **Pickpocket Dam (Brentwood).** Represents an upstream boundary to the watershed, and will quantify the load entering the Exeter/Squamscott from upstream communities.
- **Watson/Norris Brook**. Represents an area of mixed commercial and residential development, presents a location for measuring inputs from septic, and management opportunities.

- **Parkman Brook.** Commercial business on septic may present a management opportunity.
- **Newfields Stream.** Drains a region with commercial on septic that may connect to the wastewater plant. Presents an opportunity to establish baseline prior to a change in condition.

Focus Area III. Great Bay monitoring measures the overall trends in water quality and ecosystems in Great Bay. Great Bay monitoring has been conducted over the past several decades by several agencies including NH DES, PREP, GBNERR and UNH. However, this monitoring program was designed to provide data for research and assessment of the estuarine system: the existing regional monitoring program was not intended to guide management decisions. As the region moves forward with costly wastewater and non-point source control measures, a deeper understanding of the ecosystem stressors and interactions will guide effective measures that lead to tangible improvements in water quality, and ultimately, to removal of the impairment listing. The sampling methods and locations include nitrogen, dissolved oxygen, marcoalgae and eelgrass. The exact methods and locations will depend on the number of partners and funding available to the monitoring collaborative.

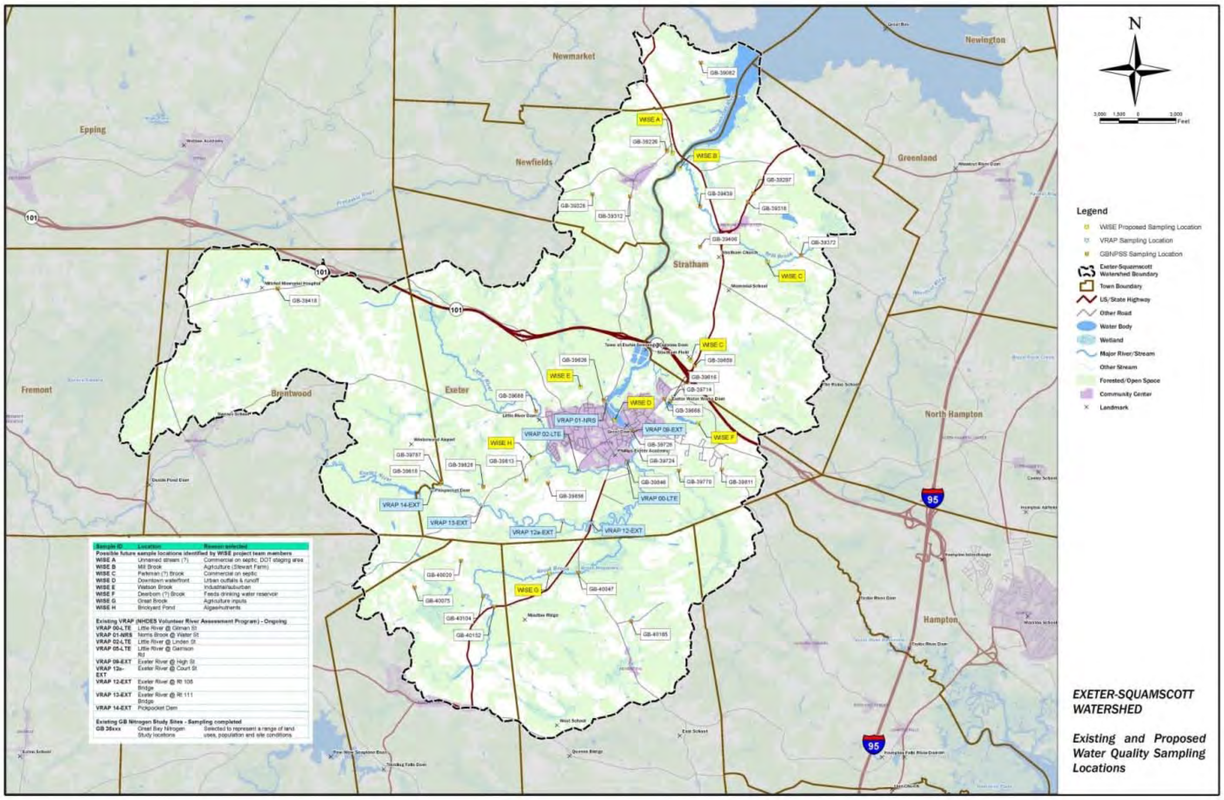


Figure 1. WISE recommended sampling locations, and existing sampling program locactions. In cases where the recommended and existing programs overlap, coordination bewteen the programs will reduce costs and increase effectivness.

D - ECOLOGICAL INDICATORS – PILOT PROGRAM

The WISE project is funding a pilot program that addresses one of the central questions related to nutrients and water quality in the Region: The relationship between nutrient concentrations and algae growth. The project team sampled algae abundance and species at locations within the watershed and Great Bay to evaluate an broad ecological indicator under a range of conditions. Ecological indicators add value, and more certainty of outcome, to water management strategies. Just as the bathroom scale shows that meeting caloric intake targets has had the desired effect, ecological indicators show that nutrient reductions have the desired ecosystem response. Further, monitoring of living indicators along with a related suite of chemical and physical attributes can:

- Identify emerging habitat and water quality impairments
- Grow understanding of physical, chemical and biological processes to link cause and effect and support more targeted and effective management
- Identify ways to protect and restore vital ecosystem services that proactively allow and demonstrate that communities are meeting legal environmental obligations and all incumbent social and economic benefits
- Identify the potential for restoration so reasonable and effective management targets and strategies can be constructed

While most ecosystem indicator monitoring using ecological indicators is the charge of state and federal agencies, it is in the best interest of regulated entities to support and even participate in this important monitoring. Ecological endpoints are more likely to capture the effects of other stressors in addition to the targeted pollutant, such as temperature or even natural effects, alerting local communities to alternative or concurrent management solutions that will solve the problem. The use of attached algae is proposed and detailed below. As an indicator it has benefits of being a robust indicator of ecosystem integrity; sensitive to nutrient enrichment; adaptable to stream and estuarine habitats; complementary to chemical and physical monitoring; and responsive to proximate sources to reduce uncertainty of cause and effect.

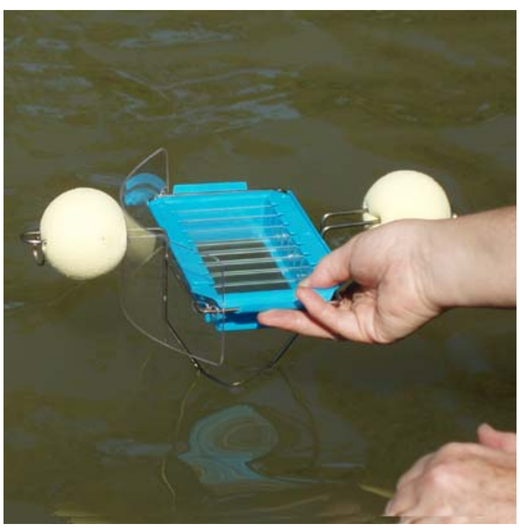
Attached Algae Indicator

Single-cell and filamentous attached algae, often collectively referred to as periphyton, are simple to collect and are responsive to environmental change, especially nutrients. Both the amount and type of the attached algae communities, especially diatoms, respond to increasing nutrient enrichment in a range of aquatic environments from fresh headwaters to saline estuaries. While the attached algal community composition does change naturally in response to these natural habitat changes such as salinity and temperature, they tend to be diverse and adapted to the prevailing conditions. When attached algae community structure is assessed using statistical indices of community integrity, values are high for each habitat under clean conditions; when stressors such as over enrichment with nutrients occur, those indices fall. Because they are prevalent, diverse and sensitive to stressors, they make ideal indicators of change in a variety of habitats.

Methods: Collecting and Analyzing Attached Algae

Glass microscope slides are a preferred substrate for attached algae growth. Several slides are placed in a floating rack that controls some variables such as current and light exposure, and provides a smooth, consistent substrate for growth of both diatoms, and non-diatom algae. After about a two week exposure, which integrates effects of variable environmental conditions included nutrient loading conditions, the slides are removed and prepared for analyses, which will include species identification and counts, algal biomass, chlorophyll-a, and pigment characterization analyses. When paired with water chemistry, meteorology, stream flow, temperature, and other relevant parameters, the changes in algal community diversity can be related to natural and anthropogenic conditions and decisions about management actions can be supported. While it is not always possible to isolate and attribute the contributed effects of single pollutants, water quality and habitat differences among stations yield clues to link stressors with effect. Placement of stations above and below presumed stressors, such as a sewage treatment plant effluent, a farm or an area of development, provide demonstrable evidence of cause and effect in many cases.

Figure 2. Attached algae sampling



Locations for Piloting Attached Algae Monitoring

Algae monitoring must be paired with water quality data, and where appropriate, the sampling stations will be co-located with existing or planned monitoring stations. Sampling could be conducted at the watershed locations selected from Table 3, and at existing National Estuarine Research Reserve System-wide Monitoring Program (SWMP) stations including the Squamscott River near the railroad bridge.

Resources permitting, additional stations may be added in a clean reference and/or headwater areas, above significant sources as well as below (such as the Exeter treatment plant discharge) to quantify the effect of the source.

Sampling Frequency and Schedule

For this pilot program, 2-week exposures are implemented at each site in June and September, 2014. Additional samples were collected in 2015 under a separate program. Protocols for sampling and deployment will follow those used by Maine DEP (Danielson, 2009), New Jersey Department of Environmental Protection (Ponader and Charles, 2005) and the USGS National Water Quality Assessment Program (NAWQA) (Carlisle et al., 2013; Charles, Knowles and Davis, 2002). Ancillary chemistry should include, at a minimum, the full suite of nutrient (nitrogen and phosphorus) species, turbidity, dissolved oxygen (DO), conductivity/salinity, temperature, stream flow, and chlorophyll-a at the time of deployment and retrieval of the glass slide substrates.

Attached Algae Analyses

The primary attached algae data included taxonomy – species identification and counts of a subsample to determine diversity – and chlorophyll-a. Data analysis will follow protocols developed by the EPA in their Rapid Bioassessment Protocol guidance (Barbour et al., 1999). Innovative analytical procedures have also been devised to look at nutrient enrichment factors and response to attached algae (Porter, 2009; Baker and King, 2010; Becker, 2013).

SCHEDULE

Monitoring for ecosystem indicators began in the Spring of 2014, with installations in June and September, and in July 2015. Watershed, River and supplemental Great Bay monitoring should begin in 2015, and continue into future years. MS4 monitoring will be required under the draft permit that is expected to become effective later in 2015 or 201. AOC effluent monitoring is ongoing, and will continue for the life of the permit.

Figure 2. Monitoring Schedule. Field monitoring pauses during the winter. The Great Bay program will build on existing long term efforts.

Element	Present	Spring 2014	Summer 2014	Fall 2014	2015	2016 and on
MS4					MS4 Issued?	
AOC Outfall	Ongoing					
River		Ongoing				
Watershed		Ongoing				
Great Bay	Ongoing					
Bioindicator Monitoring		June sampling	August sampling	Reporting	June sampling	

PARTNERS

The monitoring program will build on several existing programs, and could be conducted by existing organizations working with the WISE communities to achieve a consistent, robust, and cost effective program which meets both regulatory and management goals. Existing monitoring programs that could be expanded to include the selected monitoring components include:

The Volunteer Rivers Assessment Program (VRAP). VRAP collects grab samples at selected locations throughout New Hampshire, including the Exeter/Squamscott watershed. Several of the watershed sampling locations identified under this plan are, or have been at some time, included in the VRAP program. This program could be expanded with a combination of additional volunteers and funding to collect additional grab samples at specified watershed locations.

The Piscataqua Region Monitoring Collaborative. The Regional Monitoring Collaborative, which is currently being formed, will allow communities, agencies, and organizations to combine their resources for the collaborative monitoring of the region. Dozens of communities surrounding the Piscataqua Region estuaries have a common interest in understanding the health of their estuaries. These shared questions are best answered with a shared monitoring program. Many other organizations will participate in the Monitoring Collaborative by collecting samples, making field measurements, or providing funding and other services, and the funding will be coordinated by PREP. This program currently maintains numerous datasondes in the Bay, and conducts ecosystem monitoring, including eelgrass, macroalgae and salt marsh mapping.

Decisions about the specific monitoring activities for each year will be made collectively by those partners who have committed funds to the Monitoring Collaborative for that year. The monitoring tasks that can be completed will be contingent on the amount of funds committed for the year. Partners will have the flexibility to target their contributions toward specific monitoring tasks or to contract for those services independently. More information on the Collaborative is included in Appendix X.

REFERENCES

Baker, M.E. and R.S. King. 2010. A new method for detecting and interpreting biodiversity and ecological community thresholds. Methods in Ecology and Evolution 1(1):25-37.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002, 2nd Ed. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Becker, M.K. 2013. A scientific decision-based framework to support management of non-conventional water quality pollutants. Thesis, Clark University, Dept. of Env. Science and Policy, Worcester, MA.100 p.

Carlisle, D.M., Meador, M.R., Short, T.M., Tate, C.M., Gurtz, M.E., Bryant, W.L., Falcone, J.A., and Woodside, M.D. 2013. The quality of our Nation's waters—Ecological health in the Nation's streams, 1993–2005. U.S. Geological Survey Circular 1391, 120 p.

Charles, D.F., C. Knowles and R.S. Davis. 2002. Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment program. Report No. 02-06. Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia, PA. 132 p.

Danielson, T.J. 2009. Protocols for sampling algae in wadeable rivers, streams, and freshwater wetlands. Report DEPLW-0634A-2009, Maine Department of Environmental Protection, Augusta. 18 p.

Hydroqual, 2012. Technical Memorandum: Squamscott River August-September 2011 Field Studies.

Ponader, K. and D. Charles. 2005. New Jersey periphyton bioassessment protocol manual. Standard operating procedures: field, lab, analysis. Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia, PA. 131 p.

PILOT PROGRAM RESULTS

Estimates of nitrogen loading were calculated in the model to indicate expected increases in nitrogen loads with downstream distance for the stations from Haigh Rd. to the Squamscott RR Bridge (Table 3). In addition to water quality monitoring, a floating sampling apparatus was deployed for the two surveys for a two week period to monitor attached algae growth on glass microscope slide substrates in response to nutrient enrichment levels. Water chemistry results showed the nitrogen signal of increasing nitrogen loads, most notably a spike in nitrogen concentration at the River Road station on the Squamscott River, just below the Exeter WWTF (**Error! Reference source not found.**) Chlorophyll-a levels in the attached algae growth were more variable, but were generally higher at the more enriched locations, especially the tidal portions at the mouths of the Squamscott, Oyster and Lamprey Rivers where they were deployed at SWMP stations (**Error! Reference source not found.**). Additional taxonomic analyses are underway, and may reveal nutrient effects in changed species composition and diversity levels.

Sampling of macroalgae was conducted on two dates at 10 transects at Sandy Point, near the mouth of the Squamscott River (about 0.5 mi from the Squamscott RR Bridge Station. Measurements of surface coverage of major species were taken 2m and 10 m from the edge of the salt marsh in the inter-tidal zone at low tide. On the second date, all macroalgae were removed from the plots for biomass measurements.

Table 3. Monitoring Station Characteristics

Monitoring Station	Name	Drainage Area (acres)	Septic Load (lb N/yr)	Storm-water Load (lb N/yr)	Ground-water Load (lb N/yr)	Total Load (lb N/yr)
AA-001	Haigh Road	40629.5	66,698	53,934	16,992	137,624
AA-002	Pickpocket	47423.7	75,418	63,405	19,811	158,634
AA-003	Great Brook	5012.4	8,119	8,773	1,858	18,750
AA-004	Little River	10106.2	12,874	17,085	3,983	33,942
AA-005	Gilman	68496.4	94,857	98,500	28,027	221,385
AA-006	High Street	68668.5	94,857	99,222	28,067	222,146
AA-007	Swazey Pkwy	69040.3	94,857	100,730	28,157	223,745
AA-009	River Road	73566.4	101,739	110,579	29,817	242,135
AA-010	Squamscott RR	80442.8	114,897	122,634	32,462	269,993

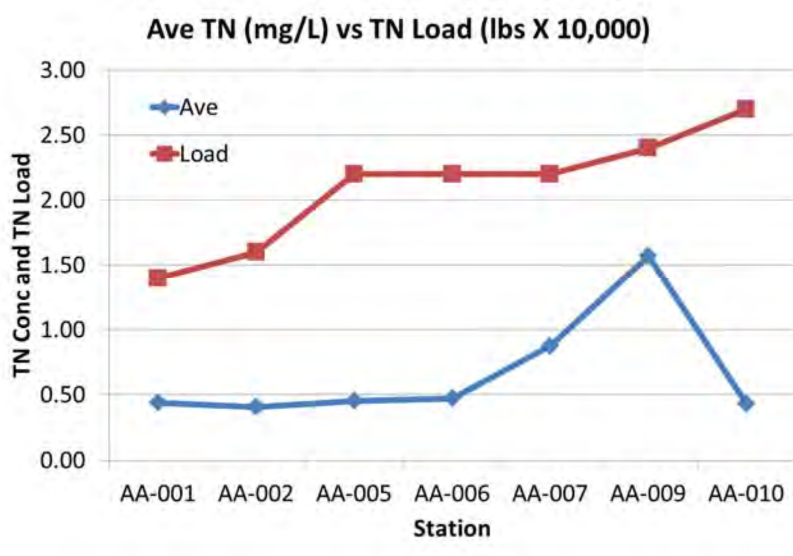


Figure 1. Total Nitrogen Load and Concentration by Station

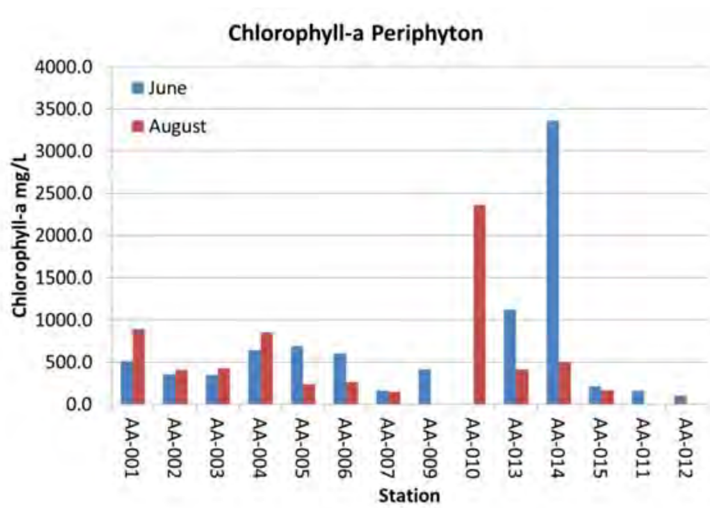


Figure 2. Chlorophyll-a Periphyton Concentration by Station

Appendix E:

Septic System Maps for Exeter, Stratham, and Newfields

Appendix E: Septic System Maps for Exeter, Stratham, and Newfields

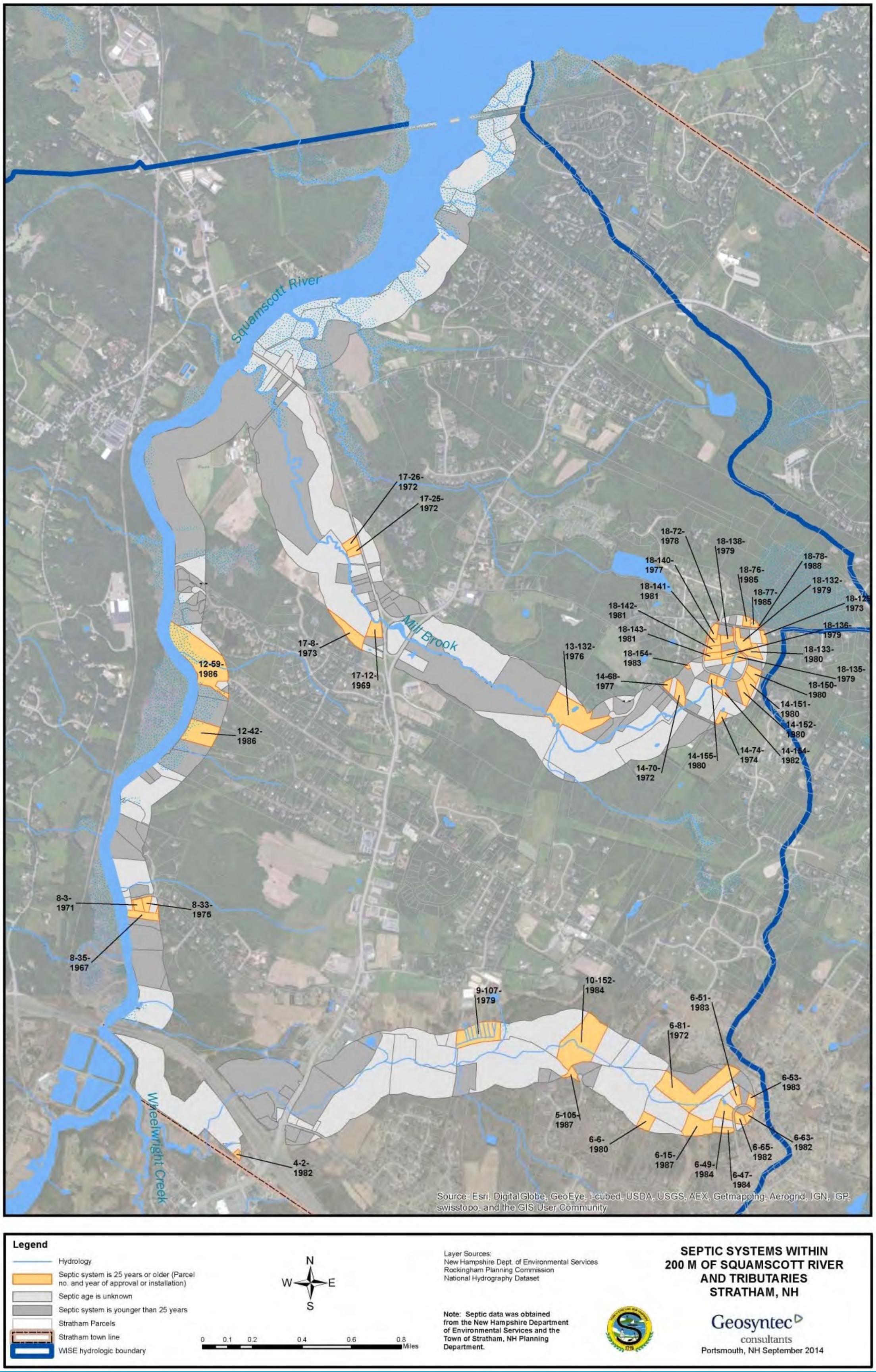
Septic system locations were identified using a method from NHDES (2014). Systesm are identified within and without 200 meters. The draft MS4 permit requires the identification of septic systems within 200 meters and over 25 years of age to be prioritized for upgrade. NHDES delineated regions serviced by municipal sewer systems based on direct information from regional municipalities and information in the USGS Water Demand Model for New Hampshire Towns. The population outside of these service areas, as determined by 2010 US Census block data, was assumed to use septic systems for waste disposal. The detailed process used to determine location of septic system is explained in Appendix G of GBNNPSS.

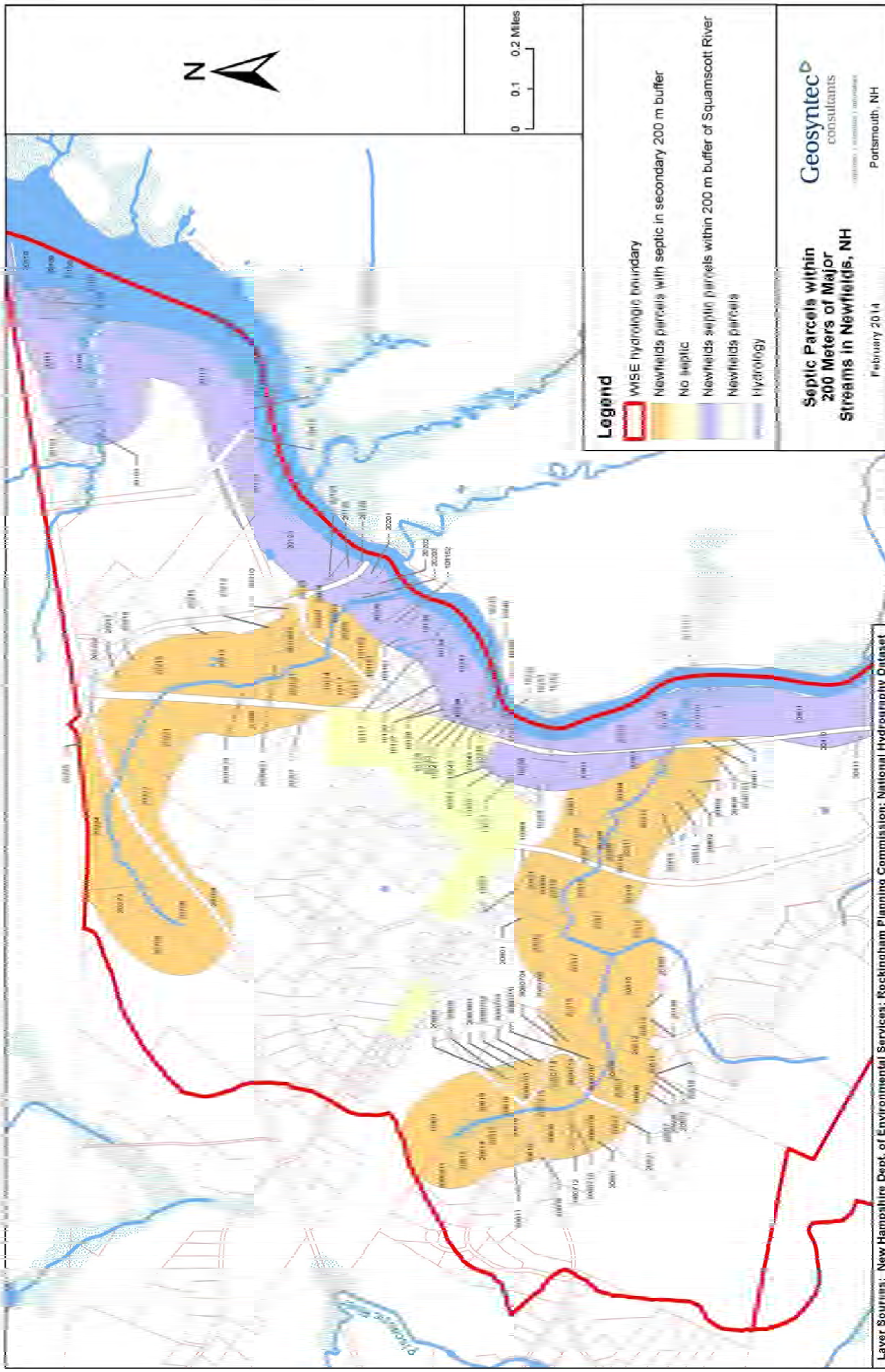
The Town of Exeter has subsurface septic systems, which serve approximately 1195 properties or 29 percent of the Exeter properties. Of the total number of septic properties within Exeter, approximately 89 percent are located within the Squamscott-Exeter River watershed; of these properties, approximately 33 percent are located within 200 meters (656 feet) of the Squamscott-Exeter River or its larger tributaries (i.e. approximately 350 properties in Exeter have septic systems and are located within 200 meters of the Squamscott-Exeter River or its major tributaries).

The Town of Stratham does not have a municipal sewer system and is entirely dependent on septic systems for wastewater treatment. Of the total number of Stratham properties, which are serviced by septic systems, approximately 66 percent are located within the Squamscott-Exeter River watershed. Of these, approximately 27 percent are located within 200 meters of the Squamscott-Exeter River (or its major tributaries). In the summer of 2014, Geosyntec reviewed all of the available septic system records at the Stratham Planning and Zoning Department; 51 properties were identified, which are located within 200 meters of the Squamscott-Exeter River (or its major tributaries) and are most likely greater than 25 years old.

The Newfields wastewater plant is owned and operated by the Water and Sewer District and serves approximately 170 households (30% of the town population). The District encompasses residences and businesses in the downtown area adjacent to the Squamscott River. In 2014, the District was expanded to add a connection to the Rt 108 corridor, anticipating future growth in that region. The extension also provides the potential for future transfer of septic systems to wastewater treatment. The Town of Newfields has subsurface septic systems, which serve approximately 555 properties or 68 percent of the Newfields properties. Of the total number of septic properties within Newfields, approximately 59 percent are located within the Squamscott-Exeter River watershed; of these properties, approximately 31 percent are located within 200 meters of the Squamscott-Exeter River or its larger tributaries (i.e. approximately 100 properties in Newfields have septic systems and are located within 200 meters of the Squamscott-Exeter River or its major tributaries.


Legend
Septic within 200 meter buffer
Watershed Boundary
Hydrology
Parcel Boundaries
Layer/Data Sources:
New Hampshire Dept.
of Environmental Services;
Rockingham Planning Commission;
National Hydrography Dataset;
Town of Exeter
NOTE:
Future work may include
data on septic system ages
N
0 375 750 1,500
Meters
DRAFT
AREAS WITH SEPTIC SYSTEMS WITHIN
200 METERS OF MAJOR TRIBUTARIES OF THE
SQUAMSCOTT-EXETER RIVER WATERSHED
IN EXETER, NH
Geosyntec consultants
Portsmouth, NH
January 2015


Squamscott River
Mill Brook
Wheelwright Creek
17-26-1972
17-25-1972
17-8-1973
17-12-1969
12-59-1986
12-42-1986
13-132-1976
14-68-1977
14-70-1972
14-155-1980
14-74-1974
14-154-1982
14-152-1980
14-151-1980
18-72-1978
18-138-1979
18-140-1977
18-141-1981
18-142-1981
18-143-1981
18-154-1983
18-76-1985
18-77-1985
18-78-1988
18-132-1979
18-136-1979
18-133-1980
18-135-1979
18-150-1980
8-3-1971
8-33-1975
8-35-1967
9-107-1979
10-152-1984
6-51-1983
6-81-1972
6-53-1983
5-105-1987
6-6-1980
6-15-1987
6-49-1984
6-47-1984
6-65-1982
6-63-1982
4-2-1982
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Legend
Hydrology
Septic system is 25 years or older (Parcel no. and year of approval or installation)
Septic age is unknown
Septic system is younger than 25 years
Stratham Parcels
Stratham town line
WISE hydrologic boundary
N
W
E
S
0 0.1 0.2 0.4 0.6 0.8 Miles
Layer Sources:
New Hampshire Dept. of Environmental Services
Rockingham Planning Commission
National Hydrography Dataset
Note: Septic data was obtained from the New Hampshire Department of Environmental Services and the Town of Stratham, NH Planning Department.
SEPTIC SYSTEMS WITHIN 200 M OF SQUAMSCOTT RIVER AND TRIBUTARIES STRATHAM, NH
Geosyntec consultants
Portsmouth, NH September 2014


N
0 0.1 0.2 Miles
Legend
WISE hydrologic boundary
Newfields parcels with septic in secondary 200 m buffer
No septic
Newfields septic parcels within 200 m buffer of Squamscott River
Newfields parcels
Hydrology
Geosyntec consultants
Portsmouth, NH
Septic Parcels within 200 Meters of Major Streams in Newfields, NH
February 2014
Layer Sources: New Hampshire Dept. of Environmental Services; Rockingham Planning Commission; National Hydrography Dataset

Appendix F:

Checklist for NPDES Permit No. NH0100871, Administrative Order on Consent Docket No. 13-010

Appendix F: Checklist for NPDES Permit No. NH0100871, Administrative Order on Consent Docket No. 13-010

This appendix includes a following checklist which details specific items by category and reporting deadlines for the Town of Exeter. EPA Region 1 issues individual facility-specific permits for the discharge of treated domestic and industrial wastewater in the State of New Hampshire. Under these individual permits, the discharges will be limited and monitored by the permittee. Of the three WISE watershed communities, the Towns of Exeter and Newfields operate and discharge treated domestic wastewater.

In 2012 after several years of study and negotiations, EPA issued a new NPDES discharge permit to the Town of Exeter with a total nitrogen (TN) effluent limit of 3 mg/l. The Town subsequently negotiated an Administrative Order on Consent (AOC) with the EPA that allows a staged approach to TN reduction which allows 5 years to construct a facility which will treat nitrogen to meet a limit of 8 mg/l TN, followed by continued upgrades and reductions in TN. The AOC requires tracking and monitoring to ensure that load reductions goals and ecosystem response are on target.

Checklist for NPDES Permit No. NH0100871
Administrative Order on Consent Docket No. 13-010

No.	REPORTING TASKS	REPORTING DEADLINE* (Based on effective date of June 24, 2013)	OVERLAPS WITH DRAFT MS4 REQUIREMENTS	ASSISTANCE FROM WISE PROJECT
1.	**Submit progress reports to EPA and NHDES summarizing the compliance with the WWTFs and Interim Effluent Limitations (Section C.1)**. Included in the quarterly reports: 1.1 Describe activities undertaken during the quarterly period directed at achieving compliance with the Order. 1.2 Identify all plans, reports and other deliverables required by the Order that have been completed and submitted during the reporting period. 1.3 Describe the expected activities to be taken during the next reporting period in order to achieve compliance with the Order.	**On or before 1/15, 4/15, 7/15, 10/15 of each year** (until 7/15/2018)	YES ☐ NO ☒	YES ☐ NO ☒
2.	**Submit annual Total Nitrogen Control Plan Report to EPA and NHDES (Section E.1)** These reports shall address: 2.1 Total nitrogen (lbs) discharged from WWTF during previous year, 2.2 Operational changes implemented during previous year, 2.3 Status of total nitrogen non-point source and storm water point source accounting system development, 2.4 The status of the non-point and point source Nitrogen Control Plan development, 2.5 Description and accounting of activities conducted by Exeter as part of its Nitrogen Control Plan, and 2.6 Description of Exeter activities affecting the total nitrogen load to Great Bay during previous year.	**Beginning 1/31/2014 and annually thereafter**	YES ☒ NO ☐ **Notes:** Tracking point and non-point sources of nitrogen are part of the draft MS4 requirements.	YES ☒ NO ☐ **Notes:** Products, including tracking tools, developed as part of the WISE project should assist the Town in completing Tasks 2.3 through 2.6.
3.	**Initiate construction of the WWTF (Section A.1)** Necessary to achieve interim effluent limits set forth in Attachment	**6/30/2016**	YES ☐ NO ☒	YES ☐ NO ☒

	1.a in accordance with NHDES approval			
4.	**Achieve substantial completion of construction of the WWTF (Section A.2)** In accordance with NHDES approval	**6/30/2018**	YES ☐ NO ☒	YES ☐ NO ☒
5.	**Submit a Total Nitrogen Non-point Source and Point Source Stormwater Control Plan to EPA and NHDES (Section D.4)** Plan shall include: 5.1 5 year schedule for implementing specific control measures as allowed by state law to address identified non-point source and stormwater Nitrogen loadings in the Town of Exeter that contribute total nitrogen to the Great Bay estuary, including the Squamscott River. 5.2 If any category of de-minimis non-point source loadings identified in the tracking and accounting program are not included in the Nitrogen Control Plan, the Town shall include an explanation in the Plan of any such exclusions. The Nitrogen Control Plan shall be implemented in accordance with the schedules contained therein.	**9/30/2018**	YES ☒ NO ☐ **Notes:** Draft MS4 permit requires an implementation schedule for specific control measures at end of permit cycle	YES ☒ NO ☐ **Notes:** Products, including a menu of best management control practices and tracking tools, developed as part of the WISE project should assist the Town in completion of Task 5.
6.	**Submit an Engineering Evaluation (Section E.2)** That includes recommendations for the implementation of any additional measures necessary to achieve compliance with the NPDES Permit, or a justification for leaving the interim discharge limit set forth in Attachment 1.a in place (or lower the interim limit to a level below 8.0 mg/L but still above 3.0 mg/L) beyond that date. Must analyze: 6.1 Total Nitrogen concentrations in the Squamscott River and downstream are trending towards targets, 6.2 Documented significant improvements in dissolved oxygen, chlorophyll a, and macro algae levels, 6.3 Non-point source and stormwater point source reductions achieved are trending towards targets and mechanisms in place to ensure continued progress.	**12/31/2023**	YES ☐ NO ☒	YES ☒ NO ☐ **Notes:** Products, including monitoring framework, menus of best management control practices and tracking tools, developed as part of the WISE project should assist the Town in completion of Task 6.

* For each specific action outlined in the Order, Exeter must submit a written notice of compliance or noncompliance within 14 days of each deadline. Noncompliance reporting must include a description, a description of actions to be taken, a description of factors that explain or mitigate the noncompliance, and an appropriate date for which Exeter will perform the required action. After a notification of noncompliance has been filed, compliance with the past-due requirement shall be reported by submitting any required documents or providing EPA and NHDES with a written report Indicating that the required action has been achieved.

No.	COMPLIANCE TASKS	COMPLIANCE DEADLINE (Based on effective date of June 24, 2013)	OVERLAPS WITH DRAFT MS4 REQUIREMENTS	ASSISTANCE FROM WISE PROJECT
A.	**Track all activities that affect total Nitrogen load to the Great Bay Estuary. (Section D.1)** This includes (not limited to): A.1 New/modified septic systems, A.2 Decentralized WWTFs, A.3 Changes to the amount of effective impervious cover, A.4 Changes to the amount of disconnected impervious cover, A.5 Conversion of existing landscape to lawns/turf and any new or modified BMPs.	**Effective Immediately**	YES ☒ NO ☐ **Notes:** Tracking requirements will also include dog waste, turf management and agriculture.	YES ☒ NO ☐ **Notes:** Tracking tools that affect nitrogen load could be developed as part of the WISE project.
B.	**Comprehensive subwatershed-based tracking/accounting system (Section D.2)** Coordinate with the NHDES, other Great Bay communities and watershed organizations in NHDES's efforts to develop and utilize a comprehensive subwatershed-based tracking/accounting system for quantifying nitrogen loading changes from Exeter to the Great Bay Estuary.	**Effective Immediately**	YES ☐ NO ☒ **Notes:** Draft MS4 permit does not require a subwatershed-based tracking and accounting system.	YES ☒ NO ☐ **Notes:** The tracking tools and accounting system developed for the WISE project, could be adopted by the subwatershed communities.
C.	**Coordinate with the NHDES to develop a subwatershed community based nitrogen allocation (Section D.3)**	**Effective Immediately**	YES ☐ NO ☒	YES ☐ NO ☒
D.	**The interim limits in Attachment 1.a shall be in effect unless and until EPA determines that the Town has not complied with the milestones set forth in the Order (Section B.3).** If and when EPA determines that the interim limits shall no longer remain in effect, the Town shall fund, design , construct and operate additional treatment facilities to meet the NPDES Permit limit of 3.0 mg/l	**Effective Immediately and no later than 5 years from EPA's determination**	YES ☐ NO ☒	YES ☐ NO ☒
E.	**Operate the WWTF so as to maximize removal efficiencies and effluent quality (Section B.4)** using all necessary treatment equipment available at the facility for optimization at the flow and load received but not requiring methanol or other carbon addition.	**At all times**	YES ☐ NO ☒	YES ☐ NO ☒

F.	**Comply with the interim total nitrogen effluent limitations and monitoring requirements contained in Attachment 1 of the Order (Section B.1 and B.2)**.	**Until 6/30/2019 or 12 months after substantial completion of the WWTF** (whichever is sooner)	YES ☐ NO ☒	YES ☐ NO ☒

Appendix G:

Checklist for 2013 Draft NH Small MS4 General Permit Requirements

Appendix G. Checklist for 2013 Draft NH Small MS4 General Permit Requirements

Municipal Separate Storm Sewer System

The following appendix provides a detailed checklist of the 2013 draft NH Small MS4 permit. This permit will likely change, however it is not expected to change substantially. This checklist will need to be updated when the final permit is issued.

Under the MS4 program, operated by EPA, towns with urbanized areas as defined by the US Census are required to obtain permit coverage for their stormwater discharges. The Towns of Exeter and Stratham are subject to the requirements of EPA's NH Small MS4 General Permit for stormwater discharges. The Town of Newfields received an MS4 permit waiver in 2013, but understands that MS4 requirements may be applied under future permit cycles. The permit expired in 2008 and is expected to be reissued by 2016. EPA released a draft permit in 2013 which contained new provisions for the 6 Minimum Measures (MM): 1) Public Education and Outreach, 2) Public Participation/Involvement, 3) Illicit Discharge Detection and Elimination, 4) Construction Site Runoff Control, 5) Post-Construction Runoff Control, 6) Pollution Prevention/Good Housekeeping. MM5 includes new requirements to develop Water Quality Response Plans (WQRPs) for stormwater outfalls that discharge to impaired water bodies. The WQRPs will assess all significant discharges to determine if they could contribute to the waterbody impairment and identify BMPs and a schedule for implementation to address the impairments.

Checklist for 2013 Draft NH Small MS4 General Permit Requirements

TASK		DEADLINE (in relation to permit effective date)
1.1	NOI is signed by appropriate official *(Appendix B, Subparagraph 11)*	Within ninety (90) Days
1.2	NOI contains certification *(Part 1.7.2.c)*	
1.3	NOI certifies eligibility regarding endangered species *(Part 1.9.1)*	
1.4	NOI certifies eligibility regarding historic properties *(Part 1.9.2)*	
2.1	Identify responsible people for program implementation	Within one (1) year
2.2	List all receiving water body segments, their classification under the applicable water quality standards, any impairment(s) and associated pollutant(s) of concern, applicable TMDLs and WLAs, and number of outfalls from the MS4 that discharge to each water body	
2.3	Document all public drinking water sources (surface water and groundwater) that may be impacted by MS4	
2.4	List all interconnected MS4s and other separate storm sewer systems receiving a discharge from the permitted MS4, the receiving water body segment(s) ultimately receiving the discharge, their classification under the applicable state water quality standards, any impairment(s) and associated pollutant(s) of concern, applicable TMDLs and WLAs, and the number of interconnections	
2.5	Documentation to support permittee's compliance with Endangered Species requirements *(Part 1.9.1)*	
2.6	Documentation to support permittee's compliance with historic properties requirements *(Part 1.9.2)*	Within one (1) year
2.7	Map of separate storm sewer system *(Part 2.3.4.6)*	
2.8	Listing of all discharges that were found to cause or contribute to an exceedance of applicable water quality standards and a description of the response(s) *(Part 2.1.1.c)*	
2.9	Description of practices to achieve compliance with Discharges Subject to an Approved TMDL *(Part 2.2.1)*	
2.10	Water Quality Response Plans (WQRP) including the person(s) or department responsible for the measure; the BMPs for the control measure or permit requirement; and the measurable goal(s) for each BMP. Each measurable goal shall include milestones and timeframes for its implementation and have a quantity or quality associated with its endpoint. Each goal must have a measure of assessment associated with it. *(Part 2.2.2)* ***(Must also comply with the Great Bay Nitrogen Requirements (Part 2.2.3): Additional and modified BMPs included in the WQRP shall include, at a minimum, the BMPs identified in Appendix H).***	Within three (3) year
2.11	Description of any other practices to achieve compliance with water quality based requirements of the Water Quality Based Effluent Limitations *(Part 2.1)*	
2.12	Description of practices to achieve compliance with Requirements to Reduce Pollutants to the Maximum Extent Practicable (MEP) *(Part 2.3)* Identify the person(s) or department responsible for the measure; the BMPs for the control	Within one (1) year

	measure or permit requirement; and the measurable goal(s) for each BMP. Each measurable goal shall include milestones and timeframes for its implementation and have a quantity or quality associated with its endpoint. Each goal must have a measure of assessment associated with it.	
2.13	Description of measures to avoid or minimize impacts to public and known private drinking water sources (surface water and groundwater). The permittee is also encouraged to include provisions to notify public water supplies in the event of an emergency.	
2.14	Annual Program Evaluation *(Part 4.1)*	
	1. Illicit Discharge Detection and Elimination (IDDE) Program (Part 2.3.4)	
3.1	Outfall Inventory *(Part 2.3.4.7) (include inventory in annual report)*	**Within two (2) years**
3.2	System Mapping – Develop a revised and more detailed map than was required by the MS4-2003 *(Part 2.3.4.6)* (*include progress towards completion of map in each annual report)* • Required mapping elements: Municipal separate storm sewer; catchment delineations; water bodies; municipal sanitary sewer system; municipal combined sewer system; storm sewer material, size and age; sanitary sewer system material, size and age; properties known or suspected to be served by a septic system; areas that have been or could be influenced by septic system discharges; location of suspected, confirmed and corrected illicit discharges.	**Within four (4) years**
3.3	Complete dry weather screening and sampling (where flowing) of every MS4 outfall and interconnection (except Excluded and Problem Catchments). May rely on screening conducted under the MS4-2003, pursuant to an EPA enforcement action, or by the state or EPA to the extent that it meets the requirements. *(Part 2.3.4.8.d)*	**Within five (5) years**
3.4	Outfall Interconnection Screening and Sampling *(Part 2.3.4.8.d)*	**Begin within three (3) months of investigation procedure finalization and no later than 15 months**
3.5	Assessment and Priority Ranking of Catchments *(Part 2.3.4.8.c)*. Permittee shall classify each catchment into one of the following categories: • Excluded Catchments: No potential illicit discharge • Problem Catchments: Known or suspected contributions of illicit discharges • High Priority Catchments: Discharging to an area of concern to public health • Low Priority Catchment Priority ranking shall be done based on screening factors and should consider the following: past complaints and reports; poor dry weather receiving water quality; density of generating sites; age of surrounding infrastructure; sewer conversion; historic combined sewer systems; density of aging septic systems; and culverted streams.	
i.	Complete the Catchment Investigation Procedure in a minimum of 80% of the MS4 area served by Problem Catchments	**Within five (5) years**
ii.	Complete the Catchment Investigation Procedure in 100% of Problem Catchments	**Within seven (7) years**
iii.	Implement the Catchment Investigation Procedure in every catchment of the MS4 where information indicates sewer input including outfall/interconnection screening sewer input based on olfactory/visual evidence or sampling	**Within seven (75) years**

results (ammonia ≥ 0.5 mg/l, surfactants ≥ 0.25 mg/l, and bacteria levels greater than the water quality criteria applicable to the receiving water; or ammonia ≥ 0.5 mg/l, surfactants ≥ 0.25 mg/l, and detectable levels of chlorine)	
iv. Complete the Catchment Investigation Procedure in 40% of the area served by all MS4 catchments	**Within seven (7) years**
v. Complete the Catchment Investigation Procedure in 100% of the area served by all MS4 catchments. May count the area of low priority catchments only if the Catchment Investigation has been started in all other MS4 catchments (considered "started" if Part 2.3.4.8.e.i-ii is complete).	**Within twelve (12) years**
3.6 Where catchments do not contain junction manholes, the dry weather screening and sampling shall be considered as meeting the manhole inspection requirement. In these catchments dry weather screenings that indicate potential presence of illicit discharges shall be further investigated *(Part 2.3.4.8.e.iii).* Investigations in these catchments may be considered complete where dry weather screening reveals no flow; no evidence of illicit discharges or SSOs is indicated through sampling results or visual or olfactory means; and no wet weather System Vulnerability Factors are identified.	
3.7 Track progress towards these milestones	**Each annual report**
2. Public Education and Outreach (Part 2.3.2)	
4.1 Distribute a minimum of two (2) educational messages to: • Residents; • Businesses, institutions (private colleges, private schools, hospitals), and commercial facilities; • Developers (construction); and • Industrial facilities. The distribution of materials to each audience shall be spaced at least one year apart. Educational messages may be printed materials such as brochures or newsletters; electronic materials such as websites; mass media such as newspaper articles or public service announcement (radio or cable); or displays in a public area such as town/city hall. The permittee may use existing materials if they are appropriate for the message the permittee chooses to deliver or the permittee may develop its own educational materials. The permittee may partner with other MS4s, community groups or watershed associations to implement the education program *(Part 2.3.2.1.b).* *If the small MS4 area has greater than thirty percent of its residents serviced by septic systems, the permittee shall include maintenance of septic systems as part of its education program.*	**Beginning the second year of the permit, distribute a minimum of two (2) educational messages over the permit term to each audience (at least eight educational messages during the permit term).**
3. Indicators of IDDE Program Progress	
5.1 Define or describe indicators for tracking program success. At a minimum, indicators shall include measures that demonstrate efforts to locate illicit discharges, the number of SSOs and illicit discharges identified and removed, the percent and area in acres of the catchment area served by the MS4 evaluated using the catchment investigation procedure, and volume of sewage removed. Evaluate and report the overall effectiveness of the program based on the tracking indicators in the annual report *(Part 2.3.4.10).*	**Each annual report**
4. Provide training to employees involved in the IDDE program	

6.1 At a minimum, provide training to employees involved in IDDE program about the program, including how to recognize illicit discharges and SSOs. Report on the frequency and type of employee training in the annual report (Part 2.3.4.11).	**Annually**
5. Implement and enforce a Construction Site Stormwater Runoff Control Program *(Part 2.3.5)*	
7.1 Construction site stormwater runoff control program shall be designed to reduce pollutants in any stormwater runoff discharged to the MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. The program shall include disturbances less than one acre if that disturbance is part of a larger common plan of development or sale that would disturb one acre or more. **Permittees authorized under the MS4-2003 shall continue to implement their existing programs and shall modify them as necessary to meet the requirements of this Part.**	**As soon as possible, but no later than three (3) years**
7.1.1. An ordinance or other regulatory mechanism that requires the use of sediment and erosion control practices at construction sites. Development of an ordinance or other regulatory mechanism was a requirement of the MS4-2003 (See Part III.B.4) and was required to be effective by May 1, 2008.	
7.1.2. Written procedures for site inspections and enforcement of sediment and erosion control measures. The procedures shall clearly define who is responsible for site inspections as well as who has authority to implement enforcement procedures. The program shall provide that the permittee may, to the extent authorized by law, impose sanctions to ensure compliance with the local program. These procedures and regulatory authorities shall be documented in the SWMP.	
7.1.3. Requirements for construction operators to implement a sediment and erosion control program. The program shall include BMPs appropriate for the conditions at the construction site. The program may include references to BMP design standards in state manuals or design standards specific to the MS4. EPA supports and encourages the use of design standards in local programs. Examples of appropriate sediment and erosion control measures for construction sites include local requirements to: • minimize the amount of disturbed area and protect natural resources; • stabilize sites when projects are complete or operations have temporarily ceased; • protect slopes on the construction site; • protect all storm drain inlets and armor all newly constructed outlets; • use perimeter controls at the site; • stabilize construction site entrances and exits to prevent off-site tracking; and • inspect stormwater controls at consistent intervals.	
7.1.4. Requirements to control wastes, including but not limited to, discarded building materials, concrete truck wash out, chemicals, litter, and sanitary wastes. These wastes may not be discharged to the MS4.	**As soon as possible, but no later than three (3) years**
7.1.5. Written procedures for site plan review. Site plan review shall include a review by the permittee of the site design, the planned operations at the construction site, planned BMPs during the construction phase, and the planned BMPs to be used to manage runoff created after development. The review procedure shall incorporate procedures for the consideration of potential water quality impacts; procedures for pre-construction review; and procedures for receipt and consideration of information submitted by the public. Site plan review procedure shall include	

evaluation of opportunities for use of low impact design and green infrastructure. When the opportunity exists, the permittee shall encourage project proponents to incorporate these practices into the site design. The permittee shall track the number of site reviews, inspections, and enforcement actions.	
8.1 Develop a report assessing current street design and parking lot guidelines and other local requirements that affect the creation of impervious cover. This assessment shall be used to provide information to determine if the design standards for streets and parking lots can be modified to support low impact design options. If the assessment indicates that changes can be made, the assessment shall include recommendations and proposed schedules to incorporate policies and standards into relevant documents and procedures to minimize impervious cover attributable to parking areas and street designs. The permittee shall involve any local planning boards and local transportation boards in this assessment to the extent feasible *(Part 2.3.6.6).* ***(Report status of this assessment in each annual report.)***	**Within two (2) years**
8.2 Develop a report assessing existing local regulations (Part 2.3.6.7)	**Within three (3) years**
8.3 Directly Connected Impervious Area (DCIA)	
8.3.1. Estimate the annual increase or decrease in the number of acres of impervious area (Part 2.3.6.8.a)	
8.3.2. Complete an inventory and priority ranking of permittee-owned property and existing infrastructure that could be retrofitted with BMPs designed to reduce the frequency, volume and pollutant loads of stormwater discharges to its MS4 through the mitigation of impervious area (Part 2.3.6.8.b).	**Within two (2) years**
8.3.3. Estimate for each sub-basin identified , the number of acres of impervious area (IA) and DCIA draining to its MS4 that have been added or removed during the prior year (Part 2.3.6.8.c)	**Second year annual report and in each subsequent annual report.**
8.3.4. Report on those permittee-owned properties and infrastructure inventoried that have been retrofitted with BMPs to mitigate IA and DCIA (Part 2.3.6.8.c)	**Third year annual report and in each subsequent annual report**
6. Develop an Operation and Maintenance Program *(Part 2.3.7)* This program shall be included as part of the SWMP (item 2 of this checklist)	**Within one (1) year**
9.1 Develop an inventory of facilities (Part 2.3.7.1)	**Within six (6) months Review annually and update as necessary**
7. Develop and implement a written Stormwater Pollution Prevention Plan (SWPPP) for permittee-owned maintenance garages, public works yards, transfer stations and other waste handling facilities where pollutants are exposed to stormwater (Part 2.3.7.2).	**No later than two (2) years**

8. Submit Annual Report	
11.1 A self-assessment review of compliance with the permit and conditions	**Annually, due ninety (90) days from the close of each reporting period.**
11.2 An assessment of the appropriateness of the selected BMPs	
11.3 The status of any plans or activities required by the Water Quality Based Effluent Limitations (Part 2.1) and/or Discharges to Impaired Waters (Part 2.2) including: • Identification of all discharges determined to be causing or contributing to an exceedance of water quality standards and description of response including all items required by Part 2.1.1.c; • For discharges subject to TMDLs, identification of specific BMPs used to address the pollutant identified as the cause of impairment and assessment of the BMPs effectiveness at controlling the pollutant (Part 2.2.1); • For discharges to impaired waters and the nitrogen-impaired waters of the Great Bay watershed and their tributaries, a description of each WQRP including the items required by Part 2.2.2.c.; and • For discharges to chloride impaired waters, identification of the specific BMPs used to address the pollutant and assessment of the BMPs effectiveness at controlling the pollutant.	
11.4 An assessment of the progress towards achieving the measurable goals and objectives of each control measure in the Requirements to Reduce Pollutants to the Maximum Extent Practicable (MEP) (Part 2.3) including • Evaluation of the public education program including a description of the targeted messages for each audience; method of distribution and dates of distribution; methods used to evaluate the program; and any changes to the program. • Description of the activities used to promote public participation including documentation of compliance with state public notice regulations. • Description of the activities related to implementation of the IDDE program including: status of the map; status and results of the illicit discharge potential ranking and assessment; identification of problem catchments; status of all protocols described in Parts 2.3.4. (program responsibilities and systematic procedure); number and identifier of catchments evaluated; number and identifier of outfalls screened; number of illicit discharges located; number of illicit discharges removed; gallons of flow removed; identification of tracking indicators and measures of progress based on those indicators; and employee training. • Evaluation of the construction runoff management including number of project plans reviewed; number of inspections; and number of enforcement actions. • Evaluation of stormwater management for new development and redevelopment including status of ordinance development and review; status of the street design assessment; and information on directly connected impervious area reductions. • Status of the O&M Programs required by Part 2.3.7.1.	

• Status of SWPPP required by Part 2.3.7.2 including inspection results. • Any additional reporting requirements in Part 3.0.	
11.5 All outfall screening and monitoring data collected by or on behalf of the permittee during the reporting period and cumulative for the permit term, including but not limited to all data collected pursuant to the IDDE Program (Parts 2.3.4) and Part 4.3. Also provide a description of any additional monitoring data received during the reporting period.	
11.6 Description of activities for the next reporting cycle.	
11.7 Description of any changes in identified BMPs or measurable goals.	
11.8 Description of activities undertaken by any entity contracted for achieving any measurable goal or implementing any control measure.	

Appendix H:

Maps of Surface Water Quality Impaired Waters

Appendix H: Maps of Surface Water Quality Impaired Waters

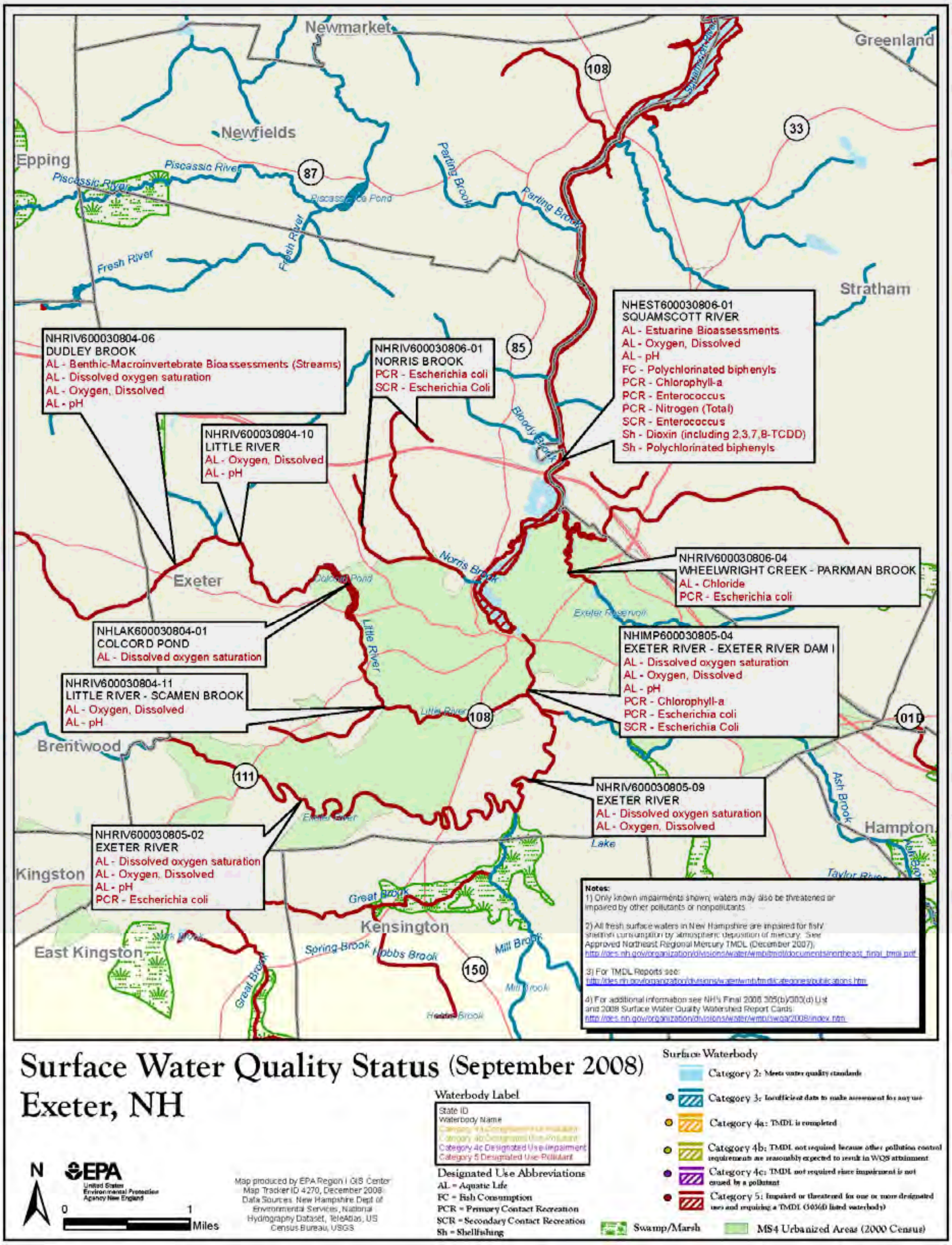
This appendix includes maps from the approved 2008 final listing as per EPA. More recent list have been submitted by NHDES as of 2012 but the maps have not been updated. The Clean Water Act requires each state to submit a list of impaired waters to the U.S. Environmental Protection Agency every two years. Listing of impaired waters (303d list) includes surface waters that:

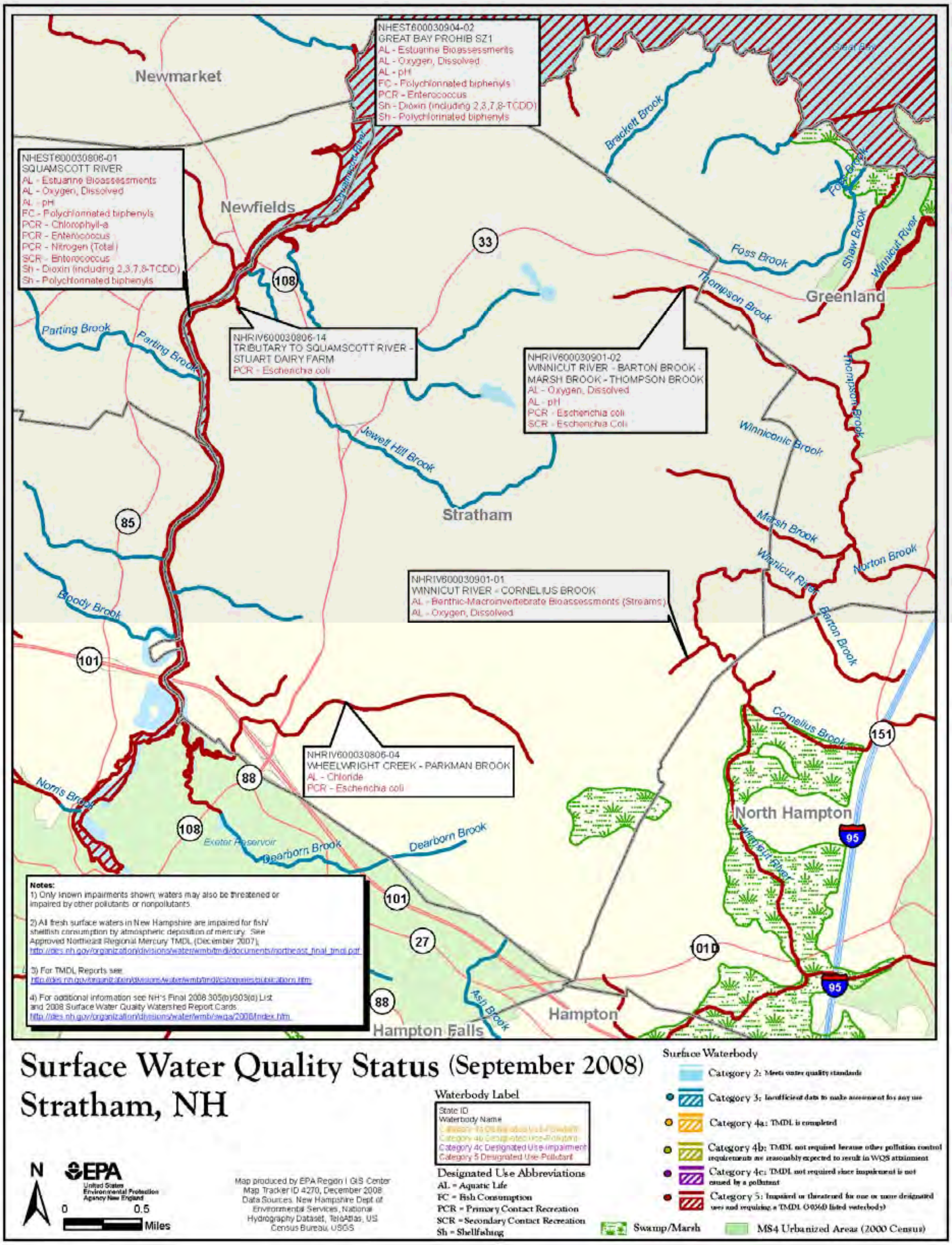
- Are impaired or threatened by a pollutant or pollutant(s),
- Are not expected to meet water quality standards within a reasonable time even after application of best available technology standards for point sources or best management practices for nonpoint sources and,
- Require development and implementation of a comprehensive water quality study (i.e., called a Total Maximum Daily Load or TMDL study) that is designed to meet water quality standards.

Impaired waters within the Town of Exeter include: Dudley Brook; Norris Brook; Little River; Squamscott River; Wheelwright Creek- Parkman Brook; Exeter River; Colcord Pond; and Little River – Scamen Brook. Under the MS4, Exeter is required to manage the drainage area and infrastructure to receiving waters and implement controls to reduce sources of impairments.

The impaired waters within the Town of Stratham include: Squamscott River; Squamscott River tributary to Stuart Dairy Farm; Winnicutt River including Barton Brook, Thompson Brook and Marsh Brook and Cornelius Brook; and Wheelwright Creek – Parkman Brook.

Many of the streams in town of Newfields (and in the region) are listed as impaired for mercury; other specific impairments include the Squamscott River and an unnamed tributary to the Squamscott River (near Rt 108, impaired for bacteria).


Newmarket
Greenland
Newfields
Epping
Piscassic River
Fresh River
Fresh River
Parting Brook
Stratham
Exeter
Brentwood
Kingston
East Kingston
Kensington
Hampton
NHRIV600030804-06
DUDLEY BROOK
AL - Benthic-Macroinvertebrate Bioassessments (Streams)
AL - Dissolved oxygen saturation
AL - Oxygen, Dissolved
AL - pH
NHRIV600030806-01
NORRIS BROOK
PCR - Escherichia coli
SCR - Escherichia Coli
NHEST600030806-01
SQUAMSCOTT RIVER
AL - Estuarine Bioassessments
AL - Oxygen, Dissolved
AL - pH
FC - Polychlorinated biphenyls
PCR - Chlorophyll-a
PCR - Enterococcus
PCR - Nitrogen (Total)
SCR - Enterococcus
Sh - Dioxin (including 2,3,7,8-TCDD)
Sh - Polychlorinated biphenyls
NHRIV600030804-10
LITTLE RIVER
AL - Oxygen, Dissolved
AL - pH
NHRIV600030806-04
WHEELWRIGHT CREEK - PARKMAN BROOK
AL - Chloride
PCR - Escherichia coli
NHLAK600030804-01
COLCORD POND
AL - Dissolved oxygen saturation
NHIMP600030805-04
EXETER RIVER - EXETER RIVER DAM I
AL - Dissolved oxygen saturation
AL - Oxygen, Dissolved
AL - pH
PCR - Chlorophyll-a
PCR - Escherichia coli
SCR - Escherichia Coli
NHRIV600030804-11
LITTLE RIVER - SCAMEN BROOK
AL - Oxygen, Dissolved
AL - pH
NHRIV600030805-09
EXETER RIVER
AL - Dissolved oxygen saturation
AL - Oxygen, Dissolved
NHRIV600030805-02
EXETER RIVER
AL - Dissolved oxygen saturation
AL - Oxygen, Dissolved
AL - pH
PCR - Escherichia coli
Notes:
1) Only known impairments shown; waters may also be threatened or impaired by other pollutants or nonpollutants
2) All fresh surface waters in New Hampshire are impaired for fish/shellfish consumption by atmospheric deposition of mercury. See Approved Northeast Regional Mercury TMDL (December 2007).
3) For TMDL Reports see:
4) For additional information see NH's Final 2008 305(b)/303(d) List and 2008 Surface Water Quality Watershed Report Cards:
Surface Water Quality Status (September 2008)
Exeter, NH
Waterbody Label
State ID
Waterbody Name
Category 4c Designated Use-Impairment
Category 5 Designated Use-Pollutant
Designated Use Abbreviations
AL = Aquatic Life
FC = Fish Consumption
PCR = Primary Contact Recreation
SCR = Secondary Contact Recreation
Sh = Shellfishing
Surface Waterbody
Category 2: Meets water quality standards
Category 3: Insufficient data to make assessment for any use
Category 4a: TMDL is completed
Category 4b: TMDL not required because other pollution control requirements are reasonably expected to result in WQS attainment
Category 4c: TMDL not required since impairment is not caused by a pollutant
Category 5: Impaired or threatened for one or more designated uses and requiring a TMDL (303(d) listed waterbody)
Swamp/Marsh
MS4 Urbanized Areas (2000 Census)
EPA
Miles


Newmarket
Newfields
Stratham
Greenland
North Hampton
Hampton
Hampton Falls
NHEST600030904-02
GREAT BAY PROHIB SZ1
AL - Estuarine Bioassessments
AL - Oxygen, Dissolved
AL - pH
FC - Polychlorinated biphenyls
PCR - Enterococcus
Sh - Dioxin (including 2,3,7,8-TCDD)
Sh - Polychlorinated biphenyls
NHEST600030806-01
SQUAMSCOTT RIVER
AL - Estuarine Bioassessments
AL - Oxygen, Dissolved
AL - pH
FC - Polychlorinated biphenyls
PCR - Chlorophyll-a
PCR - Enterococcus
PCR - Nitrogen (Total)
SCR - Enterococcus
Sh - Dioxin (including 2,3,7,8-TCDD)
Sh - Polychlorinated biphenyls
NHRIV600030806-14
TRIBUTARY TO SQUAMSCOTT RIVER - STUART DAIRY FARM
PCR - Escherichia coli
NHRIV600030901-02
WINNICUT RIVER - BARTON BROOK - MARSH BROOK - THOMPSON BROOK
AL - Oxygen, Dissolved
AL - pH
PCR - Escherichia coli
SCR - Escherichia Coli
NHRIV600030901-01
WINNICUT RIVER - CORNELIUS BROOK
AL - Benthic-Macroinvertebrate Bioassessments (Streams)
AL - Oxygen, Dissolved
NHRIV600030806-04
WHEELWRIGHT CREEK - PARKMAN BROOK
AL - Chloride
PCR - Escherichia coli
Brackett Brook
Foss Brook
Shaw Brook
Winnicut River
Thompson Brook
Parting Brook
Jewell Hill Brook
Winniconic Brook
Marsh Brook
Norton Brook
Barton Brook
Cornelius Brook
Moody Brook
Norris Brook
Exeter Reservoir
Dearborn Brook
Ash Brook
Notes:
1) Only known impairments shown; waters may also be threatened or impaired by other pollutants or nonpollutants.
2) All fresh surface waters in New Hampshire are impaired for fish/shellfish consumption by atmospheric deposition of mercury. See Approved Northeast Regional Mercury TMDL (December 2007),
http://des.nh.gov/organization/divisions/water/wmb/tmdl/documents/northeast_final_tmdl.pdf
3) For TMDL Reports see:
4) For additional information see NH's Final 2008 305(b)/303(d) List and 2008 Surface Water Quality Watershed Report Cards.
http://des.nh.gov/organization/divisions/water/wmb/swqa/2008/index.htm
Surface Water Quality Status (September 2008)
Stratham, NH
Waterbody Label
State ID
Waterbody Name
Category 4c Designated Use-Impairment
Category 5 Designated Use-Pollutant
Designated Use Abbreviations
AL = Aquatic Life
FC = Fish Consumption
PCR = Primary Contact Recreation
SCR = Secondary Contact Recreation
Sh = Shellfishing
Surface Waterbody
Category 2: Meets water quality standards
Category 3: Insufficient data to make assessment for any use
Category 4a: TMDL is completed
Category 4b: TMDL not required because other pollution control requirements are reasonably expected to result in WQS attainment
Category 4c: TMDL not required since impairment is not caused by a pollutant
Category 5: Impaired or threatened for one or more designated uses and requiring a TMDL (303d listed waterbody)
Swamp/Marsh
MS4 Urbanized Areas (2000 Census)
EPA
United States Environmental Protection Agency New England
Map produced by EPA Region I GIS Center
Map Tracker ID 4270, December 2008
Data Sources: New Hampshire Dept of Environmental Services, National Hydrography Dataset, TeleAtlas, US Census Bureau, USGS
N
0 0.5 Miles

Appendix I:

Tracking and Accounting Forms

Appendix I: Tracking and Accounting Forms

This appendix includes sample tracking and accounting forms. Included are 2 draft forms from Exeter and Rochester.

The Towns are currently or will be soon required to document pollutant load reductions to Great Bay to record progress towards achieving water quality goals. Specific detailed requirements are listed in the AOC and the draft NH MS4. An essential element of this will be developing a system for tracking progress for nutrient control strategies for point-source and non-point source parameters. A second essential element is the accounting for total nitrogen reduction based on the tracking measures.

EPA has provided guidance to communities on expected activities for tracking and accounting which are summarized below.

1. Property Use Information
    a. Existing Use
    b. Proposed Use
    c. Is the existing land use being converted to another type of land uses
    d. % of current Land use being converted to another type of land use
    e. Parcel Area (acres)
    f. Existing Total Impervious Cover (acres)
    g. Existing Total Disconnected Impervious Area (acres)
    h. Proposed Total Impervious Area (acres)
    i. Proposed Total Disconnected or Treated Impervious Area (acres)

2. Environmental Sensitivity
    a. Is the property in the Shoreland Protection District?
    b. Name of Receiving Water(s) where stormwater runoff from the property discharges too
    c. Distance from Receiving Water (feet)
    d. Buffer Size
    e. Public or Private waste water. Does the property have a septic system ?
    f. Percent runoff to outfall

3. Septic System Information (if applicable)
    a. Septic System Type
    b. Septic System Size (gallons)
    c. New or Replacement
    d. Date of Installation
    e. Distance of septic system from closest down-gradient or cross-gradient water body
    f. Name of closest down-gradient or cross-gradient water body
    g. Maintenance Requirements
    h. Maintenance Schedule

4. Proposed BMP Information - Treatment for Nitrogen
    a. Calculated Annual Nitrogen Load for entire Parcel (lbs N/year)
    b. Calculated Annual Nitrogen Load to BMP (lbs N/year)
    c. Best Management Practices Type
    d. Assumed BMP Efficiency (% Removal Efficiency)
    e. Calculated Annual Nitrogen Load Reduction (lbs N/year)
    f. Operations and Maintenance Plan
    g. Suggested Maintenance Schedule

Non-structural strategies may include fertilizer controls, street sweeping efforts and good housekeeping measures.

Town of Exeter, Planning Department
Land Use Development and Stormwater Accounting Information
for Non-point Source and Point Source Nitrogen Control Plan

Project Basics for Filing

Project Name	Address	Map/Lot #	Zoning District	Planning Board Case Number

Schedule **MS4 Information**

Date of Planning Board Final Approval	Start Date of Construction	Date of Certificate of Occupancy (CO)	Does stormwater runoff from the property discharge to an MS4? (Y/N)	If yes, Outfall ID #

Property Use Information

Existing Use	Proposed Use	Is the existing land use being converted to another type of land use (Y/N)? If yes, please describe	% of current Land use being converted to another type of land use	Parcel Area (acres)	Existing Total Impervious Area (acres)	Existing Total Disconnected Impervious Area (acres)	Proposed Total Impervious Area (acres)	Proposed Total Disconnected Impervious Area (acres)

*See Impervious Cover worksheet for calculation of impervious and disconnected impervious areas

Environmental Sensitivity

Is the property in the Shoreland Protection District? (Y/N)	Name of Receiving Water(s) where stormwater runoff from the property discharges too	Distance from Receiving Water (feet)	Buffer Size	Public or Private waste water. Does the property have a septic system ? (Y/N)	Percent runoff to outfall

Septic System Information (if applicable)

Septic System Type	Septic System Size (gallons)	New or Replacement	Date of Installation	Distance of septic system from closest down-gradient or cross-gradient water	Name of closest down-gradient or cross-gradient	Maintenance Requirements	Maintenance Schedule*

				body	water body		

Proposed BMP Information—Runoff Reduction

Best Management Practices Type	Number size	Drainage Area to BMP	Design Storm Size (inches)	Water Quality Volume (ft^3)	Underdrain (Y/N)	% Runoff Volume Reduction	BMP Disconnection Multiplier	Effective Impervious Area

*See Runoff Reduction worksheet for calculation.

Proposed BMP Information (Continued)--Treatment for Nitrogen

Calculated Annual Nitrogen Load for entire Parcel (Lbs N/year)	Calculated Annual Nitrogen Load to BMP (Lbs N/year)	Best Management Practices Type	Assumed BMP Efficiency (% Removal Efficiency)	Calculated Annual Nitrogen Load Reduction (Lbs N/year)	Maintenance Requirements	Suggested Maintenance Schedule*

*See BMP Nitrogen Load and Treatment worksheet for calculations;T riggers automatic maintenance reminder

Education / Outreach

Education /Outreach Approach	Buffer or Wetland Identification Discs	Homeowner Association Documentation	Maintenance Reminders*	Other

Chapter 50 CHECKLIST

Project Name: _____________ Map: _____Lot: _____Date of Submittal:_______

Applicant/Agent: __________________Signature: ________________________

Staff review by: ___________________ Date:________

☐	**Engineer**	___________________________	**Architect**	___________________________
☐	**New Development**		☐	**Re-Development**
☐	**Total Area of Disturbance ________________________ Square Feet (SF)**			
☐	**COMPLETED STORMWATER PERMIT APPLICATION SUBMITTED** *Note: A Stormwater Permit Application is **NOT** required if the project **(See 50.5 Applicability Standards)**:* • *Has an area of disturbance less than 5,000 SF and is located outside of a critical area (see Definitions)* • *Is normal maintenance and improvement of land in agricultural use provided in the **Manual of Best Management Practices for Nutrient Management** as established by NH Dept. of Agriculture, Markets and Food dated June 2011, or as amended* • *Is maintenance of existing landscaping, gardens, or lawn areas* • *Is construction of any fence that will not alter existing terrain or drainage patterns* • *Is construction of utilities (gas, water, electric, telephone, etc.) other than drainage, disturbing less than 20,000 contiguous square feet, within the limits of an existing paved roadway will not permanently alter terrain, groundcover, or drainage patterns, and trenches are paved at the end of each working day* • *Is emergency repairs to any stormwater management facility or practice that poses a threat to public health or safety, or as deemed necessary by the Office of Code Enforcement or DPW* • *Is a disturbance solely related to pavement reclamation and repaving of a street or road*			
☐	**STORMWATER MANAGEMENT AND EROSION CONTROL PLAN *(See 50.6-50.9)*:** *Note: A Stormwater Management and Erosion Control Plan is required if one of the following applies:* • *The project has an area of disturbance greater than 20,000 SF* • *The project is a subdivision of more than three building lots (i.e., Major Subdivision)* • *The project involves phasing of more than three contiguous lots per year of an existing or proposed subdivision* • *The project involves construction of utilities (gas, water, electric, telephone, etc.) requiring contiguous ground disturbance of greater than 20,000 SF unless the disturbance is proposed within the limits of an existing paved roadway utilizing a contractor with no history of erosion concerns.* • *The proposed work is in or adjacent to a critical area (see Definitions)*			

Chapter 50 CHECKLIST

☐	**DRAINAGE ANALYSIS**				
	24-Hour Storm Event		***Runoff***	***Pre-Development***	***Post-Development***
	☐	1-inch	Rate	___________Feet^3/Sec (CFS)	___________________ CFS
	☐	1-inch	Volume	___________Feet^3 (CF)	___________________ CF
	☐	2-Year	Rate	___________CFS	___________________ CFS
	☐	2-Year	Volume	___________CF	___________________ CF
	☐	10-Year	Rate	___________CFS	___________________ CFS
	☐	10-Year	Volume	___________CF	___________________ CF
	☐	25-Year	Rate	___________CFS	___________________ CFS
	☐	25-Year	Volume	___________CF	___________________ CF
	☐	100-Year	Rate	___________CFS	___________________ CFS

☐	**NARRATIVE DRAINAGE REPORT**		
	☐	Description of construction period and earth movement schedule including:	
		☐	Anticipated project start and completion dates
		☐	Sequence and duration of grading and construction activities
		☐	Sequence and timing of installation and/or application of soil erosion and sediment control measures as well as sequence for final stabilization of the project site.
	☐	Description of the onsite and adjacent wetlands, streams and other water resources including methods used to identify these resources and a description of any buffer setbacks that may apply, steep slopes, critical habitat, existing vegetation, 100-year floodplain limits and whether any downstream water bodies are listed as impaired according to DES' most recent 303(d) list	
	☐	Description of existing drainage patterns, receiving water bodies or drainage infrastructure and soil types for recharge potential	
	☐	Description of subwatershed area limits including any offsite and upstream areas contributing flow to shared drainage channels and/or infrastructure	
	☐	Description of proposed changes in impervious cover areas and any changes in pre- and post-development drainage patterns	
	☐	Description of LID measures that were considered but deemed impractical and rationale why certain LID measures are not practical for the site	
	☐	Description of measures and calculations for proposed measures used to achieve no net increase in runoff volumes leaving the site	
	☐	If an increase in post-development runoff volume is anticipated due to limited applicability for LID measures and site constraints, provide an assessment and supporting calculations to demonstrate no adverse impacts to downstream infrastructure, adjacent properties or aquatic habitat	
	☐	Descriptions, details, and design criteria and calculations for all structural, non-structural, permanent, and temporary erosion and sedimentation control measures and BMPs. This	

		information should include seeding mixtures and rates, types of sod, methods of seedbed preparation, expected seeding dates (or limitations on seeding timeframes), type and rate of lime and fertilizer application, and type and quantity of mulching for temporary and permanent control facilities
	☐	Design calculations for all temporary and permanent structural control BMP measures
	☐	Where proposed changes are anticipated within mapped limits of the 100-year floodplain, provide hydrologic and hydraulic analysis to show no net increase in flood elevations for the 100-year flood
	☐	Proposed schedule for the inspection and maintenance of all erosion control measures onsite prior to achieving final site stabilization. Inspections must be conducted by a 3rd party, qualified professional such as a PE, CPESC, CPSWQ at least once every 7 calendar days, or once every 14 calendar days and within 24 hours after a storm event of 0.25 inches or greater
	☐	Description of procedures for removing temporary erosion control measures and removal of accumulated sediment captured by such measures
	☐	Calculations for the infiltration or exfiltration system. These calculations should also account for frozen ground conditions, when the devices may not function at their optimal design
	☐	Any other specific study, calculation, or investigation as requested by the City
	☐	Description of procedures to limit and/or optimize the use of deicing materials and minimize offsite increases in chloride levels in adjacent surface and ground water
	☐	Maintenance and inspection plan for post-construction monitoring of stormwater BMPs to ensure long-term performance and functionality including details of who will be responsible for inspections and maintenance, proposed schedule, documentation, submittal procedures and contingency plans if future maintenance is required
	☐	Copies of pertinent State and Federal Permits
☐	**SITE PLAN DRAWINGS AND SUPPORTING DETAILS CONTAINING THE FOLLOWING:**	
	☐	Locus map showing property boundaries
	☐	North arrow, scale, date
	☐	Property lines, easements, structures, roads and utilities
	☐	Topographic contours at two-foot (2’) intervals
	☐	Critical areas
	☐	Within the project area and 200 feet outside of project boundary, limits of surface waters, wetlands, and drainage patterns and watershed boundaries
	☐	Existing Vegetation
	☐	Extent of 100-year floodplain boundaries if published or determined
	☐	Soils information for proposed disturbed areas from a National Cooperative Soil Survey (NCSS) soil series map (web based or hard copy) or a High Intensity Soil Map of the site, prepared in accordance with Society of Soil Scientists of Northern New England (SSSNNE) Special Publication No. 1. Highly erodible soils shall be determined by soil series
	☐	Areas of soil disturbance
	☐	Areas of cut and fill

	☐	Locations of earth stockpiles		
	☐	Locations of equipment storage and staging		
	☐	Locations of proposed construction and/or vehicle or equipment fueling areas		
	☐	Stump disposal plan		
	☐	Highlighted areas of poorly and very poorly drained soils		
	☐	Highlighted areas of poorly and/or very poorly drained soils proposed to be filled		
	☐	Locations of all permanent control measures		
	☐	Identification of permanent snow storage areas		
	☐	Identification of snow management measures during construction		
	☐	Identification of all permanent control measures and responsibility for continued maintenance		
	☐	Plans showing the entire drainage area affecting or being affected by the development of the site. Proposed lot boundaries and drainage areas shall be clearly shown on the Plan		
	☐	The direction of flow of runoff through the use of arrows shall clearly be shown on the Plan.		
	☐	The location, elevation, and size of all existing and proposed catch basins, drywells, drainage ditches, swales, retention basins, and storm sewers shall be shown on the Plan		
☐	**TRACKING AND ACCOUNTING FOR MS4 AND NPDES REPORTING**			
	☐	***Property Use Information***		***Tracking Item (Entry Required)***
		☐	Existing Use	
		☐	Proposed Use	
		☐	Is the existing land use being converted to another type of land use (Y/N)? If yes, describe	
		☐	% of current Land use being converted to another type of land use	
		☐	Parcel Area (acres)	
		☐	Existing Total Impervious Cover (acres)	
		☐	Existing Total Disconnected Impervious Area (acres)	
		☐	Proposed Total Impervious Area (acres)	
		☐	Proposed Total Disconnected or Treated Impervious Area (acres)	
	☐	***Environmental Sensitivity***		***Tracking Item (Entry Required)***
		☐	Is the property in the Shoreland Protection District? (Y/N)	
		☐	Name of Receiving Water(s) where stormwater runoff from the property discharges too	

		☐	Distance from Receiving Water (feet)	
		☐	Buffer Size	
		☐	Public or Private waste water. Does the property have a septic system ? (Y/N)	
		☐	Percent runoff to outfall	
	☐		***Septic System Information (if applicable)***	***Tracking Item (Entry Required)***
		☐	Septic System Type	
		☐	Septic System Size (gallons)	
		☐	New or Replacement	
		☐	Date of Installation	
		☐	Distance of septic system from closest down-gradient or cross-gradient water body	
		☐	Name of closest down-gradient or cross-gradient water body	
		☐	Maintenance Requirements	
		☐	Maintenance Schedule	
	☐		***Proposed BMP Information - Treatment for Nitrogen****	***Tracking Item (Entry Required)***
		☐	Calculated Annual Nitrogen Load for entire Parcel (lbs N/year)	
		☐	Calculated Annual Nitrogen Load to BMP (lbs N/year)	
		☐	Best Management Practices Type	
		☐	Assumed BMP Efficiency (% Removal Efficiency)	
		☐	Calculated Annual Nitrogen Load Reduction (lbs N/year)	
		☐	Operations and Maintenance Plan (Y/N)	
		☐	Suggested Maintenance Schedule	

*See DES Pollutant Load Calculations at http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_ch8.pdf or DPW approved alternate

Appendix J:

Maintenance Checklists for Green Infrastructure

Appendix J: Maintenance Checklists for Green Infrastructure

This appendix includes a series of checklists developed at the UNH Stormwater Center for the maintenance of green infrastructure. The checklists can also be found at:

http://www.unh.edu/unhsc/specs-and-fact-sheets-0

They include:

1. Biofilter
2. Gravel Wetland
3. Porous Pavement Routine Maintenance
4. Porous Pavement Winter Maintenance
5. Sand Filter Maintenance

Regular Inspection and Maintenance Guidance for Bioretention Systems / Tree Filters

Regular inspection and maintenance is critical to the effective operation of bioretention system and tree filters. It is the responsibility of the owner to maintain the bioretention in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, overly wet or dry (I.E., drought), regional hydrologic conditions, and any changes or redevelopment in the upstream land use.

ACTIVITIES

Visual inspections are routine for system maintenance. This includes looking for standing water, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Mulch and/or vegetation coverage is integral to the performance of the system, Including infiltration rate and nutrient uptake. Vegetation care is important to system productivity and health.

Activity	Frequency
A record should be kept of the time to drain for the system completely after a storm event. The system should drain completely within 72 hours.	After every major storm in the first few months, then biannually.
Check to insure the filter surface remains well draining after storm events. **Remedy**: If filter bed is clogged, draining poorly, or standing water covers more than 15% of the surface 48 hours after a precipitation event, then remove top few inches of discolored material. Till or rake remaining material as needed.	
Check inlets and outlets for debris. **Remedy**: Rake in and around the system to clear it of debris. Also, clear the inlet and overflow if obstructed.	Quarterly initially, biannually, frequency adjusted as needed after 3 inspections
Check for animal boroughs and short circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted	
Check to insure the filter bed does not contain more than 2 inches accumulated material **Remedy:** Remove sediment as necessary. If 2 inches or more of filter bed has been removed, replace media with either mulch or a (50% sand, 20% woodchips, 20% compost, 10% soil) mixture.	
During extended periods without rainfall, inspect plants for signs of distress. **Remedy:** Plants should be watered until established (typical only for first few months) or as needed thereafter.	
Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets, outlets, sidewalls.	Annually
Check for robust vegetation coverage throughout the system. **Remedy:** If at least 50 % vegetation coverage is not established after 2 years, reinforcement planting should be performed.	
Check for dead or dying plants, and general long term plant health. **Remedy:** This vegetation should be cut and removed from the system. If woody vegetation is present, care should be taken to remove dead or decaying plant Material. Separation of Herbaceous vegetation rootstock should occur when over-crowding is observed.	As needed

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)		Comments/Corrective Action
1. Initial Inspection After Planting and Mulching			
Plants are stable, roots not exposed	**S**	**U**	
Surface is at design level, typically 4” below overpass	**S**	**U**	
Overflow bypass / inlet (if available) is functional	**S**	**U**	
2. Debris Cleanup (2 times a year minimum, Spring & Fall)			
Litter, leaves, and dead vegetation removed from the system	**S**	**U**	
Prune perennial vegetation	**S**	**U**	
3. Standing Water (1 time a year, After large storm events)			
No evidence of standing water after 72 hours	**S**	**U**	
4. Short Circuiting & Erosion (1 times a year, After large storm events)			
No evidence of animal boroughs or other holes	**S**	**U**	
No evidence of erosion	**S**	**U**	
5. Drought Conditions (As needed)			
Water plants as needed	**S**	**U**	
Dead or dying plants	**S**	**U**	
6. Overflow Bypass / Inlet Inspection (1 times a year, After large storm events)			
No evidence of blockage	**S**	**U**	
Good condition, no need for repair	**S**	**U**	
7. Vegetation Coverage (once a year)			
50 % coverage established throughout system by first year	**S**	**U**	
Robust coverage by year 2 or later	**S**	**U**	
8. Mulch Depth (if applicable)(once every 2 years)			
Mulch at original design depth after tilling or replacement	**S**	**U**	
9. Vegetation Health (once every 3 years)			
Dead or decaying plants removed from the system	**S**	**U**	
10. Tree Pruning (once every 3 years)			
Prune dead, diseased, or crossing branches	**S**	**U**	

Corrective Action Needed	Due Date
1.	
2.	
3.	

Regular Inspection and Maintenance Guidance for Gravel Wetland Stormwater Management Device

Regular inspection and maintenance is critical to the effective operation of Gravel Wetland systems. It is the responsibility of the owner to maintain the Gravel Wetland in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, overly wet or dry (I.E., drought), regional hydrologic conditions, and any changes or redevelopment in the upstream land use.

ACTIVITIES

Visual inspections are routine for system maintenance. This includes looking for standing water, accumulated leaves, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Vegetation coverage is integral to the performance of the system and vegetation care is important to system productivity and health. A gravel wetland is a subsurface horizontal filtration system and does not rely upon the surface soils for treatment. As such, surface infiltration rates are expected to be low and not a criterion for cleaning. Rather, stormwater access to subsurface treatment is by way of inlet standpipes. It is important to ensure these inlets are performing properly.

1ST YEAR POST-CONSTRUCTION ACTIVITY	FREQUENCY
1. Check that plants have adequate water, are well established and healthy. **Remedy:** Water plants as necessary, remove or treat diseased vegetation as necessary and re-vegetate poorly established plants as necessary	After every major storm in the first few months, then biannually.
2. Check for erosion in the system and short circuiting (holes) in the surface wetland soils. **Remedy:** Soil piping, erosion, and holes should be filled, lightly compacted, and reseeded.	
POST-CONSTRUCTION ACTIVITY	**FREQUENCY**
3. Check inlets outlets and stand pipes for leaves and debris. **Remedy**: Rake in and around the system to clear it of debris. Also, clear the inlet, outlets and standpipes if obstructed.	Quarterly initially, biannually, frequency adjusted as needed after 3 inspections
4. Check for animal burrows and short circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted	
5. Check that the depth of accumulated sediment in the sedimentation chamber is less than 12 inches or 10 percent of the pretreatment volume. **Remedy:** The sedimentation chamber, forebay, and treatment cells outlet devices should be cleaned when drawdown times exceed 36 hours. Remove material with rakes where possible rather than heavy construction equipment to avoid compaction of the gravel wetland surface. Heavy equipment could be used if the system is designed with dimensions that allow equipment to be located outside the gravel wetland, while a backhoe shovel reaches inside the gravel wetland to remove sediment. Removed sediments should be dewatered (if necessary) and disposed of in an acceptable manner.	
6. Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets and outlets.	Annually
7. Check for robust vegetation coverage throughout the system. **Remedy:** If at least 50 % vegetation coverage is not established after 2 years, reinforcement planting should be performed.	
8. Cut and remove vegetation from the Gravel Wetland System and forebay in order to maintain nitrogen removal performance. **Remedy:** The vegetation should be cut and removed from the system to prevent nitrogen from cycling back into the system.	Once every 3 years

CHECKLIST FOR INSPECTION OF GRAVEL WETLAND

Location:		Inspector:
Date:	Time:	Site Conditions:
Date Since Last Rain Event:		

Inspection Items	**Satisfactory (S) or Unsatisfactory (U)**	**Comments/Corrective Action**
1st Year Post-Construction Monitoring (After every major storm for the first three months)		
Plants are stable, roots not exposed	**S U**	
Vegetation is established and thriving	**S U**	
No evidence of holes in the wetland soil causing short-circuiting	**S U**	
No evidence of erosion at inlet and outlet structures	**S U**	
Post-Construction Routine Monitoring (at least every 6 months thereafter as per USEPA Good House-Keeping Requirements. Inspection frequency can be reduced to annual following 2 years of monitoring indicating the rate of sediment accumulation is less than cleaning criteria listed below.)		
1. Standing Water		
Gravel wetland surface is free of standing water or other evidence of clogging, such as discolored or accumulated sediments	**S U**	
2. Short Circuiting & Erosion		
No evidence of animal burrows or other holes	**S U**	
No evidence of erosion	**S U**	
3. Drought Conditions (As needed)		
Water plants as needed	**S U**	
Dead or dying plants	**S U**	
4. Sedimentation Chamber or Forebay Inlet Inspection		
No evidence of sediment accumulation, trash, and debris.	**S U**	
Good condition, no need for repair	**S U**	
5. Vegetation Coverage		
50 % coverage established throughout system by first year	**S U**	
Robust coverage by year 2 or later	**S U**	
6. Inlet and Outlet Controls		
Flow is unobstructed in openings (grates, orifices, etc)	**S U**	
Structures are operational with no evidence of deterioration	**S U**	
7. Vegetation removal (once every 3 years)		
Prune dead, diseased, or decaying plants	**S U**	

Corrective Action Needed	**Due Date**
1.	
2.	
3.	

Regular Inspection and Maintenance Guidance for Porous Pavements

Regular inspection and maintenance is critical to the effective operation of porous pavement. It is the responsibility of the owner to maintain the pavement in accordance with the minimum design standards. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less, frequent maintenance needs, depending on a variety of factors including the occurrence of large storm events, seasonal changes, and traffic conditions.

Inspection Activities

Visual inspections are an integral part of system maintenance. This includes monitoring pavement to ensure water drainage, debris accumulation, and surface deterioration.

Activity	Frequency
Check for standing water on the surface of the pavement after a precipitation event. If standing water remains within 30 minutes after rainfall had ended, cleaning of porous pavement is recommended.	2 to 4 times per year, more frequently for high use sites or sites with higher potential for run-on
Vacuum sweeper shall be used regularly to remove sediment and organic debris on the pavement surface. The sweeper may be fitted with water jets.	
Pavement vacuuming should occur during spring cleanup following the last snow event to remove accumulated debris, at minimum.	
Pavement vacuuming should occur during fall cleanup to remove dead leaves, at minimum.	
Power washing can be an effective tool for cleaning clogged areas. This should occur at mid pressure typically less than 500 psi and at an angle of 30 degrees or less.	
Check for debris accumulating on pavement, especially debris buildup in winter. For loose debris, a power/leaf blower or gutter broom can be used to remove leaves and trash.	
Check for damage to porous pavements from non-design loads. Damaged areas may be repaired by use of infrared heating and rerolling of pavement. Typical costs may be 2,000/ day for approximately 500 ft of trench.	

Maintenance Activities

Routine preventative cleaning is more effective than corrective cleaning.

Activity	Frequency
Controlling run-on and debris tracking is key to extending the life of porous surfaces. Erosion and sedimentation control of adjacent areas is crucial. Vacuuming adjacent non porous asphalt can be effective at minimizing run-on.	Whenever vacuuming adjacent porous pavements
Repairs may be needed from cuts of utilities. Repairs can be made using standard (non-porous) asphalt for most damages. Repairs using standard asphalt should not exceed 15% of total area.	As needed
Do not store materials such as sand/salt, mulch, soil, yard waste, and other stock piles on porous surfaces.	
Stockpiled snow areas on porous pavements will require additional maintenance and vacuuming. Stockpiling on snow on porous pavements is not recommended and will lead to premature clogging.	
Damage can occur to porous pavement from non-design loads. Precautions such as clearance bars, signage, tight turning radius, high curbs, and video surveillance may be required where there is a risk off non-design loads.	
Posting of signage is recommended indicating presence of porous pavement. Signage should display limitation of design load (i.e. passenger vehicles only, light truck traffic, etc. as per pavement durability rating.)	

CHECKLIST FOR INSPECTION OF POROUS PAVEMENTS

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)		Comments/Corrective Action
1. Salt / Deicing *Note complete winter maintenance guidance is available at UNHSC			
Use salt only for ice management	**S**	**U**	
Piles of accumulated salt removed in spring	**S**	**U**	
2. Debris Cleanup (2-4 times a year minimum, Spring & Fall)			
Clean porous pavement to remove sediment and organic debris on the pavement surface via vacuum street sweeper.	**S**	**U**	
Adjacent non porous pavement vacuumed	**S**	**U**	
Clean catch basins (if available)	**S**	**U**	
3**. Controlling Run-On (2-4 times a year)**			
Adjacent vegetated areas show no signs of erosion and run-on to porous pavement	**S**	**U**	
4. Outlet / Catch Basin Inspection (if available) (2 times a year, After large storm events)			
No evidence of blockage	**S**	**U**	
Good condition, no need for cleaning/repair	**S**	**U**	
5. Poorly Drained Pavement (2-4 times a year)			
Pavement has been pressure washed and vacuumed	**S**	**U**	
6. Pavement Condition (2-4 times a year minimum, Spring & Fall)			
No evidence of deterioration	**S**	**U**	
No cuts from utilities visible	**S**	**U**	
No evidence of improper design load applied	**S**	**U**	
7. Signage / Stockpiling (As Needed)			
Proper signage posted indicating usage for traffic load	**S**	**U**	
No stockpiling of materials and no seal coating	**S**	**U**	

Corrective Action Needed	Due Date
1.	
2.	
3.	

Winter Maintenance Guidelines for Porous Pavements





Maintenance Guidelines

- Road surfaces, porous and non-porous, are commonly not treated and plowed until 2 or more inches of snow accumulation.
- Plow after every storm. If possible plow with a slightly raised blade, while not necessary, this will help prevent pavement scarring.
- Up to ~75% salt reduction for porous asphalt can be achieved. Salt reduction amounts are site specific and are affected by degree of shading.

  USE SALT REDUCTION NUMBERS WITH CAUTION!!!
- Pervious concrete salt reduction will vary and is heavily dependent upon shading. For shaded areas, pervious concrete may not achieve salt reduction.
- Apply anti-icing treatments prior to storms. Anti-icing has the potential to provide the benefit of increased traffic safety at the lowest cost and with less environmental impact.
- Deicing is NOT required for black ice development. Meltwater readily drains through porous surfaces thereby preventing black ice.
- Apply deicing treatments during, and after storms as necessary to control compact snow and ice not removed by plowing.
- Sand application should be limited since its use will increase the need for vacuuming
- Vacuum porous areas a minimum of 2-4 times per year, especially after winter and fall seasons when debris accumulation and deposition is greatest.
- If ponding water is observed during precipitation cleaning is recommended.

Winter Maintenance Challenges

- Mixed precipitation and compact snow or ice is problematic for all paved surfaces, but is particularly problematic for porous surfaces. This is corrected by application of excess deicing chemicals.
- De-icing chemicals work by lowering the freezing point of water. Generally, the longer a de-icing chemical has to react, the greater the amount of melting. Meltwater readily drains through porous surfaces thereby reducing chemical contact time. This is corrected by excess salt application.
- Excess salt application in these instances is offset by the overall reduced salt during routine winter maintenance and salt reduction.

Additional Resources

- The UNH Stormwater Center: http://www.unh.edu/erg/cstev/
- Pennsylvania Asphalt Pavement Association (PAPA) Porous Asphalt Pavements Guide: http://www.pahotmix.org/PDF/porous1.pdf
- National Asphalt Pavement Association (NAPA) Porous Asphalt Pavements for Stormwater Management Revised 11/2008, Information Series 131

INSPECTION AND MAINTENANCE GUIDANCE FOR UNDERGROUND SANDFILTER

REGULAR INSPECTION AND MAINTENANCE IS CRITICAL TO THE EFFECTIVE OPERATION OF AN UNDERGROUND SAND FILTER. IT IS THE RESPONSIBILITY OF THE CITY OF PORTSMOUTH TO MAINTAIN THE UNDERGROUND SANDFILTER IN ACCORDANCE WITH THE MINIMUM DESIGN STANDARDS. THIS PAGE PROVIDES GUIDANCE ON MAINTENANCE ACTIVITIES THAT ARE TYPICALLY REQUIRED FOR UNDERGROUND SAND FILTERS, ALONG WITH A SUGGESTED FREQUENCY FOR EACH ACTIVITY. INDIVIDUAL FILTERS MAY HAVE MORE, OR LESS, FREQUENT MAINTENANCE NEEDS, DEPENDING UPON A VARIETY OF FACTORS INCLUDING THE OCCURRENCE OF LARGE STORM EVENTS, OVERLY WET OR DRY (I.E., DROUGHT) REGIONAL HYDROLOGIC CONDITIONS, AND ANY CHANGES OR REDEVELOPMENT IN THE UPSTREAM LAND USE.

INSPECTION ACTIVITIES

Activity	Frequency
A record should be kept of the time to drain the filter bed completely after a storm event. The filter bed should drain completely within 48 hours.	After every major storm in the first few months, then biannually
Check to insure the filter surface does not clog after storm events	
Check inlets an outlets for debris and high efficiency	Quarterly initially, Biannually
Check to see that the filter bed is draining completely within 48 hours after a rain event	
Check to see that the filter bed does not contain more than 6 inches accumulated material	
Check to see that the pre-treatment sediment chamber is not more than 50% full.	Annually
Check to see that the pre-treatment sediment chamber is not full of trash, debris, and floatables	
Inspect inlets and outlets to ensure good condition and no evidence of deterioration	
Ensure that no noticeable odors are detected outside of the facility.	
Check to see if high-flow bypass is functioning	

MAINTENANCE ACTIVITIES

Activity	Frequency
Ensure the activities in the area minimize oil/grease and sediment entry to the system.	Biannually, frequency adjusted as needed after 3 inspections
Check to see that the filter bed is clean of sediment. Remove sediment as necessary.	
If filter bed is clogged or draining poorly, remove top few inches of discolored material. Till or rake remaining material as needed.	
If 6 inches or more of filter bed has been removed, replace media with sand meeting design specifications	As needed
Repair or replace any damaged structural parts, inlets, outlets, valves	

CHECKLIST FOR INSPECTION OF UNDERGROUND SANDFILTER

Location:
Inspector:
Date: Time: Site Conditions:
Date Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Complete drainage of filter within 48 hours after rain event		
2. Sediment accumulation on filter bed, 6" or less		
3. Clogging of filter surface		
4. Filter clear of debris		
5. Pre-treatment chamber less than 50% full or ≥ 6 inches		
6. Pre-treatment chamber empty of trash, debris, and floatables		
7. Clogging of inlet/outlet structures		
8. Cracking, spalling, or deterioration of concrete		
9. Leaks or seeps in filter		
10. Animal burrows		
11. Undesirable vegetation		
12. Undesirable odors		
13. Complaints from residents		
14. Public hazards noted		
15. High-flow bypass structure functioning and clear of debris		

IF ANY OF THE ABOVE INSPECTION ITEMS ARE UNSATISFACTORY, LIST CORRECTIVE ACTIONS AND THE CORRESPONDING COMPLETION DATES.

Corrective Action Needed	Due Date
1.	
2.	
3.	
4.	
5.	