# APPENDIX F

# REQUIREMENTS OF APPROVED TOTAL MAXIMUM DAILY LOADS

## I. Chloride TMDLs

Permittees that operate regulated MS4s in the municipalities identified in Derry, Londonderry, Salem and Windham that discharge to Beaver Brook; Dinsmore Brook; North Tributary to Canobie Lake; Policy-Porcupine Brook, and any other permittee that discharges to those waterbodies, shall reduce chloride discharges to support achievement of the WLA included in the applicable approved TMDL[1] by complying with EITHER Appendix F Part I.1 or Appendix F Part I.2 below.

1. The permittee shall develop a Chloride Reduction Plan that includes specific actions designed to achieve chloride reduction on municipal roads and facilities, and on private facilities that drain to the MS4. The Chloride Reduction Plan shall be completed within one (1) year of the effective date of the permit and shall include, at a minimum:

    a. For municipally maintained surfaces:

        i. Tracking of the amount of salt applied to all municipally owned and maintained surfaces and reporting of salt use using the UNH Technology Transfer Center online tool (http://www.roadsalt.unh.edu/Salt/) beginning in the year 2 annual report;

        ii. Planned activities for salt reduction on municipally owned and maintained surfaces, which may include but are not limited to:
            - Operational changes such as pre-wetting, pre-treating the salt stockpile, increasing plowing prior to de-icing, monitoring of road surface temperature, etc.;
            - Implementation of new or modified equipment providing pre-wetting capability, better calibration rates, or other capability for minimizing salt use;
            - Training for municipal staff and/or contractors engaged in winter maintenance activities;
            - Adoption of guidelines for application rates for roads and parking lots (see NHDES, Chloride Reduction Implementation Plan for Dinsmore Brook, App. J and K (February 2011); Winter Parking Lot and Sidewalk Maintenance Manual (Revised edition June 2008); and the application guidelines on page 17 of Minnesota Snow and Ice Control: Field Handbook for Snow Operators (September 2012) for examples );
            - Regular calibration of spreading equipment;
            - Designation of no-salt and/or low salt zones;

[1] Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Beaver Brook in Derry and Londonderry, NH (2008), Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Dinsmore Brook in Windham, NH (2008), Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: North Tributary to Canobie Lake in Windham, NH (2008), Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Policy-Porcupine Brook in Salem and Windham, NH (2008)

- Public education regarding impacts of salt use, methods to reduce salt use on private property, modifications to driving behavior in winter weather, etc.; and
- Measures to prevent exposure of salt stockpiles (if any) to precipitation and runoff; and

iii. An estimate of the total tonnage of salt reduction expected by each activity; and

iv. A schedule for implementation of planned activities including immediate implementation of operational and training measures, continued annual progress on other measures, and full implementation of the Plan by the end of the permit term.

b. For privately maintained facilities that drain to the MS4:

i. Identification of private parking lots with 10 or more parking spaces draining to the MS4;

ii. Requirements for private parking lot owners and operators and private street owners and operators (1) that any commercial salt applicators used for applications of salt to their parking lots or streets be trained and certified in accordance with Env-Wq 2203, and (2) to report annual salt usage within the municipal boundaries using the UNH Technology Transfer Center online tool (http://www.roadsalt.unh.edu/Salt/) or report salt usage directly to the permittee, in which case this information should be reported on the permittees annual report.

iii. Requirements for new development and redevelopment to minimize salt usage, and to track and report amounts used using the UNH Technology Transfer Center online tool (http://www.roadsalt.unh.edu/Salt/).

c. At any time during the permit term the permittee may be relieved of additional requirements in Appendix F part I.1.a-b. as follows.

i. The permittee is relieved of its additional requirements as of the date when the following conditions are met:

1. The applicable TMDL has been modified or revised and EPA has approved a new TMDL applicable for the receiving water that indicates that no additional stormwater controls for the control of chloride are necessary for the permittee's discharge based on wasteload allocations in the newly approved TMDL

ii. When the criteria in Appendix F part I.1.c.i. are met, the permittee shall document the date of the approved TMDL in its SWMP and is relieved of any remaining requirements of Appendix F part I.1.a.-b. as of that date and the permittee shall comply with the following:

1. The permittee shall identify in its SWMP all activities implemented in accordance with the requirements of Appendix F part.I.1.a.-b. to date to reduce chloride in their discharges including implementation schedules for non-structural BMPs and any maintenance requirements for structural BMPs
2. The permittee shall continue to implement all requirements of Appendix F part I.a.-b. required to be implemented prior to the date of the newly approved TMDL, including ongoing implementation of identified non-structural BMPs and routine maintenance and replacement of all structural BMPs in accordance with manufacturer or design specifications,

2. The MS4 operator shall work with NHDES to develop an Alternative Chloride Reduction Plan consistent with the applicable TMDL. The MS4 operator shall submit a NHDES-approved Alternative Chloride Reduction Plan that is consistent with the TMDL Implementation Plan and includes schedules and milestones to meet applicable Waste Load Allocations, with their Notice of Intent (NOI) as an alternative to the requirements described in Appendix F part I.1. above.
    a. The Alternative Chloride Reduction Plan shall be subject to EPA review and the public comment period consistent with the NOI procedures at part 1.7.4.b. of the permit.
    b. The permittee shall keep the written plan (hardcopy or electronic) as part of their SWMP.
    c. The permittee shall implement all operator-specific permit requirements included in the permittee's authorization letter from EPA based on the Alternative Chloride Reduction Plan.
    d. Unless the operator-specific permit requirements related to the Alternative Chloride Reduction Plan are authorized by EPA, the permittee is subject to the requirements described in Appendix F part I.1. above.

## II. Bacteria TMDLs

Permittees that operate regulated MS4s in the municipalities identified on Table F-1 that discharge to waterbodies listed on Table F-1 in Appendix F, and any other permittee that discharges to waterbodies listed on Table F-1 in Appendix F, shall reduce bacteria or pathogen discharges to support achievement of the WLA included in the approved TMDLs[2] by complying with EITHER Appendix F Part II.1 or Appendix F Part II.2 below.

1. Traditional and non-traditional MS4s operating in the municipalities listed in Table F-1 and/or that discharge to a waterbody listed on Table F-1 shall comply with the following BMPs in addition to the requirements of part 2.3 of the Permit, as described below:

    a. Enhancement of BMPs required by part 2.3 of the permit that shall be implemented during this permit term:

        i. Part 2.3.3. Public Education: The permittee shall replace its Residential program with an annual message encouraging the proper management of pet waste, including noting any existing ordinances where appropriate, at a minimum. The permittee or its agents shall disseminate educational materials to dog owners at the time of issuance or renewal of a dog license, or other appropriate time. Education materials shall describe the detrimental impacts of improper management of pet waste, requirements for waste collection and disposal, and penalties for non-compliance. The permittee shall also provide information to owners of septic systems about proper maintenance in any catchment that discharges to a water body impaired for bacteria or pathogens.

        ii. Part 2.3.4 Illicit Discharge: The permittee shall implement the illicit discharge program required by this permit. Catchments draining to any waterbody impaired for bacteria or pathogens shall be designated either Problem Catchments or HIGH priority in implementation of the IDDE program.

    b. At any time during the permit term the permittee may be relieved of additional requirements in Appendix F part II.1.a., as follows:

        i. The permittee is relieved of its additional requirements as of the date when the following conditions are met:

            1. The applicable TMDL has been modified or revised and EPA has approved a new TMDL applicable for the receiving water that indicates that no additional stormwater controls for the control of bacteria/pathogens are necessary for the permittee's discharge based on wasteload allocations in the newly approved TMDL

[2] Hampton/Seabrook Harbor Bacteria TMDL, May 2004, Little Harbor Bacteria TMDL, June 2006, Final Report New Hampshire Statewide TMDL for Bacteria Impaired Waters, September 2010, Final Report TMDL Report for 58 Bacteria Impaired Waters in New Hampshire, August2011, Final TMDL Report for 44 Bacteria Impaired Waters in New Hampshire, September 2013, Final TMDL Report for 3 Bacteria Impaired Waters in New Hampshire, September 2015, Bacteria TMDL Report for Camp Hadar Beach on Captain Pond in Salem, NH, September 2016

ii. When the criteria in Appendix F Part II.1.b.i. are met, the permittee shall document the date of the approved TMDL in its SWMP and is relieved of any remaining requirements of Appendix F Part II.1.a. as of that date and the permittee shall comply with the following:
   1. The permittee shall identify in its SWMP all activities implemented in accordance with the requirements of Appendix F Part II.1.a. to date to reduce bacteria/pathogen in their discharges including implementation schedules for non-structural BMPs and any maintenance requirements for structural BMPs
   2. The permittee shall continue to implement all requirements of Appendix F Part II.1.a. required to be implemented prior to the date of the newly approved TMDL, including ongoing implementation of identified non-structural BMPs and routine maintenance and replacement of all structural BMPs in accordance with manufacturer or design specifications

2. The MS4 operator shall work with NHDES to develop an Alternative Bacteria/Pathogens Reduction Plan consistent with the applicable TMDL. The MS4 operator shall submit a NHDES-approved Alternative Bacteria/Pathogens Reduction Plan that is consistent with the TMDL Implementation Plan and includes schedules and milestones to meet applicable Waste Load Allocations, with their Notice of Intent (NOI) as an alternative to the requirements described in Appendix F Part II.1. above.

a. The Alternative Bacteria/Pathogens Reduction Plan shall be subject to EPA review and the public comment period consistent with the NOI procedures at Part 1.7.4.b. of the permit.
b. The permittee shall keep the written plan (hardcopy or electronic) as part of their SWMP.
c. The permittee shall implement all operator-specific permit requirements included in the permittee's authorization letter from EPA based on the Alternative Bacteria/Pathogens Reduction Plan.
d. Unless the operator-specific permit requirements related to the Alternative Bacteria/Pathogens Reduction Plan are authorized by EPA, the permittee is subject to the requirements described in Appendix F Part II.1. above.

**Table F-1 – Waterbodies and Primary Municipalities subject to a Bacteria TMDL.**

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| ALLENSTOWN | CATAMOUNT POND - BEAR BROOK STATE PARK BEACH | NHLAK700060503-02-02 | Escherichia coli |
| AMHERST | BABOOSIC LAKE - TOWN BEACH | NHLAK700060905-01-02 | Escherichia coli |
| AMHERST; MILFORD | SOUHEGAN RIVER | NHRIV700060906-16 | Escherichia coli |
| AMHERST; MERRIMACK | BABOOSIC LAKE | NHLAK700060905-01-01 | Escherichia coli |
| BEDFORD | PATTEN BROOK | NHRIV700060803-12 | Escherichia coli |
| BEDFORD | MCQUADE BROOK | NHRIV700060905-13 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| GOFFSTOWN; BEDFORD | RIDDLE BROOK | NHRIV700060905-18 | Escherichia coli |
| DERRY | ISLAND POND - CHASE'S GROVE | NHLAK700061101-01-02 | Escherichia coli |
| DERRY | BEAVER LAKE - GALLIEN'S BEACH | NHLAK700061203-02-02 | Escherichia coli |
| DERRY | HOODS POND - TOWN BEACH | NHLAK700061203-03-02 | Escherichia coli |
| DERRY | RAINBOW LAKE - KAREN-GENA BEACH | NHLAK700061203-05-02 | Escherichia coli |
| DERRY | BEAVER BROOK | NHRIV700061203-09 | Escherichia coli |
| DERRY | TAYLOR BROOK | NHRIV700061101-05 | Escherichia coli |
| DOVER; ROLLINSFORD | SALMON FALLS RIVER | NHEST600030406-01 | Enterococcus |
| DOVER; ROLLINSFORD | SALMON FALLS RIVER | NHEST600030406-01 | Fecal coliform |
| DOVER | COCHECO RIVER | NHEST600030608-01 | Enterococcus |
| DOVER | COCHECO RIVER | NHEST600030608-01 | Fecal coliform |
| DOVER | DOVER WWTF SZ-NH | NHEST600031001-01-02 | Enterococcus |
| DOVER | COCHECO RIVER - CENTRAL AVE DAM | NHIMP600030608-04 | Escherichia coli |
| DOVER | BELLAMY RIVER - SAWYERS MILL DAM POND | NHIMP600030903-02 | Escherichia coli |
| DOVER; ROLLINSFORD | FRESH CREEK POND | NHLAK600030608-01 | Escherichia coli |
| ROCHESTER; SOMERSWORTH; DOVER | BLACKWATER BROOK-CLARK BROOK | NHRIV600030608-02 | Escherichia coli |
| ROCHESTER; DOVER | COCHECO RIVER | NHRIV600030608-03 | Escherichia coli |
| DOVER | REYNERS BROOK | NHRIV600030608-04 | Escherichia coli |
| DOVER | COCHECO RIVER | NHRIV600030608-05 | Escherichia coli |
| DOVER | INDIAN BROOK | NHRIV600030608-06 | Escherichia coli |
| DOVER | BERRY BROOK | NHRIV600030608-15 | Escherichia coli |
| DOVER | JACKSON BROOK | NHRIV600030608-16 | Escherichia coli |
| DOVER | BELLAMY RIVER | NHRIV600030903-09 | Escherichia coli |
| DOVER | VARNEY BROOK - CANNEY BROOK | NHRIV600030903-11 | Escherichia coli |
| DOVER | GARRISON BROOK | NHRIV600030903-13 | Escherichia coli |
| DOVER | BELLAMY RIVER NORTH | NHEST600030903-01-01 | Fecal Coliform |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| DOVER | UPPER PISCATAQUA RIVER-NH-NORTH | NHEST600031001-01-01 | Fecal coliform |
| DOVER | UPPER PISCATAQUA RIVER-NH-SOUTH | NHEST600031001-01-03 | Fecal coliform |
| DOVER | BELLAMY RIVER SOUTH1 | NHEST600030903-01-02 | Enterococcus/Fecal Coliform |
| DOVER | COCHECO RIVER - WATSON-WALDRON DAM POND | NHIMP600030608-02 | Escherichia coli |
| DURHAM | OYSTER RIVER | NHEST600030902-01-03 | Enterococcus |
| DURHAM | ADAMS POINT SOUTH - COND APP1 | NHEST600030904-04-06 | Enterococcus/Fecal Coliform |
| DURHAM | OYSTER RIVER | NHIMP600030902-04 | Escherichia coli |
| DURHAM | BEARDS CREEK | NHIMP600030902-06 | Escherichia coli |
| DURHAM | OYSTER RIVER | NHRIV600030902-05 | Escherichia coli |
| DURHAM | LONGMARSH BROOK - BEAUDETTE BROOK | NHRIV600030902-06 | Escherichia coli |
| DURHAM | HAMEL BROOK | NHRIV600030902-08 | Escherichia coli |
| DURHAM | COLLEGE BROOK | NHRIV600030902-09 | Escherichia coli |
| DURHAM | RESERVOIR BROOK | NHRIV600030902-10 | Escherichia coli |
| DURHAM | LITTLEHOLE CREEK | NHRIV600030902-11 | E coli |
| DURHAM | CROMMENT CREEK | NHEST600030904-04-02 | Fecal Coliform |
| DURHAM | ADAMS POINT TRIB | NHEST600030904-06-11 | Fecal Coliform |
| DURHAM | OYSTER RIVER MOUTH | NHEST600030904-06-17 | Fecal Coliform |
| EXETER | EXETER RIVER - EXETER RIVER DAM I | NHIMP600030805-04 | Escherichia coli |
| EXETER | EXETER RIVER | NHRIV600030805-02 | Escherichia coli |
| EXETER | NORRIS BROOK | NHRIV600030806-01 | Escherichia coli |
| GOFFSTOWN; MANCHESTER | NAMASKE LAKE | NHLAK700060607-02 | Escherichia coli |
| GOFFSTOWN | HARRY BROOK | NHRIV700060607-15 | Escherichia coli |
| GOFFSTOWN | CATAMOUNT BROOK | NHRIV700060607-20 | Escherichia coli |
| GOFFSTOWN | GLEN LAKE - PUBLIC (STATE OWNED) BEACH | NHLAK700060607-01-02 | Escherichia coli |
| GREENLAND | UNKNOWN RIVER - WINNICUT RIVER DAM POND | NHIMP600030901-02 | Escherichia coli |
| GREENLAND | HAINES BROOK | NHRIV600030901-03 | Escherichia coli |
| GREENLAND | NORTON BROOK | NHRIV600030901-06 | E coli |
| GREENLAND | FOSS BROOK | NHRIV600030904-05 | E coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| GREENLAND | SHAW BROOK | NHRIV600030904-13 | Escherichia coli |
| GREENLAND | UNNAMED BROOK | NHRIV600030904-21 | Escherichia coli |
| GREENLAND | WINNICUT RIVER | NHEST600030904-01 | Fecal coliform |
| GREENLAND; STRATHAM; NORTH HAMPTON | WINNICUT RIVER-BARTON BROOK-MARSH BROOK-THOMPSON BROOK | NHRIV600030901-02 | Escherichia coli |
| HAMPSTEAD | WASH POND - TOWN BEACH | NHLAK700061101-03-02 | Escherichia coli |
| HAMPSTEAD | SUNSET LAKE - SUNSET PARK BEACH | NHLAK700061101-03-03 | Escherichia coli |
| HAMPTON | HAMPTON RIVER MARINA SZ | NHEST600031004-09-08 | Enterococcus |
| HAMPTON | ATLANTIC OCEAN - HAMPTON BEACH STATE PARK BEACH | NHOCN000000000-02-10 | Enterococcus |
| HAMPTON | TAYLOR RIVER | NHEST600031003-03 | Fecal Coliform |
| HAMPTON | HAMPTON FALLS RIVER | NHEST600031004-01-03 | Fecal Coliform |
| HAMPTON | TAYLOR RIVER (LOWER) | NHEST600031004-02-02 | Fecal Coliform |
| HAMPTON | HAMPTON RIVER 2, R, 65.60, AC | NHEST600031004-04-02 | Enterococcus |
| HAMPTON; SEABROOK | HAMPTON HARBOR SEG. 04-03 | NHEST600031004-04-03 | Fecal Coliform |
| HAMPTON; SEABROOK | HAMPTON HARBOR SEG. 09-01 | NHEST600031004-09-01 | Fecal Coliform |
| HAMPTON | HAMPTON/SEABROOK HARBOR 02 | NHEST600031004-09-02 | |
| HOLLIS | SILVER LAKE - STATE PARK BEACH | NHLAK700061001-02-02 | Escherichia coli |
| AMHERST; MILFORD; HOLLIS | WITCHES BROOK | NHRIV700061001-02 | Escherichia coli |
| HOLLIS | FLINTS BROOK, | NHRIV700040402-03 | Escherichia coli |
| HOOKSETT | MESSER BROOK | NHRIV700060802-09 | E coli |
| HOOKSETT; MANCHESTER | MERRIMACK RIVER | NHRIV700060802-14-02 | Escherichia coli |
| HUDSON | ROBINSON POND | NHLAK700061203-06-01 | Escherichia coli |
| HUDSON | ROBINSON POND - TOWN BEACH | NHLAK700061203-06-02 | Escherichia coli |
| HUDSON | LAUNCH BROOK | NHRIV700061203-26 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| KINGSTON | COUNTRY POND - LONE TREE SCOUT RESV. BEACH | NHLAK700061403-03-03 | Escherichia coli |
| KINGSTON | GREAT POND - KINGSTON STATE PARK BEACH | NHLAK700061403-06-02 | Escherichia coli |
| KINGSTON | GREAT POND - CAMP BLUE TRIANGLE BEACH | NHLAK700061403-06-03 | Escherichia coli |
| KINGSTON | Park Association Beach, Great Pond | NHLAK700061403-06-05 | Escherichia coli |
| MANCHESTER | MERRIMACK RIVER - AMOSKEAG DAM | NHIMP700060802-04 | Escherichia coli |
| MANCHESTER | CRYSTAL LAKE-TOWN BEACH | NHLAK700060703-02-02 | Escherichia coli |
| GOFFSTOWN; MANCHESTER | UNNAMED BROOK - TO PISCATAQUOG RIVER | NHRIV700060607-35 | E coli |
| MANCHESTER; AUBURN; LONDONDERRY | COHAS BROOK - LONG POND BROOK | NHRIV700060703-05 | Escherichia coli |
| MANCHESTER | UNNAMED BROOK - FROM PINE ISLAND POND TO MERRIMACK RIVER | NHRIV700060703-09 | Escherichia coli |
| MANCHESTER | RAYS BROOK | NHRIV700060802-15 | E coli |
| MANCHESTER; BEDFORD | MERRIMACK RIVER | NHRIV700060803-14-02 | Escherichia coli |
| MERRIMACK | NATICOOK LAKE - WASSERMAN PARK BEACH | NHLAK700061002-04-02 | Escherichia coli |
| MANCHESTER; BEDFORD; MERRIMACK; LITCHFIELD | MERRIMACK RIVER | NHRIV700060804-11 | Escherichia coli |
| AMHERST; MERRIMACK | SOUHEGAN RIVER | NHRIV700060906-18 | Escherichia coli |
| AMHERST; MERRIMACK; NASHUA; HOLLIS | PENNICHUCK BROOK - WITCHES BROOK | NHRIV700061001-07 | Escherichia coli |
| MERRIMACK; LITCHFIELD | MERRIMACK RIVER | NHRIV700061002-13 | Escherichia coli |
| MERRIMACK | SOUHEGAN RIVER | NHRIV700060906-25 | Escherichia coli |
| MILFORD | SOUHEGAN RIVER - MCLANE DAM | NHIMP700060906-08 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| MILFORD | PURGATORY BROOK | NHRIV700060904-07 | Escherichia coli |
| WILTON; MILFORD | SOUHEGAN RIVER | NHRIV700060904-14 | Escherichia coli |
| MILFORD | GREAT BROOK - OX BROOK | NHRIV700060906-12 | Escherichia coli |
| MILFORD | SOUHEGAN RIVER | NHRIV700060906-13 | Escherichia coli |
| MILTON | MILTON POND - MILTON POND REC AREA BEACH | NHLAK600030404-01-03 | Escherichia coli |
| MILTON | DAMES BROOK | NHRIV600030601-07 | Escherichia coli |
| MILTON | JONES BROOK | NHRIV600030402-04 | Escherichia coli |
| NASHUA | NASHUA RIVER - NASHUA CANAL DIKE | NHIMP700040402-03 | E coli |
| NASHUA | NASHUA RIVER - JACKSON PLANT DAM POND | NHIMP700040402-05 | Escherichia coli |
| NASHUA | NASHUA RIVER | NHRIV700040402-08 | Escherichia coli |
| NASHUA | NASHUA RIVER | NHRIV700040402-09 | Escherichia coli |
| MERRIMACK; LITCHFIELD; HUDSON; NASHUA | MERRIMACK RIVER | NHRIV700061002-14 | Escherichia coli |
| NASHUA | SALMON BROOK - HASSELLS BROOK - OLD MAIDS BROOK - HALE BROOK | NHRIV700061201-05 | Escherichia coli |
| NASHUA | SALMON BROOK | NHRIV700061201-07 | Escherichia coli |
| HUDSON; NASHUA | MERRIMACK RIVER | NHRIV700061206-24 | Escherichia coli |
| NEW CASTLE | ATLANTIC OCEAN - NEW CASTLE BEACH | NHOCN000000000-02-02 | Enterococcus |
| NEWMARKET; GREENLAND; STRATHAM | GREAT BAY PROHIB SZ1 | NHEST600030904-02 | Enterococcus |
| NEWMARKET | LAMPREY RIVER | NHEST600030709-01 | Enterococcus |
| NORTH HAMPTON; HAMPTON | LITTLE RIVER | NHEST600031004-10 | Fecal coliform |
| NORTH HAMPTON | ATLANTIC OCEAN - STATE BEACH1 | NHOCN000000000-02-09 | Enterococcus/Fecal Coliform |
| NORTH HAMPTON | CHAPEL BROOK | NHEST600031002-03 | Fecal coliform |
| NORTH HAMPTON | TRIBUTARY TO CHAPEL BROOK | NHRIV600031002-23 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| NORTH HAMPTON | CHAPEL BROOK | NHRIV600031002-24 | Escherichia coli |
| PELHAM | LONG POND - TOWN BEACH | NHLAK700061205-02-02 | Escherichia coli |
| WINDHAM; HUDSON; PELHAM | BEAVER BROOK | NHRIV700061203-22 | Escherichia coli |
| PELHAM | BEAVER BROOK - TONYS BROOK | NHRIV700061205-01 | Escherichia coli |
| HAMPSTEAD; PLAISTOW; ATKINSON | KELLY BROOK - SEAVER BROOK | NHRIV700061401-04 | Escherichia coli |
| PORTSMOUTH; NEW CASTLE | LOWER PISCATAQUA RIVER - SOUTH | NHEST600031001-02-02 | Enterococcus |
| PORTSMOUTH | UPPER SAGAMORE CREEK | NHEST600031001-03 | Fecal coliform |
| PORTSMOUTH | UPPER SAGAMORE CREEK | NHEST600031001-03 | Enterococcus |
| PORTSMOUTH; NEW CASTLE; RYE | LOWER SAGAMORE CREEK | NHEST600031001-04 | Enterococcus |
| PORTSMOUTH | SOUTH MILL POND | NHEST600031001-09 | Enterococcus |
| PORTSMOUTH | NORTH MILL POND | NHEST600031001-10 | Enterococcus |
| PORTSMOUTH; GREENLAND | PICKERING BROOK | NHRIV600030904-06 | Escherichia coli |
| PORTSMOUTH | SAGAMORE CREEK | NHRIV600031001-03 | Escherichia coli |
| PORTSMOUTH | LOWER HODGSON BROOK | NHRIV600031001-04 | Escherichia coli |
| PORTSMOUTH | UPPER HODGSON BROOK | NHRIV600031001-05 | Escherichia coli |
| PORTSMOUTH | PAULS BROOK - PEASE AIR FORCE BASE | NHRIV600031001-07 | Escherichia coli |
| PORTSMOUTH | BORTHWICK AVE TRIBUTARY | NHRIV600031001-09 | Escherichia coli |
| PORTSMOUTH | NEWFIELDS DITCH | NHRIV600031001-10 | Escherichia coli |
| RAYMOND | LAMPREY RIVER - CARROLL LAKE BEACH | NHRIV600030703-07-02 | Escherichia coli |
| ROCHESTER | SALMON FALLS RIVER - BAXTER MILL DAM POND | NHIMP600030405-04 | Escherichia coli |
| ROCHESTER | COCHECO RIVER - GONIC DAM POND | NHIMP600030607-02 | Escherichia coli |
| ROCHESTER | COCHECO RIVER | NHRIV600030603-06 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| ROCHESTER | COCHECO RIVER | NHRIV600030603-08 | Escherichia coli |
| ROCHESTER | WILLOW BROOK | NHRIV600030603-10 | Escherichia coli |
| ROCHESTER | ISINGLASS RIVER | NHRIV600030607-10 | E coli |
| ROCHESTER | COCHECO RIVER - CITY DAM 1 | NHIMP600030603-01 | Escherichia coli |
| ROCHESTER | COCHECO RIVER - HATFIELD | NHIMP600030603-02 | Escherichia coli |
| ROCHESTER | AXE HANDLE BROOK - HOWARD BROOK | NHRIV600030602-03 | Escherichia coli |
| ROLLINSFORD | SALMON FALLS RIVER - SOUTH BERWICK DAM | NHIMP600030406-04 | Escherichia coli |
| SOMERSWORTH; ROLLINSFORD | FRESH CREEK - TWOMBLY BROOK | NHRIV600030608-08 | Escherichia coli |
| ROLLINSFORD | ROLLINS BROOK | NHRIV600030608-10 | Escherichia coli |
| DOVER; ROLLINSFORD | FRESH CREEK | NHRIV600030608-11 | Escherichia coli |
| RYE | WITCH CREEK1 | NHEST600031002-01-01 | Enterococcus/Fecal Coliform |
| RYE | BERRYS BROOK1 | NHEST600031002-01-02 | Enterococcus/Fecal Coliform |
| NEW CASTLE; RYE | LITTLE HARBOR | NHEST600031002-02 | Total Fecal; Enterococcus |
| RYE | PARSONS CREEK | NHEST600031002-05 | Fecal coliform |
| RYE | ATLANTIC OCEAN - PIRATES COVE BEACH | NHOCN000000000-02-04 | Enterococcus |
| RYE | ATLANTIC OCEAN - CABLE BEACH | NHOCN000000000-02-05 | Enterococcus |
| RYE | ATLANTIC OCEAN - SAWYER BEACH1 | NHOCN000000000-02-06 | Enterococcus/Fecal Coliform |
| RYE | ATLANTIC OCEAN - JENNESS BEACH | NHOCN000000000-02-07 | Enterococcus |
| RYE; NORTH HAMPTON | BASS BROOK BEACH OUTFALL AREA1 | NHOCN000000000-03-01 | Enterococcus/Fecal Coliform |
| NORTH HAMPTON | ATLANTIC OCEAN - BASS BEACH1 | NHOCN000000000-03-02 | Enterococcus/Fecal Coliform |
| PORTSMOUTH; GREENLAND; RYE | BERRY'S BROOK | NHRIV600031002-01 | Escherichia coli |
| RYE | UNNAMED BROOKS - TO ATLANTIC OCEAN AT CONCORD POINT | NHRIV600031002-03 | Escherichia coli |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| RYE | UNNAMED BROOK TO BASS BEACH | NHEST600031002-04 | Fecal coliform |
| RYE | UNNAMED BROOK - FROM EEL POND TO ATLANTIC OCEAN RYE OUTFALL | NHRIV600031002-10 | Escherichia coli |
| SALEM | ARLINGTON MILL RESERVOIR-SECOND ST BEACH | NHLAK700061101-04-02 | E coli |
| SALEM | CAPTAIN POND - CAPTAIN'S BEACH | NHLAK700061102-03-02 | Escherichia coli |
| SALEM | CAPTAIN POND - CAMP OTTER SWIM AREA BEACH | NHLAK700061102-03-03 | Escherichia coli |
| SALEM | MILLVILLE LAKE - TOWN BEACH | NHLAK700061102-06-02 | E coli |
| SALEM | Merrimack River | NHRIV700061102-03-06 | Escherichia coli |
| SALEM | ARLINGTON MILL RESERVOIR-ARLINGTON POND IMPROVEMENT ASSOC | NHLAK700061101-04-03 | Escherichia coli |
| SALEM | SALEM TOWN BEACH-HEDGEHOG POND | NHLAK700061102-13 | Escherichia coli |
| SANDOWN | EXETER RIVER | NHRIV600030802-03 | Escherichia coli |
| SEABROOK | MILL CREEK | NHEST600031004-07 | Enterococcus |
| SEABROOK | MILL CREEK | NHEST600031004-07 | Enterococcus |
| SEABROOK | BLACKWATER RIVER | NHEST600031004-08-04 | Enterococcus |
| SEABROOK | SEABROOK HARBOR BEACH | NHEST600031004-09-05 | Enterococcus |
| SEABROOK | ATLANTIC OCEAN - SEABROOK TOWN BEACH | NHOCN000000000-02-11 | Enterococcus |
| SEABROOK | CAINS BROOK - NOYES POND | NHIMP600031004-06 | E coli |
| SEABROOK | CAIN'S BROOK | NHRIV600031004-10 | Escherichia coli |
| SEABROOK | CAIN'S BROOK | NHRIV600031004-12 | Escherichia coli |
| SEABROOK | UNNAMED BROOK TO CAINS MILL POND | NHRIV600031004-21 | E coli |
| SEABROOK | Hunts Island Creek, P/Uc, 15.99, Ac | NHEST600031004-06 | Fecal Coliform |
| SEABROOK | BLACKWATER RIVER 1, R, 69.47, AC | NHEST600031004-08-01 | Enterococcus |

| Towns | Waterbody Name | Assessment Unit # | Impairment |
|---|---|---|---|
| SEABROOK | BLACKWATER RIVER 2, R, 71.07, AC | NHEST600031004-08-02 | Enterococcus |
| SOMERSWORTH | SALMON FALLS RIVER - LOWER GREAT FALLS DAM | NHIMP600030406-02 | Escherichia coli |
| SOMERSWORTH; DOVER | WILLAND POND | NHLAK600030405-03 | E coli |
| ROCHESTER; SOMERSWORTH | SALMON FALLS RIVER | NHRIV600030405-14 | Escherichia coli |
| SOMERSWORTH | SALMON FALLS RIVER | NHRIV600030406-03 | Escherichia coli |
| STRATHAM; EXETER | WHEELWRIGHT CREEK - PARKMAN BROOK | NHRIV600030806-04 | Escherichia coli |
| STRATHAM | TRIB TO SQUAMSCOTT RIVER - STUART DAIRY FARM | NHRIV600030806-14 | Escherichia coli |
| STRATHAM | SQUAMSCOTT RIVER | NHEST600030806-01 | Enterococcus |
| WILTON | CAMP ANN JACKSON GIRL SCOUT POND SWIMMING AREA | NHIMP700060902-13-02 | E coli |
| WILTON | SOUHEGAN RIVER - PINE VALLEY MILL | NHIMP700060904-08 | Escherichia coli |
| WILTON | SOUHEGAN RIVER - TUCKER BROOK | NHRIV700060902-05 | Escherichia coli |
| WILTON | SOUHEGAN RIVER | NHRIV700060902-13 | Escherichia coli |
| WILTON | STONY BROOK - TOWN BEACH (GOSS PARK) | NHRIV700060903-16-02 | Escherichia coli |
| WILTON | SOUHEGAN RIVER - STONY BROOK | NHRIV700060904-13 | Escherichia coli |
| WINDHAM | TOWN BEACH - COBBETTS POND | NHLAK700061204-01-03 | Escherichia coli |

## III. Lake and Pond Phosphorus TMDLs

Permittees that operate regulated MS4s in the municipalities identified on Table F-2 that discharge to waterbodies listed on Table F-2 in Appendix F or their tributaries, and any other permittee that discharges to waterbodies listed on Table F-2 in Appendix F or their tributaries, shall reduce phosphorus discharges to support achievement of the WLA included in the approved TMDLs complying with EITHER Appendix F Part III.1 or Appendix F Part III.2 below.

1. The permittee shall develop a Lake Phosphorus Control Plan (LPCP) designed to reduce the amount of phosphorus in stormwater discharges from its MS4 to the impaired waterbody or its tributaries consistent with assumptions and requirements of the WLA for the phosphorous loadings published in the applicable phosphorus TMDL (see Table F-2 for TMDL names and links to applicable phosphorus TMDLs). Table F-2, Appendix F provides the percent reductions in stormwater total phosphorus load for each municipality to be consistent with the assumptions and requirements of the WLA

**Table F-2: Waterbodies and Primary Municipalities subject to a Lake or Pond Phosphorus TMDL**

| Towns | Water Body Name | % Reduction In TP Load for all Sources | TMDL Link |
|---|---|---|---|
| Amherst; Merrimack | Baboosic Lake | 44% | Baboosic TMDL |
| Merrimack | Horseshoe Pond | 76% | Horseshoe TMDL |
| Manchester | Nutt Pond | 71% | Nutt TMDL |
| Manchester | Pine Island Pond | 64% | Pine Island TMDL |
| Hudson | Robinson Pond | 48% | Robinson TMDL |
| Bedford | Sebbins Pond | 64% | Sebbins TMDL |
| Sandown | Showell Pond | 69% | Showell TMDL |
| Manchester | Stevens Pond | 50% | Stevens TMDL |
| Derry | Hoods Pond | 76% | Hoods TMDL |
| Kingston | Halfmoon Pond | 74% | Halfmoon TMDL |
| Kingston | Greenwood Pond | 69% | Greenwood TMDL |
| Hollis | Flints Pond | 40% | Flints TMDL |
| Manchester | Dorrs Pond | 62% | Dorrs TMDL |
| Kingston; Newton | Country Pond | 52% | Country TMDL |
| Raymond | Governors Lake | 47% | Governors TMDL |
| Bedford | Sandy Pond | 51% | Sandy TMDL |

a. The permittee shall develop a Lake Phosphorous Control Plan (LPCP) as part of its written SWMP and update the LPCP in annual reports pursuant to Part 4.4 of the Permit. The LPCP shall describe measures the permittee will undertake to reduce the amount of phosphorous in MS4 discharges.

b. The LPCP shall be implemented in accordance with the following schedule and contain the following elements:

i. LPCP Implementation Schedule – The permittee shall complete the implementation of its LPCP as soon as possible but no later than 15 years after the effective date of the permit.

ii. The LPCP shall be implemented in accordance with the following schedule and contain the following elements:

| Number | LPCP Component and Milestones | Completion Date |
|---|---|---|
| 1 | Legal Analysis | 2 years after permit effective date |
| 2 | Funding source assessment | 3 years after permit effective date |
| 3 | Define LPCP scope (LPCP Area) | 4 years after permit effective date |
| 4 | Calculate Baseline Phosphorus, Allowable Phosphorus Load and Phosphorus Reduction Requirement | 4 years after permit effective date |
| 5 | Description of planned nonstructural and structural controls | 5 years after permit effective date |
| 6 | Description of Operation and Maintenance (O&M) Program | 5 years after permit effective date |
| 7 | Implementation schedule | 5 years after permit effective date |
| 8 | Cost and Funding Source Assessment | 5 years after permit effective date |
| 9 | Complete written LPCP | 5 years after permit effective date |
| 10 | Full implementation of nonstructural controls. | 6 years after permit effective date |
| 11 | Performance Evaluation. | 6 and 7 years after permit effective date |
| 12 | 1. Performance Evaluation.<br>2. Full implementation of all structural controls used to demonstrate that the total phosphorus export rate ($P_{exp}$) from the LPCP Area in mass/yr is equal to or less than the applicable Allowable Phosphorus Load($P_{allow}$) plus the applicable Phosphorus Reduction Requirement ($P_{RR}$) multiplied by 0.80<br>$P_{exp} \leq P_{allow} + (P_{RR}\ X\ 0.80)$ | 8 years after permit effective date |
| 13 | Performance Evaluation | 9 years after permit effective date |

| | | |
|---|---|---|
| 14 | 1. Performance Evaluation.<br>2. Update LPCP<br>3. Full implementation of all structural controls used to demonstrate that the total phosphorus export rate ($P_{exp}$) from the LPCP Area in mass/yr is equal to or less than the applicable Allowable Phosphorus Load($P_{allow}$) plus the applicable Phosphorus Reduction Requirement ($P_{RR}$) multiplied by 0.60<br>$P_{exp} \leq P_{allow} + (P_{RR}\ X\ 0.60)$<br>OR that the permittee has reduced their phosphorus export rate by 30kg/year (whichever is greater, unless full Phosphorus Reduction Requirement has been met) | 10years after permit effective date |
| 15 | Performance Evaluation | 11 and 12 years after permit effective date |
| 16 | 1. Performance Evaluation.<br>2. Full implementation of all structural controls used to demonstrate that the total phosphorus export rate ($P_{exp}$) from the LPCP Area in mass/yr is equal to or less than the applicable Allowable Phosphorus Load($P_{allow}$) plus the applicable Phosphorus Reduction Requirement ($P_{RR}$) multiplied by 0.30<br>$P_{exp} \leq P_{allow} + (P_{RR}\ X\ 0.30)$ | 13years after permit effective date |
| 17 | Performance Evaluation | 14 years after permit effective date |
| 18 | 1. Performance Evaluation.<br>2. Full implementation of all structural controls used to demonstrate that the total phosphorus export rate ($P_{exp}$) from the LPCP Area in mass/yr is equal to or less than the applicable Allowable Phosphorus Load($P_{allow}$)<br>$P_{exp} \leq P_{allow}$ | 15years after permit effective date |

**Table F-3: LPCP components and milestones**

iii. Description of LPCP Components:

Legal Analysis- The permittee shall develop and implement an analysis that identifies existing regulatory mechanisms available to the MS4 such as by-laws and ordinances and describe any changes to these regulatory mechanisms that may be necessary to effectively implement the LPCP. This may include the creation or amendment of financial and regulatory authorities. The permittee shall adopt necessary regulatory changes by the end of the permit term.

Scope of the LPCP (LPCP Area) - The permittee shall indicate the area in which the permittee plans to implement the LPCP, this area is known as the "LPCP Area". The permittee must choose one of the following: 1) to implement its LPCP in the entire area within its jurisdiction discharging to the impaired waterbody (for a municipality this would be the municipal boundary) or 2) to implement its LPCP in only the urbanized area portion of its jurisdiction discharging to the impaired waterbody. If the permittee chooses to implement the LPCP in its entire jurisdiction discharging to the impaired waterbody, the permittee may demonstrate compliance with the Phosphorus Reduction Requirement and Allowable Phosphorus Load requirements applicable to it through structural and non-structural controls on discharges that occur both inside and outside the urbanized area. If the permittee chooses to implement the LPCP in its urbanized area only discharging to the impaired waterbody, the permittee must demonstrate compliance with the Phosphorus Reduction Requirement and Allowable Phosphorus Load requirements applicable to it through structural and non-structural controls on discharges that occur within the urbanized area only.

Calculate Baseline Phosphorus Load ($P_{base}$), Phosphorus Reduction Requirement ($P_{RR}$) and Allowable Phosphorus Load ($P_{allow}$) –Permittees shall calculate their numerical Allowable Phosphorus Load and Phosphorus Reduction Requirement in mass/yr by first estimating their Baseline Phosphorus Load in mass/yr from its LPCP Area consistent with the methodology in Attachment 1 to Appendix F or the applicable TMDL, the baseline shall only be estimated using land use phosphorus export coefficients in Attachment 1 to Appendix F or the applicable TMDL methodology and not account for phosphorus reductions resulting from implemented structural BMPs completed to date. Table F-2 contains the percent phosphorus reduction required from urban stormwater consistent with the TMDL of each impaired waterbody. The permittee shall apply the applicable required percent reduction in Table F-2 to the calculated Baseline Phosphorus Load to obtain the permittee specific Phosphorus Reduction Requirement in mass/yr. The Phosphorus Reduction Requirement load shall then be subtracted from the Baseline Phosphorus Load to obtain the permittee specific Allowable Phosphorus Load..

Description of planned non-structural controls – The permittee shall describe the non-structural stormwater control measures to be implemented to support the achievement of the milestones in Table F-3. The description of non-structural controls shall include the planned measures, the areas where the measures will be implemented, and the annual phosphorus reductions that are expected to result from their implementation. Annual phosphorus reduction from non-structural BMPs shall be calculated consistent with Attachment 2 to Appendix F. The permittee shall update the description of planned non-structural controls as needed to support the achievement of the milestones in Table F-3, including an update in the updated written LPCP 10 years after the permit effective date.

Description of planned structural controls – The permittee shall develop a priority ranking of areas and infrastructure within the municipality for potential implementation of phosphorus control practices. The ranking shall be developed through the use of available screening and monitoring results collected during the permit term either by the permittee or another entity and the mapping required pursuant to Part 2.3.4.6 of the Permit. The permittee shall also include in this prioritization a detailed assessment of site suitability for potential phosphorus control measures based on soil types and other factors. The permittee shall coordinate this activity with the requirements of Part 2.3.6.e. of the Permit. A description and the result of this priority ranking shall be included in the LPCP. The permittee shall describe the structural stormwater control measures necessary to support achievement of the milestones in Table F-3. The description of structural controls shall include the planned measures, the areas where the measures will be implemented, and the annual phosphorus reductions in units of mass/yr that are expected to result from their implementation. Structural measures to be implemented by a third party may be included in the LPCP. Annual phosphorus reduction from structural BMPs shall be calculated consistent with Attachment 3 to Appendix F. The permittee shall update the description of planned structural controls as needed to support the achievement of the milestones in Table F-3, including an update in the updated written LPCP 10 years after the permit effective date.

<u>Description of Operation and Maintenance (O&M) Program for all planned and existing structural BMPs</u> – The permittee shall establish an Operation and Maintenance Program for all structural BMPs being claimed for phosphorus reduction credit as part the LPCP. This includes BMPs implemented to date as well as BMPs to be implemented. The Operation and Maintenance Program shall become part of the PCP and include: (1) inspection and maintenance schedule for each BMP according to BMP design or manufacturer specification and (2) program or department responsible for BMP maintenance.

<u>Implementation Schedule</u> – An initial schedule for implementing the BMPs, including, as appropriate: funding, training, purchasing, construction, inspections, monitoring, O&M and other assessment and evaluation components of implementation. Implementation of planned BMPs must begin upon completion of the LPCP, and all non-structural BMPs shall be fully implemented within six years of the permit effective date. Where planned structural BMP retrofits or major drainage infrastructure projects are expected to take additional time to construct, the permittee shall within four years of the effective date of the permit have a schedule for completion of construction consistent with the reduction requirements in Table F-3. The permittee shall complete the implementation of its LPCP as soon as possible or at a minimum in accordance with the milestones set forth in Table F-3. The implementation schedule shall be updated as needed to support the achievement of the milestones in Table F-3, including an update in the updated written LPCP 10 years after the permit effective date.

<u>Cost and funding source assessment</u> – The permittee shall estimate the cost for implementing its LPCP and describe known and anticipated funding mechanisms. The permittee shall describe the steps it will take to implement its funding plan. This may include but is not limited to

conceptual development, outreach to affected parties, and development of legal authorities.

Complete written LPCP – The permittee must complete the written LPCP 5 years after permit effective date. The complete LPCP shall include item numbers 1-8 in Table F-3. The permittee shall make the LPCP available to the public for public comment during the LPCP development. EPA encourages the permittee to post the LPCP online to facilitate public involvement. The LPCP shall be updated as needed with an update 10 years after the permit effective date at a minimum to reflect changes in BMP implementation to support achievement of the phosphorus export milestones in Table F-3. The updated LPCP shall build upon the original LPCP and include additional or new BMPs the permittee will use to support the achievement of the milestones in Table F-3.

Performance Evaluation – The permittee shall evaluate the effectiveness of the LPCP by tracking the phosphorus reductions achieved through implementation of structural and non-structural BMPs[3] and tracking increases in phosphorus loading from the LPCP Area beginning six years after the effective date of the permit. Phosphorus reductions shall be calculated consistent with Attachment 2 (non-structural BMP performance), Attachment 3 (structural BMP performance) and Attachment 1 (reductions through land use change), to Appendix F for all BMPs implemented to date[4]. Phosphorus load increases resulting from development shall be calculated consistent with Attachment 1 to Appendix F. Phosphorus loading increases and reductions in units of mass/yr shall be added or subtracted from the calculated Baseline Phosphorus Load to estimate the yearly phosphorous export rate from the LPCP Area in mass/yr. The permittee shall also include all information required in Part III.1.c. of this Appendix in each performance evaluation.

c. Reporting. Beginning 6 years after the permit effective date, the permittee shall include the following in each annual report submitted pursuant to Part 4.4 of the Permit:
   i. All non-structural control measures implemented during the reporting year along with the phosphorus reduction in mass/yr ($P_{NSred}$) calculated consistent with Attachment 2 to Appendix F
   ii. Structural controls implemented during the reporting year and all previous years including:
      1. Location information of structural BMPs (GPS coordinates or street address)

[3] In meeting its phosphorus reduction requirements a permittee may quantify phosphorus reductions by actions undertaken by another entity, except where those actions are credited to another permittee identified in Appendix F Table F-2

[4] Annual phosphorus reductions from structural BMPs installed in the LPCP Area prior to the effective date of this permit shall be calculated consistent with Attachment 3 to Appendix F. Phosphorus Reduction Credit for previously installed BMPs will only be given if the Permittee demonstrates that the BMP is performing up to design specifications and certifies that the BMP is properly maintained and inspected according to manufacturer design or specifications. This certification shall be part of the annual performance evaluation during the year credit is claimed for the previously installed BMP.

2. Phosphorus reduction from all structural BMPs implemented to date in mass/yr ($P_{Sred}$) calculated consistent with Attachment 3 to Appendix F
3. Date of last completed maintenance for each Structural control

iii. Phosphorus load increases due to development over the previous reporting period and incurred to date ($P_{DEVinc}$) calculated consistent with Attachment 1 to Appendix F.

iv. Estimated yearly phosphorus export rate ($P_{exp}$) from the LPCP Area calculated using Equation 1. Equation 1 calculates the yearly phosphorus export rate by subtracting yearly phosphorus reductions through implemented nonstructural controls and structural controls to date from the Baseline Phosphorus Load and adding loading increases incurred through development to date. This equation shall be used to demonstrate compliance with the phosphorus reduction milestones required as part of each phase of the LPCP.

$$P_{exp}\left(\frac{mass}{yr}\right) = P_{base}\left(\frac{mass}{yr}\right) - \left(P_{Sred}\left(\frac{mass}{yr}\right) + P_{NSred}\left(\frac{mass}{yr}\right)\right) + P_{DEVinc}\left(\frac{mass}{yr}\right)$$

**Equation 1. Equation used to calculate yearly phosphorus export rate from the chosen LPCP Area. $P_{exp}$=Current phosphorus export rate from the LPCP Area in mass/year. $P_{base}$=baseline phosphorus export rate from LPCP Area in mass/year. $P_{Sred}$= yearly phosphorus reduction from implemented structural controls in the LPCP Area in mass/year. $P_{NSred}$= yearly phosphorus reduction from implemented non-structural controls in the LPCP Area in mass/year. Area in mass/year. $P_{DEVinc}$= yearly phosphorus increase resulting from development since the year baseline loading was calculated in the LPCP Area in mass/year.**

v. Certification that all structural BMPs are being inspected and maintained according to the O&M program specified as part of the PCP. The certification statement shall be:

*I certify under penalty of law that all source control and treatment Best Management Practices being claimed for phosphorus reduction credit have been inspected, maintained and repaired in accordance with manufacturer or design specification. I certify that, to the best of my knowledge, all Best Management Practices being claimed for a phosphorus reduction credit are performing as originally designed.*

d. At any time during the permit term the permittee may be relieved of additional requirements in Appendix F Part III.1.a - b as follows.

i. The permittee is relieved of its additional requirements as of the date when the following conditions are met:

1. The applicable TMDL has been modified or revised and EPA has approved a new TMDL applicable for the receiving water that indicates that no additional stormwater controls for the control of phosphorus are necessary for the permittee's discharge based on wasteload allocations in the newly approved TMDL

ii. When the criteria in Appendix F part III.1.d.i. are met, the permittee shall document the date of the approved TMDL in its SWMP and is relieved of any remaining requirements of Appendix F part III.1.a.-b. as of that date and the permittee shall comply with the following:

1. The permittee shall identify in its SWMP all activities implemented in accordance with the requirements of Appendix F part III.1.a.-b. to date to reduce phosphorus in their discharges including implementation schedules for non-structural BMPs and any maintenance requirements for structural BMPs
2. The permittee shall continue to implement all requirements of Appendix F part III.1.a.-b. required to be implemented prior to the date of the newly approved TMDL, including ongoing implementation of identified non-structural BMPs and routine maintenance and replacement of all structural BMPs in accordance with manufacturer or design specifications, and the reporting requirements of Appendix F part III.1.c. remain in place.

2. The MS4 operator shall work with NHDES to develop an Alternative Phosphorus Reduction Plan consistent with the applicable TMDL. The MS4 operator shall submit a NHDES-approved Alternative Phosphorus Reduction Plan that is consistent with the TMDL Implementation Plan and includes schedules and milestones to meet applicable Waste Load Allocations consistent with the schedules and milestones contained in Appendix F part III.1 above, with their Notice of Intent (NOI) as an alternative to the requirements described in Appendix F part III.1 above.

a. The Alternative Phosphorus Reduction Plan shall be subject to EPA review and the public comment period consistent with the NOI procedures at part 1.7.4.b. of the permit.
b. The permittee shall keep the written plan (hardcopy or electronic) as part of their SWMP.
c. The permittee shall implement all operator-specific permit requirements included in the permittee's authorization letter from EPA based on the Alternative Phosphorus Reduction Plan.
d. Unless the operator-specific permit requirements related to the Alternative Phosphorus Reduction Plan are authorized by EPA, the permittee is subject to the requirements described in Appendix F part III.1 above.

# ATTACHMENT 1 TO APPENDIX F

## Method to Calculate Baseline Phosphorus Load, Phosphorus Reduction Requirements and Phosphorus load increases due to development ($P_{DEVinc}$)

The methods and annual phosphorus load export rates presented in Attachments 1, 2 and 3 are for the purpose of measuring load reductions for various stormwater BMPs treating runoff from different site conditions (i.e. impervious or pervious) and land uses (e.g. commercial, industrial, residential, etc.). The estimates of annual phosphorus load and load reductions due to BMPs are intended for use by the permittee to measure compliance with its Phosphorus Reduction Requirement under the permit.

This attachment provides the method to calculate a baseline phosphorus load discharging in stormwater for the impaired municipalities subject to Lakes and Ponds TMDL. A complete list of municipalities subject to these TMDLs is presented in Appendix F, Table F-2. This method shall be used to calculate the following annual phosphorus loads:

1) Baseline Phosphorus Load for Permittees
2) Phosphorus Reduction Requirement

This attachment also provides the method to calculate stormwater phosphorus load increases due to increases in impervious cover from development within the applicable watershed area for the municipalities subject to the Lakes & Ponds TMDL requirements:

3) Phosphorus Load Increases Due to Increases in Impervious Cover from Development

The **Baseline Phosphorus Load** is a measure of the annual phosphorus load discharging in stormwater from the impervious and pervious areas of the impaired Lake Phosphorus Control Plan (LPCP) Area.

The **Baseline Phosphorus Pounds Reduction** referred to as the permittee's **Phosphorus Reduction Requirement in mass/year** represents the required reduction in annual phosphorus load in stormwater to meet the WLA for the impaired watershed. The percent phosphorus reduction for each watershed (identified in Appendix F, Table F-2) is applied to the Baseline Phosphorus Load to calculate the Phosphorus Reduction Requirement.

The **Phosphorus load increases due to development ($P_{DEVinc}$)** is the stormwater phosphorus load increases due to development within the Lake Phosphorus Control Plan (LPCP) area over the previous reporting period and incurred to date. Increases in stormwater phosphorus load from development will increase the permittee's baseline phosphorus load and therefore, the phosphorus reduction requirement. Installation of new BMPs including decreases in impervious cover and all associated phosphorus load reductions shall be accounted for as BMPs in accordance with the calculation methodologies in Attachment 3 to Appendix F.

Examples are provided to illustrate use of the methods. Table 1-1 below provides annual composite phosphorus load export rates (PLERs) by land use category for calculating the Baseline Phosphorus Load and the Phosphorus Reduction Requirement. The permittee shall select the land use category that most closely represents the actual use of the watershed. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial land use category for the purpose of calculating phosphorus loads.

Table 1-2 below provides annual PLERs by land use category for impervious and pervious areas. The permittee shall select the land use category that most closely represents the actual use of the watershed. For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial/industrial land use category for the purpose of calculating phosphorus loads. Table 1-3 below provides a crosswalk table of land use categories in Tables 1-1 and 1-2 and the codes used NH GRANIT and those used in the TMDL reports.

The composite PLERs in Table 1-1 to be used for calculating Baseline Phosphorus Load are based on the specified directly connected impervious area (DCIA). If the permittee determines through mapping and site investigations that the overall DCIA for the collective area for each land use category is different than the corresponding values in Table 1-1, then the permittee is encouraged to submit this information in its annual report and request EPA to recalculate the composite PLERs for the permittees to use in refining the Baseline Phosphorus Load calculation for the LPCP.

**<u>(1) Baseline Phosphorus Load:</u>** The permittee shall calculate the **Baseline Phosphorus Load** by the following procedure:

1) Determine the total MS4 drainage area (acre) associated with the impaired watershed or the permittee's chosen Lake Phosphorus Control Plan (LPCP) area;

2) Sort the total area associated with the watershed into land use categories;

3) Calculate the annual phosphorus load associated with each land use category by multiplying the total area of land use by the appropriate land use-based composite phosphorus load export rate provided in Table 1-1; and

4) Determine the Baseline Phosphorus Load by summing the land use loads.

**<u>Example 1-1 to determine Baseline Phosphorus Load:</u>**
LPCP area A is 18.0 acres, with 11.0 acres of industrial area ($_{IND}$) (e.g. access drives, buildings, and parking lots), 3.0 acres of medium-density residential ($_{MDR}$) and 4.0 acres of unmanaged wooded area ($_{FOR}$).

The **Baseline Phosphorus Load** = (Baseline P Load $_{IND}$) + (Baseline P Load $_{MDR}$) + (Baseline P Load $_{FOR}$)

**<u>Where:</u>**
Baseline P Load $_{IND}$ = ($TA_{IND}$) x (PLER for industrial use (Table 1-1))
= 11.0 acre x 1.27 lbs/acre/year
= 14.0 lbs P/year

Baseline P Load $_{MDR}$ = ($TA_{MDR}$) x (PLER for medium density residential (Table 1-1))
= 3.0 acre x 0.49 lbs/acre/year
= 1.5 lbs P/year

Baseline P Load $_{FOR}$ = ($TA_{FOR}$) x (PLER for forest (Table 1-1))

= 4.0 acre x 0.12 lbs/acre/year
= 0.5 lbs P/year

Baseline P Load = 14.0 lbs P/year + 1.5 lbs P/year + 0.5 lbs P/year
= **16.0 lbs P/year**

**(2) Baseline Phosphorus Pounds Reduction (Phosphorus Reduction Requirement):** The Baselines Phosphorus Reduction requirement is the amount of reduction in annual phosphorus load (in pounds) that the permittee is required to achieve in the contributing MS4 drainage area or the permittee's chosen LPCP area. The permittee shall calculate the **Phosphorus Reduction Requirement** by multiplying the **Baseline Phosphorus Load** by the applicable percent phosphorus reduction for that watershed specified in Table F-2 (Appendix F).

**Example 1-2 to determine Watershed Phosphorus Reduction Requirement:**
Table F-2 identifies LPCP area A's percent phosphorus reduction as 45%; therefore the LPCP Phosphorus Reduction Requirement is:

Phosphorus Reduction Requirement = (Baseline Phosphorus Load) x (0.45)
= (16.0 lbs P/year) x (0.45)
= **7.2 lbs P/year**

**(3) Phosphorus load increases due to development ($P_{DEVinc}$):** To estimate the increases in stormwater phosphorus load due to development in the LPCP Area, the permittee will use the procedure described below. Alternatively, the permittee may provide an alternative analysis that uses applicable distinct PLERs provided in Table 1-2 to calculate increases in phosphorus load:

1) Determine the total area in which new development has occurred since the most recent baseline phosphorus (P) load analysis and distribute the area according to the land use categories (see Table 1-1) used in the most recent baseline P load analysis;

2) Calculate the pre-new development baseline load from each area by land use category using the composite PLERs in Table 1-1 and sum the P loads to determine baseline P load for the area prior to new-development ($P_{BL-PreDEV}$);

3) Distribute the total new-development area into impervious and pervious subareas according to the most representative land use land use categories (see Table 1-2) for the new-development use categories;

4) Calculate the P load for each new-development land use-based impervious and pervious subarea by multiplying the subarea by the appropriate distinct PLERs provided in Table 1-2 and sum the P loads to determine the new P load for the total area in which new development has occurred ($P_{New-DEV}$); and

5) Determine the P load increase due to development ($P_{DEVinc}$) by subtracting the baseline P load from the new-development P load ($P_{DEVinc} = P_{New-DEV} - P_{BL-PreDEV}$).

Note: If structural BMPs are installed as part of new development to treat runoff, then the revised Phosphorus Reduction Requirement will be subsequently reduced by the amount of BMP load reduced by that BMP as calculated in Attachment 3 and will be tracked and accounted for as an implemented BMP. For the purpose of the phosphorus load reduction requirment in the permit, the removal of impervious cover in the LPCP area shall be treated as a BMP and shall be accounted for using the methods in Attachment 3 to Appendix F.

**Example 1-3 to determine phosphorus load increases due to new development:** A Permittee has tracked a total area of 14.5 acres of new development in the LPCA area since the previous Baseline P load calculation. Tables 1-3-1 and 1-3-2 summarize the necessary information for the pre-development areas and resulting new development areas, respectively, to calculate the phosphorus load increase due to new development in the LPCP area.

**Table 1-3-1: Pre-development baseline phosphorus loads for new-development areas within LPCP area.**

| Land Use prior to new development | Area of new development (acres) | Pre-Dev PLER (lbs/acre/yr)* | $P_{BL\text{-}PreDEV}$ Pre-Dev Baseline P load (lbs/yr) | New development Land Use created |
|---|---|---|---|---|
| Commercial | 6.7 | 1.13 | 7.6 | Commercial |
| Industrial | 4.8 | 1.27 | 6.1 | Industrial |
| Forest | 3.0 | 0.12 | 0.4 | High Density Residential |
| | | | **∑ = 14.1 lbs/yr** | |

*From Table 1-1

**Table 1-3-2: Phosphorus loads from new-development areas within LPCP area.**

| New Development Land Use | New impervious cover (IC) area (acres) | New pervious cover (PC) area & HSG (acres - HSG) | IC PLER** (lbs/acre/yr) | PC PLER** (lbs/acre/yr) | $P_{New\text{-}DEV}$ New development P load (lbs/yr) |
|---|---|---|---|---|---|
| Commercial | 6.1 | 0.6 - B | 1.78 | 0.12 | 10.9 |
| Industrial | 4.4 | 0.4 - C | 1.78 | 0.21 | 7.9 |
| High Density Residential | 2.1 | 0.9 - B | 2.32 | 0.12 | 5.0 |
| | | | | | **∑ = 23.8 lbs/yr** |

**From Table 1-2

The increased phosphorus load due to new development in the LPCP area is:

$P_{DEVinc} = P_{New\text{-}DEV} - P_{BL\text{-}PreDEV}$
$= 23.8$ lbs/yr – 14.1 lbs/yr
= **9.3 lbs P/yr increase**

The increased phosphorus load of 9.3 lbs/yr due to new development in the LPCP area shall be added to the permittee’s Baseline Phosphorus Load and the Phosphorus Reduction Requirement shall be increased by multiplying the 9.3 lbs/yr times the applicable percent reduction value from Table F-2. For example, if the percent reduction value is 30% then the increase to the Phosphorus Reduction Requirement ($PRR_{increase}$) would be:

$PRR_{increase}$ = 9.3 lbs/yr x 0.30
= **2.8 lbs/yr**

**Table 1-1. Annual composite phosphorus load export rates**

| Land Cover | Representative DCIA, % | Composite PLERs, lb/ac/yr | Composite PLERs, kg/ha/yr |
|---|---|---|---|
| **Commercial** | **57** | **1.13** | **1.27** |
| **Industrial** | **67** | **1.27** | **1.42** |
| **High Density Residential** | **36** | **1.04** | **1.16** |
| **Medium Density Residential** | **16** | **0.49** | **0.55** |
| **Low Density Residential** | **11** | **0.30** | **0.34** |
| **Highway/Freeway** | **44** | **0.73** | **0.82** |
| **Forest** | **0.1** | **0.12** | **0.13** |
| **Open Space** | **8** | **0.26** | **0.29** |
| **Agriculture** | **0.4** | **0.45** | **0.50** |

**Table 1-2: Average annual distinct P Load export rates for use in estimating P Load reduction credits for the NH MS4 Permit**

| Phosphorus Source Category by Land Use | Land Surface Cover | P Load Export Rate, lbs/acre/year | P Load Export Rate, kg/ha/yr |
|---|---|---|---|
| Commercial (Com) and Industrial (Ind) | Directly connected impervious | 1.78 | 2.0 |
| | Pervious | See* DevPERV | See* DevPERV |
| Multi-Family (MFR) and High-Density Residential (HDR) | Directly connected impervious | 2.32 | 2.6 |
| | Pervious | See* DevPERV | See* DevPERV |
| Medium -Density Residential (MDR) | Directly connected impervious | 1.96 | 2.2 |
| | Pervious | See* DevPERV | See* DevPERV |
| Low Density Residential (LDR) - "Rural" | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Highway (HWY) | Directly connected impervious | 1.34 | 1.5 |
| | Pervious | See* DevPERV | See* DevPERV |
| Forest (For) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | 0.13 | 0.13 |

| | | | |
|---|---|---|---|
| Open Land (Open) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Agriculture (Ag) | Directly connected impervious | 1.52 | 1.7 |
| | Cover Crop/Grazing | 0.7 | 0.8 |
| | Row Crop | 2.0 | 2.2 |
| | Hayland- no manure | 0.4 | 0.4 |
| *Developed Land Pervious (DevPERV)- Hydrologic Soil Group A | Pervious | 0.03 | 0.03 |
| *Developed Land Pervious (DevPERV)- Hydrologic Soil Group B | Pervious | 0.12 | 0.13 |
| *Developed Land Pervious (DevPERV) - Hydrologic Soil Group C | Pervious | 0.21 | 0.24 |
| *Developed Land Pervious (DevPERV) - Hydrologic Soil Group C/D | Pervious | 0.29 | 0.33 |
| *Developed Land Pervious (DevPERV) - Hydrologic Soil Group D | Pervious | 0.37 | 0.41 |

**Table 1-3: Crosswalk of land use groups for NH MS4 P Load Calculations to NH GRANIT and ENSR-LRM (Lake P TMDL Analysis)**

| Description of Land Use (LU) Groups for Calculating P Load Using PLERs | NH GRANIT LU Category Codes [2] | ENSR-LRM LU[1] |
|---|---|---|
| Commercial | 1210-1290, 1442, 1146, 1520-30, 1590, 1610-90, and 1790 | Urban 3 and 5 |
| Industrial, | 1300, 1370, 1410-20, 1460-80, 1510, and 1580 | Urban 4 |
| High Density Residential | 1110-1120, 1140 | Urban 2 |
| Medium Density Residential | 1130 and 1150 | |
| Low Density Residential | 1190 | Urban 1 |
| Highway/Freeway | 1440-45, 1447-50 and 1490 | Urban 4 |
| Forest | 3000, 4000, 6000, 190 | Forest 1-4, Open 1 |
| Open Land | 1710-90, 1800 | Open 2 and 3 |
| Agriculture | 2000 and 2900 | Agric 1-4 |

[1]Land use codes from lake/pond phosphorus TMDLs
[2]See Table 1, page 4 at following link:
http://www.granit.unh.edu/resourcelibrary/GRANITresources/standards/LUStandards-I93-061107.pdf

# ATTACHMENT 2 TO APPENDIX F

## Phosphorus and Nitrogen Reduction Credits for Selected Enhanced Non-Structural BMPs

The permittee shall use the methods explained below to calculate phosphorus and nitrogen (nutrient) load reduction credits for the following enhanced non-structural control practices implemented in the Watershed:

1) Enhanced Street/Pavement Cleaning Program;
2) Catch Basin Cleaning;
3) Turf Grass Fertilizer Management with No Applications of Fertilizers that Contain Phosphorus*; and
4) Organic Waste and Leaf Litter Collection program

* "Phosphorus free" fertilizers that contain no more than 0.67% phosphorus shall be considered a fertilizer that does not contain phosphorus and applicable for earning this credit.

The methods include the use of default phosphorus and nitrogen reduction factors that EPA has determined are acceptable for calculating phosphorus load reduction credits for these practices.

The methods and annual nutrient load export rates presented in this attachment are for the purpose of counting load reductions for various BMPs treating storm water runoff from varying site conditions (i.e., impervious or pervious surfaces) and different land uses (e.g. industrial and commercial) within the applicable watershed. Respectively, Tables 2-1 and 2-2 below provide annual phosphorus load and nitrogen export rates by land use category for impervious and pervious areas. The estimates of annual phosphorus loads and load reductions resulting from BMP implementation are intended for use by the permittee to measure compliance with its Phosphorus Reduction Requirement in accordance with Appendix F to the permit. The estimates of annual nitrogen load and load reductions resulting from BMP implementation are intended for use by the permittee to track and account for nitrogen load reductions in accordance with Appendix H to the permit.

Examples are provided to illustrate use of the methods and area applicable to both phosphorus and nitrogen, except for turf grass fertilizer management, which applies only to phosphorus at this time. In calculating nutrient loads, the permittee shall select the land use category that most closely represents the actual use for the area in question. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial land use category for the purpose of calculating phosphorus and nitrogen loads. Table 2-3 provides a crosswalk table of nutrient load export rate (PLER and NLER) land use categories in Tables 2-1 and 2-2, and the corresponding land use category codes used in NH GRANIT. For pervious areas, permittees should use the appropriate value for the hydrologic soil group (HSG) if known, otherwise, assume HSG C conditions.

**<u>Alternative Methods and/or Nutrient Reduction Factors</u>:** A permittee may propose alternative methods and/or nutrient reduction factors for calculating phosphorus and nitrogen load reduction credits for these non-structural practices. EPA will consider alternative methods and/or nutrient reduction factors, provided that the permittee submits adequate supporting documentation to EPA. At a minimum, supporting documentation shall consist of a description of the proposed method, the technical basis of the method, identification of alternative nutrient reduction factors, supporting calculations, and identification of references and sources of information that support the use of the alternative method and/or factors in the applicable watershed areas. If EPA determines that the alternative methods and/or factors are not adequately supported, EPA will notify the permittee, and the permittee may receive no phosphorus or nitrogen reduction credit other than a reduction credit calculated by the permittee following the methods in this attachment for the identified practices.

**Table 2-1: Average annual distinct phosphorus (P) load export rates for use in estimating P load reduction credits in the NH MS4 Permit**

| Phosphorus Source Category by Land Use | Land Surface Cover | P Load Export Rate, lbs./acre/year | P Load Export Rate, kg/ha/yr. |
|---|---|---|---|
| Commercial (COM) and Industrial (IND) | Directly connected impervious | 1.78 | 2.0 |
| | Pervious | See* DevPERV | See* DevPERV |
| Multi-Family (MFR) and High-Density Residential (HDR) | Directly connected impervious | 2.32 | 2.6 |
| | Pervious | See* DevPERV | See* DevPERV |
| Medium -Density Residential (MDR) | Directly connected impervious | 1.96 | 2.2 |
| | Pervious | See* DevPERV | See* DevPERV |
| Low Density Residential (LDR) - "Rural" | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Highway (HWY) | Directly connected impervious | 1.34 | 1.5 |
| | Pervious | See* DevPERV | See* DevPERV |
| Forest (FOR) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | 0.13 | 0.13 |
| Open Land (OPEN) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Agriculture (AG) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | 0.45 | 0.5 |
| *Developed Land Pervious (DevPERV) – HSG A | Pervious | 0.03 | 0.03 |
| *Developed Land Pervious (DevPERV) – HSG B | Pervious | 0.12 | 0.13 |
| *Developed Land Pervious (DevPERV) – HSG C | Pervious | 0.21 | 0.24 |
| *Developed Land Pervious (DevPERV) – HSG C/D | Pervious | 0.29 | 0.33 |

| | | | |
|---|---|---|---|
| *Developed Land Pervious (DevPERV) – HSG D | Pervious | 0.37 | 0.41 |

Notes:
- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate.
- Agriculture includes row crops, actively managed hay fields, and pasture lands. Institutional land uses, such as government properties, hospitals and schools, are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

**Table 2-2: Average annual distinct nitrogen (N) load export rates for use in estimating N load reduction credits in the NH MS4 Permit**

| Nitrogen Source Category by Land Use | Land Surface Cover | N Load Export Rate, lbs./acre/year | N Load Export Rate, kg/ha/yr. |
|---|---|---|---|
| Commercial (COM) and Industrial (IND) | Directly connected impervious | 15.0 | 16.9 |
| | Pervious | See* DevPERV | See* DevPERV |
| All Residential | Directly connected impervious | 14.1 | 15.8 |
| | Pervious | See* DevPERV | See* DevPERV |
| Highway (HWY) | Directly connected impervious | 10.5 | 11.8 |
| | Pervious | See* DevPERV | See* DevPERV |
| Forest (FOR) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | 0.5 | 0.6 |
| Open Land (OPEN) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Agriculture (AG) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | 2.6 | 2.9 |
| *Developed Land Pervious (DevPERV) – HSG A | Pervious | 0.3 | 0.3 |
| *Developed Land Pervious (DevPERV) – HSG B | Pervious | 1.2 | 1.3 |
| *Developed Land Pervious (DevPERV) – HSG C | Pervious | 2.4 | 2.7 |
| *Developed Land Pervious (DevPERV) – HSG C/D | Pervious | 3.1 | 3.5 |
| *Developed Land Pervious (DevPERV) – HSG D | Pervious | 3.6 | 4.1 |

Notes:
- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate.
- Agriculture includes row crops. Actively managed hay fields and pasture lands. Institutional land uses such as government properties, hospitals and schools are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

**Table 2-3: Crosswalk of land use groups for NH MS4 P Load calculations to land use codes in NH GRANIT**

| Description of Land Use (LU) Groups for Calculating P Load Using PLERs | NH GRANIT LU Category Codes [1] |
|---|---|
| Commercial | 1210-1290, 1442, 1146, 1520-30, 1590, 1610-90, and 1790 |
| Industrial, | 1300, 1370, 1410-20, 1460-80, 1510, and 1580 |
| High Density Residential | 1110, 1120 and1140 |
| Medium Density Residential | 1130 and 1150 |
| Low Density Residential | 1190 |
| Highway/Freeway | 1440-45, 1447-50 and 1490 |
| Forest | 3000, 4000, 6000, 190 |
| Open Land | 1710-90, 1800 |
| Agriculture | 2000 and 2900 |

[1]NH GRANIT land use categories can be found at the following link (See Table 1, page 4): http://www.granit.unh.edu/resourcelibrary/GRANITresources/standards/LUStandards-I93-061107.pdf

**(1) Enhanced Street/Pavement Cleaning Program:** The permittee may earn a phosphorus or a nitrogen reduction credit for conducting an enhanced cleaning program of impervious surfaces. Table 2-2 below outlines the default phosphorus removal factors for enhanced street/pavement cleaning programs. The credit shall be calculated by using the following equation:

$$\text{Phosphorus Credit}_{P\ sweeping} = IA_{swept} \times PLER_{IC\text{-}land\ use} \times PRF_{sweeping} \times AF \quad \textbf{(Equation 2-1)}$$

$$\text{Nitrogen Credit}_{N\ sweeping} = IA_{swept} \times NLER_{IC\text{-}land\ use} \times NRF_{sweeping} \times AF \quad \textbf{(Equation 2-2)}$$

**Where:**

$\text{Credit}_{sweeping}$ = Amount of nutrient load removed by enhanced sweeping program (lbs./year)

$IA_{swept}$ = Area of impervious surface that is swept under the enhanced sweeping program (acres)

$PLER_{IC\text{-}land\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb./acre/yr.) (see Table 2-1)

$NLER_{IC\text{-}land\ use}$ = Nitrogen Load Export Rate for impervious cover and specified land use (lb./acre/yr.) (see Table 2-2)

$PRF_{sweeping}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-4).

$NRF_{sweeping}$ = Nitrogen Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-4).

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo. /12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the applicable watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus and/or nitrogen using long-term local rainfall data.

**Table 2-4: Nutrient reduction efficiency factors for sweeping impervious areas ($PRF_{sweeping}$ & $NRF_{sweeping}$)**

| Frequency[1] | Sweeper Technology | $PRF_{sweeping}$ | $NFR_{sweeping}$ |
|---|---|---|---|
| 2/year (spring and fall)[2] | Mechanical Broom | 0.01 | 0.01 |
| 2/year (spring and fall)[2] | Vacuum Assisted | 0.02 | 0.02 |
| 2/year (spring and fall)[2] | High-Efficiency Regenerative Air-Vacuum | 0.02 | 0.02 |
| | | | |
| Monthly | Mechanical Broom | 0.03 | 0.03 |
| Monthly | Vacuum Assisted | 0.04 | 0.04 |
| Monthly | High Efficiency Regenerative Air-Vacuum | 0.08 | 0.08 |
| | | | |
| Weekly | Mechanical Broom | 0.05 | 0.06 |
| Weekly | Vacuum Assisted | 0.08 | 0.07 |
| Weekly | High Efficiency Regenerative Air-Vacuum | 0.10 | 0.10 |

**Example 2-1: Calculation of enhanced street/pavement cleaning program phosphorus load reduction credit ($Credit_{P\ sweeping}$):** A permittee proposes to implement an enhanced street/pavement cleaning program and perform monthly cleaning from March 1 – December 1 (9 months), using a high efficiency regenerative air-vacuum assisted sweeper on 20.3 acres of parking lots and roadways in a high-density residential area of the LPCP area. For this site the needed information to calculate the **phosphorus** load reduction is:

$IA_{swept}$ = 20.3 acres
$PLER_{IC\text{-}HDR}$ = 2.32 lb./acre/yr. (from Table 2-1)
$PRF_{sweeping}$ = 0.08 (from Table 2-4)
AF = (9 months / 12 months) = 0.75

Substitution into equation 2-2 yields a $Credit_{sweeping}$ of 2.8 pounds of phosphorus removed per year.

$Credit_{P\ sweeping}$ = $IA_{swept}$ x $PLER_{land\ use}$ x $PRF_{sweeping}$ x AF
= 20.3 acres x 2.32 lbs./acre/yr. x 0.08 x 0.75
**= 2.8 lbs./yr.**

The corresponding **nitrogen** load reduction credit ($Credit_{N\ sweeping}$) for the same sweeping program in the specified LPCP area is calculated as follows:

$IA_{swept}$ = 20.3 acres
$NLER_{IC\text{-}HDR}$ = 14.1 lb./acre/yr. (from Table 2-2)

[1] For full credit for monthly and weekly frequency, sweeping must be conducted year round. Otherwise, the credit should be adjusted proportionally based on the duration of the sweeping season (using AF factor).

[2] In order to earn credit for semi-annual sweeping the sweeping must occur in the spring following snow-melt and road sand applications to impervious surfaces and in the fall after leaf-fall and prior to the onset to the snow season.

$NRF_{sweeping}$ = 0.08 (from Table 2-4)
AF = (9 months / 12 months) = 0.75

Substitution into equation 2-2 yields a $Credit_{sweeping}$ of 17.2 pounds of nitrogen removed per year.

$Credit_{N\ sweeping} = IA_{swept} \times NLER_{land\ use} \times NRF_{sweeping} \times AF$
$= 20.3$ acres x 14.1 lbs./acre/yr. x 0.08 x 0.75
**= 17.2 lbs./yr.**

**(2) Catch Basin Cleaning:** The permittee may earn a nutrient reductions credit for phosphorus and nitrogen, $Credit_{CB}$, by removing accumulated materials from catch basins (i.e., catch basin cleaning) in the Watershed such that a minimum sump storage capacity of 50% is maintained throughout the year. The credit shall be calculated by using the following equations for phosphorus and nitrogen:

$$Credit_{P\ CB} = IA_{CB} \times PLER_{IC\text{-}land\ use} \times PRF_{CB} \qquad \textbf{(Equation 2-3)}$$

$$Credit_{N\ CB} = IA_{CB} \times NLER_{IC\text{-}land\ use} \times NRF_{CB} \qquad \textbf{(Equation 2-4)}$$

**Where:**

$Credit_{CB}$ = Amount of nutrient load removed by catch basin cleaning (lb. /year)
$IA_{CB}$ = Impervious drainage area to catch basins (acres)
$PLER_{IC\text{-}land\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb./acre/yr.) (see Table 2-1)
$NLER_{IC\text{-}land\ use}$ = Nitrogen Load Export Rate for impervious cover and specified land use (lb./acre/yr.) (see Table 2-2)
$PRF_{CB}$ = Phosphorus Reduction Factor for catch basin cleaning (See Table 2-5)
$NRF_{CB}$ = Nitrogen Reduction Factor for catch basin cleaning (See Table 2-5)

**Table 2-5: Phosphorus reduction efficiency factor ($PRF_{CB}$) for catch basin cleaning**

| Practice | $PRF_{CB}$ | $NRF_{CB}$ |
|---|---|---|
| Catch Basin Cleaning to maintain 50% free-storage capacity in CB sump | 0.02 | 0.06 |

**Example 2-2: Calculation for catch basin cleaning credit ($Credit_{CB}$):**

A permittee will conduct a CB maintenance program that will remove accumulated sediments and contaminants captured in the CBs. The program will maintain at least a 50% free-storage capacity in CB sumps in the same LPCA area as specified in Example 2-1. Catch basins in the applicable watershed drains runoff from 20.3 acres of HDR impervious area. For this site the needed information to calculate the **phosphorus** load reduction credit is:

$IA_{CB}$ = 20.3 acre
$PLER_{IC\text{-}HDR}$ = 2.32 lbs./acre/yr. (from Table 2-1)

$PRF_{CB}$ = 0.02 (from Table 2-5)

Substitution into equation 2-3 yields a $Credit_{P\ CB}$ of 0.9 pounds of phosphorus removed per year:

$Credit_{P\ CB}$ = $IA_{CB}$ x $PLER_{IC\text{-}HDR}$ x $PRF_{CB}$
= 20.3 acre x 2.32 lbs./acre/yr. x 0.02
**= 0.9 lbs. P/yr.**

Note: The same methodology is applicable for calculating the nitrogen load reduction credit ($Credit_{N\ CB}$).

**(3) Turf Grass Fertilizer Management with No Applications of Fertilizers that Contain Phosphorus:** If a permittee has historically and regularly used fertilizer containing phosphorus in LPCA watershed area, the permittee may earn a phosphorus reduction credit by not applying fertilizers that contain phosphorus to turf grass pervious areas within the LPCP area. The application of any fertilizers containing phosphorus to turf grass areas within the LPCP area at any time during the reporting year by the permittee or any contractor or subcontractor acting on behalf of the permittee shall preclude the permittee from earning this credit for such areas for the reporting year. Note: "Phosphorus free" fertilizers that contain no more than 0.67% phosphorus shall be considered a fertilizer that does not contain phosphorus and is applicable for earning this credit. The permittee must provide written certification to EPA annually that no fertilizers containing phosphorus have been applied by the permittee or its agents (including contractors and subcontractors) to turf grass areas within the LPCP area for which the permittee is claiming credit ($Credit_{no\ P\ fertilizer}$). The $Credit_{no\ P\ fertilizer}$ shall be determined using the following equation:

$Credit_{no\ P\ fertilizer}$ = ($Area_{turf\ grass\ no\ P}$) x ($PLER_{PC\text{-}HSG}$) x (0.33) **(Equation 2-5)**

**Where:**

$Credit_{no\ P\ fertilizer}$ = Amount of phosphorus load reduction credit for not applying fertilizers containing phosphorus (lbs./year)

$Area_{turf\ grass\ no\ P}$ = All applicable turf grass area (acre) within LPCP area which have not received applications of phosphorus containing fertilizers

$PLER_{PC\text{-}HSG}$ = Phosphorus Load Export Rate for pervious cover and HSG (lbs./acre/yr.) (see Table 2-1)

0.33 = 33% phosphorus reduction factor for not applying fertilizers containing phosphorus

**Example 2-3: Calculation for no phosphorus fertilizer credit for turf grass areas ($Credit_{no\ P\ fertilizer}$):** A permittee has the option of applying phosphorus free fertilizer to the lawns and landscaped areas of municipally owned facilities located within the LPCP area. The municipality has determined through soil tests that additional phosphorus is not needed to support healthy turf grass growth for 19.1 acre of turf grass associated with the facilities. The HSG for all of the 19.1 acres of turf grass is presently unknown (assume HSG C). The needed information to calculate the $Credit_{no\ P\ fertilizer}$ for the 19.1 acres of turf grass area is:

Area $_{\text{turf grass no P}}$ = 19.1 acres; and
PLER $_{\text{PC-HSG C}}$ = 0.21 lbs./ac/yr. (from Table 2-1)

Substitution into equation 2-5 yields a Credit $_{\text{no P fertilizer}}$ of 2.1 pounds of phosphorus removed per year.

Credit $_{\text{no P fertilizer}}$ = (19.1 acres) x (0.21 lbs./acre/yr.) x (0.33)
**= 1.3 lbs./yr.**

**(4) Enhanced Organic Waste and Leaf Litter Collection program:** The permittee may earn phosphorus and nitrogen reduction credits by performing regular gathering, removal and proper disposal of landscaping wastes, organic debris, and leaf litter from impervious surfaces within applicable watershed areas (i.e., LPCP area or Great Bay watershed). In order to earn this credit (Credit $_{\text{leaf litter}}$), the permittee must gather and remove all landscaping wastes, organic debris, and leaf litter from impervious roadways and parking lots at least once per week during the period of September 1 to December 1 of each year. Credit can only be earned for those impervious surfaces that are cleared of organic materials in accordance with the description above. The gathering and removal shall occur immediately following any landscaping activities in the applicable watershed and at additional times when necessary to achieve a weekly cleaning frequency. The permittee must ensure that the disposal of these materials will not contribute pollutants to any surface water discharges. The permittee may use an enhanced sweeping program (e.g., weekly frequency) as part of earning this credit provided that the sweeping is effective at removing leaf litter and organic materials. The Credit $_{\text{leaf litter}}$ for phosphorus and nitrogen load reductions shall be determined by equations 2-6 and 2-7, respectively:

Credit $_{\text{P leaf litter}}$ = (IA $_{\text{leaf litter}}$) x (PLER $_{\text{IC-land use}}$) x (0.05) **(Equation 2-6)**

Credit $_{\text{N leaf litter}}$ = (IA $_{\text{leaf litter}}$) x (NLER $_{\text{IC-land use}}$) x (0.05) **(Equation 2-7)**

**Where:**

| | |
|---|---|
| Credit $_{\text{leaf litter}}$ | = Amount of nutrient load reduction credit for organic waste and leaf litter collection program (lb. /year) |
| IA $_{\text{leaf litter}}$ | = Impervious area (acre) in applicable watersheds that are subject to enhanced organic waste and leaf litter collection program |
| PLER $_{\text{IC-land use}}$ | = Phosphorus Load Export Rate for impervious cover and specified land use (lbs./acre/yr.) (see Table 2-1) |
| NLER $_{\text{IC-land use}}$ | = Phosphorus Load Export Rate for impervious cover and specified land use (lbs./acre/yr.) (see Table 2-1) |
| 0.05 | = 5% nutrient reduction factor for organic waste and leaf litter collection program in the applicable watershed |

**Example 2-4: Calculation for organic waste and leaf litter collection program credit (Credit $_{\text{leaf litter}}$):** A permittee will implement an organic waste and leaf litter collection program by sweeping the parking lots and access drives at a minimum of once per week using a mechanical broom sweeper for the period of September 1 to December 1 over

12.5 acres of impervious roadways and parking lots in an industrial/commercial area of the LPCP area. Also, the permittee will ensure that organic materials are removed from impervious areas immediately following all landscaping activities in the area. For this site the needed information to calculate the $\text{Credit}_{\text{leaf litter}}$ for **phosphorus** is:

$\text{IA}_{\text{leaf litter}}$ = 12.5 acres; and
$\text{PLER}_{\text{IC-commercial}}$ = 1.78 lbs./acre/yr. (from Table 2-1)
Substitution into equation 2-6 yields:

$\text{Credit}_{\text{P leaf litter}}$ = (12.5 acre) x (1.78 lbs./acre/yr.) x (0.05)
= **1.1 lbs. P/yr.**

Note: The same methodology is applicable for calculating the nitrogen load reduction credit ($\text{Credit}_{\text{N leaf litter}}$) for the specified organic waste leaf litter collection program.

**Associated Street/Pavement Cleaning Credit**

The permittee also may earn a phosphorus reduction credit for enhanced cleaning of roads and parking lot areas (i.e., $\text{Credit}_{\text{P sweeping}}$) for using the mechanical broom sweeper weekly during the three month leaf litter collection program.

Using equation 2-1, $\text{Credit}_{\text{P sweeping}}$ is:
$\text{Credit}_{\text{P sweeping}} = \text{IA}_{\text{swept}} \times \text{PLER}_{\text{IC-land use}} \times \text{PRF}_{\text{sweeping}} \times \text{AF}$ **(Equation 2-1)**
$\text{IA}_{\text{swept}}$ = 12.5 acre
$\text{PLE}_{\text{IC-commercial}}$ = 1.78 lbs./acre/yr. (from Table 2-1)
$\text{PRF}_{\text{sweeping}}$ = 0.05 (from Table 2-4)
AF = 3 mo./12 mo. = 0.25

Substitution into equation 2-1 yields a $\text{Credit}_{\text{P sweeping}}$ of 0.3 pounds of phosphorus removed per year.

$\text{Credit}_{\text{P sweeping}} = \text{IA}_{\text{swept}} \times \text{PLER}_{\text{IC-commercial}} \times \text{PRF}_{\text{sweeping}} \times \text{AF}$
= 12.5 acre x 1.78 lbs./acre/yr. x 0.05 x 0.25
**= 0.3 lbs. P/yr.**

# ATTACHMENT 3 TO APPENDIX F

## Methods to Calculate Phosphorus and Nitrogen Load Reductions for Structural Stormwater Best Management Practices

### List of Tables

**List of Figures**

**Methods to Calculate Phosphorus and Nitrogen Load Reductions for Structural Stormwater Best Management Practices in the Watershed**

This attachment provides methods to determine design storage volume capacities and to calculate phosphorus and nitrogen (nutrient) load reductions for the following structural Best Management Practices (structural BMPs) for a LPCP area or watershed tributary to Great Bay:

1) Infiltration Trench;
2) Surface Infiltration Practices (i.e., basins, rain gardens and bio-retention);
3) Bio-filtration Practice;
4) Gravel Wetland System;
5) Enhanced Bio-filtration with Internal Storage Reservoir (ISR);
6) Sand Filter;
7) Porous Pavement;
8) Wet Pond or wet detention basin;
9) Dry Pond or detention basin; and
10) Dry Water Quality Grass Swale with Detention.

Additionally, this attachment provides methods to design and quantify associated nutrient load reduction credits for the following four types of semi-structural BMPs

11) Impervious Area Disconnection through Storage (e.g., rain barrels, cisterns, etc.);
12) Impervious Area Disconnection;
13) Conversions of Impervious Area to Permeable Pervious Area; and
14) Soil Amendments to Enhance Permeability of Pervious Areas.

Methods and examples are provided in this Attachment to calculate phosphorus and nitrogen (nutrient) load reductions for structural BMPs for the four following purposes:

1) To determine the design volume of a structural BMP to achieve a known nutrient load reduction target when the contributing drainage area is 100% impervious;
2) To determine the nutrient load reduction for a structural BMP with a known design volume capacity when the contributing drainage area is 100% impervious;
3) To determine the design volume of a structural BMP to achieve a known nutrient load reduction target when the contributing drainage area has impervious and pervious surfaces; and
4) To determine the nutrient load reduction for a structural BMP with a known design volume capacity when the contributing drainage area has impervious and pervious surfaces.

Examples are also provided for estimating nutrient load reductions associated with the four semi-structural/non-structural BMPs.

Also, this attachment provides the methodology for calculating the annual stormwater phosphorus and/or nitrogen load that will be delivered to BMPs for treatment (BMP Load) and to be used for quantifying phosphorus and/or nitrogen load reduction credits. The methods and annual nutrient export load rates presented in this Attachment are for the purpose of calculating load reductions for various BMPs treating storm water runoff from varying site conditions (i.e., impervious or pervious surfaces) and different land uses (e.g. commercial and institutional). The estimates of annual phosphorus load and load reductions resulting from BMP implementation are intended for use by the permittee to demonstrate compliance with its Phosphorus Reduction Requirement in accordance with Appendix F to the permit. The estimates of annual nitrogen load and load reductions resulting from BMP implementation are intended for use by the permittee to track and account for nitrogen load reductions in accordance with Appendix H to the permit.

**Structural BMP performance credits:** For each structural BMP type identified above (BMPs 1-10), long-term cumulative performance information is provided to calculate phosphorus and nitrogen load reductions or to determine needed design storage volume capacities to achieve a specified reduction target (e.g., 65% phosphorus load reduction). The performance information is expressed as cumulative phosphorus and/or nitrogen load removed (% removed) depending on the physical storage capacity of the structural BMP (expressed as inches of runoff from impervious area) and is provided at the end of this Attachment (see Tables 3-5 through 3-25 and performance curves Figures 3-1 through 3-20). Multiple tables and performance curves are provided for the infiltration practices to represent cumulative phosphorus load reduction performance for six infiltration rates (IR), 0.17, 0.27, 0.53, 1.02, 2.41, and 8.27 inches/hour. These infiltration rates represent the saturated hydraulic conductivity of the soils. The permittee may use the performance curves provided in this attachment to interpolate phosphorus and nitrogen load removal reductions for field measured infiltration rates that are different than the infiltration rates used to develop the performance curves. Otherwise, the permittee shall use the performance curve for the IR that is nearest, but less than, the field measured rate.

The Design Storage Volume or physical storage capacity (as referred to on the x-axis of performance curves) equals the total physical storage volume of the control structure to contain water at any instant in time. Typically, this storage capacity is comprised of the surface ponding storage volume prior to overflow and subsurface storage volumes in storage units and pore spaces of coarse filter media. Table 3-5 provides the formulae to calculate physical storage capacities for the structural control types for using the performance curves.

**Semi-Structural/Non-structural BMP performance credits:** For each semi-structural/non-structural BMP type identified above (BMPs 11-14), long-term cumulative performance information is provided to calculate phosphorus and/or nitrogen load reductions or to determine needed design specifications to achieve a desired reduction target (e.g., 50% phosphorus load reduction). The performance information is expressed as cumulative runoff volume reduction (% removed) depending on the design specifics and actual field conditions. Cumulative percent runoff volume reduction is being used as a surrogate to estimate both the cumulative phosphorus load and nitrogen load reduction credits for these BMPs.

To represent a wide range of potential conditions for implementing these types of BMPs, numerous performance tables and curves have been developed to reflect a wide range of potential conditions and designs such as varying storage volumes (expressed in terms of varying ratios of storage volume to impervious area (0.1 to 2.0 inches)); varying ratios of impervious source area to receiving pervious area based on hydrologic soil groups (HSGs) A, B, C and D (8:1, 6:1, 4:1, 2: 1 and 1:1); and varying discharge time periods for temporary storage (1, 2 or 3 days). The credits are provided at the end of this Attachment (see Tables 3-26 through 3-33 and performance curves Figures 3-21 through 3-41).

EPA will consider phosphorus and/or nitrogen load reductions calculated using the methods provided below to be valid for the purpose of demonstrating compliance with the terms of this permit for BMPs that have not been explicitly modeled, if the desired BMP has functionality that is similar to one of the simulated BMP types. Regarding functionality, only the surface infiltration, the infiltration trench and the four semi-structural/non-structural BMP types were simulated to direct storm water runoff into the ground (i.e., infiltration). All other simulated BMPs represent practices that are not hydraulically connected to the sub-surface soils (i.e., no infiltration) and have either under-drains or impermeable liners. Following are some simple guidelines for selecting the BMP type and/or determining whether the results of any of the BMP types provided are appropriate for another BMP of interest.

**Infiltration Trench** is a practice that provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils. Performance results for the infiltration trench can be used for all subsurface infiltration practices including systems that include pipes and/or chambers that provide temporary storage. Also, the results for this BMP type can be used for bio-retention systems that rely on infiltration when the majority of the temporary storage capacity is provided in the void spaces of the soil filter media and porous pavements that allow infiltration to occur. General design specifications for infiltration trench systems are provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.
(http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Surface Infiltration** represents a practice that provides temporary surface storage of runoff (e.g., ponding) for subsequent infiltration into the ground. Appropriate practices for use of the surface infiltration performance estimates include infiltration basins, infiltration swales (not conveyance swales), rain gardens and bio-retention systems that rely on infiltration and provide the majority of storage capacity through surface-ponding. If an infiltration system includes both surface storage through ponding and a lessor storage volume within the void spaces of a coarse filter media, then the physical storage volume capacity used to determine the long-term cumulative phosphorus removal efficiency from the infiltration basin performance curves would be equal to the sum of the surface storage volume and the void space storage volume. General design specifications for various surface infiltration systems are provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.
(http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Bio-filtration** is a practice that provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity is typically made of void spaces in the filter media and temporary ponding at the surface of the practice. Once the runoff has passed through the filter media it is collected by an under-drain pipe for discharge. The performance curve for this control practice assumes zero infiltration. If a filtration system has subsurface soils that are suitable for infiltration, then user should use the either performance curves for the infiltration trench or the infiltration basin depending on the predominance of storage volume made up by free standing storage or void space storage. Depending on the design of the filter media manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. Design specifications for bio-filtration systems are provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Gravel Wetland** performance results should be used for practices that have been designed in accordance or share similar features with the design specifications for subsurface gravel wetland systems provided in the report prepared by the University of New Hampshire Stormwater Center entitled *Design and Maintenance of Subsurface Gravel Wetland Systems* and dated February 4, 2015 (https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/NHDOT_SGW_02-06-15_Final_Report.pdf).

**Enhanced Bio-filtration with Internal Storage Reservoir (ISR)** is a practice that provides temporary storage of runoff for filtering through an engineered soil media, augmented for enhanced phosphorus removal, followed by detention and denitrification in a subsurface internal storage reservoir (ISR) comprised of gravel. Runoff flows are routed through filter media and directed to the underlying ISR via an impermeable membrane for temporary storage. An elevated outlet control at the top of the ISR is designed to provide a retention time of at least 24 hours in the system to allow for sufficient time for denitrification and nitrogen reduction to occur prior to discharge. The design storage capacity for using the cumulative performance curves is comprised of void spaces in the filter media, temporary ponding at the surface of the practice and the void spaces in the gravel ISR. The cumulative phosphorus load reduction curve for this control is intended to be used for systems in which the filter media has been augmented with materials designed and/or known to be effective at capturing phosphorus. If the filter media is not augmented to enhance phosphorus capture, then the phosphorus performance curve for the Bio-Filter should be used for estimating phosphorus load reductions. The University of New Hampshire Stormwater Center (UNHSC) developed the design of this control practice and a design template can be found at UNHSC's website (https://www.unh.edu/unhsc/news/unhsc-innovative-bioretention-template-pollutant-reductions-great-bay-estuary-watershed).

**Sand Filter** performance results should be used for practices that have been designed in accordance or share similar features with the design specifications for sand filter systems provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Porous Pavement** performance results represent systems with an impermeable under-liner and an under-drain. *If porous pavement systems do not have an impermeable under-liner so that filtered runoff can infiltrate into sub-soils, then the performance results for an infiltration trench may be used for these systems.* Design specifications for porous pavement systems are provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Extended Dry Detention Pond** performance results should only be used for practices that have been designed in accordance with the design specifications for extended dry detention ponds provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm).

**Water Quality Grass Swale with Detention** performance results should only be used for practices that have been designed in accordance with the design specifications for a water quality swale with check dams to temporarily store the target storage volume capture provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf)

**Impervious Area Disconnection using Storage (e.g., rain barrels, cistern, etc.)** performance results are for collecting runoff volumes from impervious areas such as roof tops, providing temporary storage of runoff volume using rain barrels, cisterns or other storage containers, and discharging stored volume to adjacent permeable pervious surfaces over an extended period of time. Such practices should be designed in accordance with the design specifications for applicable buffers (e.g., developed area buffers) provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm)

**Impervious Area Disconnection** performance results are for diverting runoff volumes from impervious areas such as roadways, parking lots and roof tops, and discharging it to adjacent vegetated permeable surfaces that are of sufficient size with adequate soils to receive the runoff without causing negative impacts to adjacent down-gradient properties. Careful consideration must be given to the ratio of impervious area to the pervious area that will receive the discharge. Also, devices such as level spreaders to disperse the discharge and provide sheet flow should be employed whenever needed to increase recharge and avoid flow concentration and short circuiting through the pervious area. Soil testing is needed to classify the permeability of the receiving pervious area in terms of HSG. Such practices should be designed in accordance with the design specifications for applicable buffers (e.g., developed area buffers) provided in the most recent version of *the New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*. (http://des.nh.gov/organization/divisions/water/stormwater/manual.htm)

**Conversion of Impervious Area to Permeable Pervious Area** nutrient load reduction credits are for replacing existing impervious surfaces (such as traditional pavements and buildings with roof tops) with permeable surfaces. To be eligible for credit, it is essential that the area previously covered with impervious surface be restored to provide natural or enhanced hydrologic functioning so that the surface is permeable. Sub-soils beneath pavements are typically highly compacted and will require reworking to loosen the soil and the possible addition of soil amendments to restore permeability. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

**Soil Amendments to Increase Permeability of Pervious Areas** performance results are for the practice of improving the permeability of pervious areas through incorporation of soil amendments, tilling and establishing dense vegetation. This practice may be used to compliment other practices such as impervious area disconnection to improve overall performance and increase reduction credits earned. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

**<u>Alternative Methods:</u>**

A permittee may propose alternative long-term cumulative performance information or alternative methods to calculate phosphorus and/or nitrogen load reductions for the structural BMPs identified above or for other structural BMPs not identified in this Attachment.

EPA will consider alternative long-term cumulative performance information and alternative methods to calculate phosphorus and/or load reductions for structural BMPs provided that the permittee provides EPA with adequate supporting documentation. At a minimum, the supporting documentation shall include:

Results of continuous BMP model simulations representing the structural BMP, using a verified BMP model and representative long-term (i.e., 10 years) climatic data including hourly rainfall data;

Supporting calculations and model documentation that justify use of the model, model input parameters, and the resulting cumulative phosphorus load reduction estimate;

If pollutant removal performance data are available for the specific BMP, model calibration results should be provided; and

Identification of references and sources of information that support the use of the alternative information and method.

If EPA determines that the long-term cumulative phosphorus and/or nitrogen load reductions developed based on alternative information are not adequately supported, EPA will notify the permittee in writing, and the permittee may receive no phosphorus reduction credit other than a reduction credit calculated by the permittee using the default phosphorus and/or nitrogen reduction factors provided in this Attachment for the identified practices. The permittee is required to submit to EPA valid phosphorus load reductions for structural BMPs in the LPCP area in accordance with the submission schedule requirements specified in the permit and Appendix F.

**<u>Method to Calculate Annual Phosphorus and/or Nitrogen Load Delivered to BMPs (BMP Load)</u>**

The **BMP Load** is the annual phosphorus and/or nitrogen load from the drainage area to each proposed or existing BMP used by permittee to claim credit against its stormwater phosphorus load reduction requirement (i.e., Phosphorus Reduction Requirement) or for tracking and accounting for nitrogen load reductions in the Great Bay watershed. The BMP Load is the starting point from which the permittee calculates the reduction in phosphorus load achieved by each existing and proposed BMP.

Examples are provided to illustrate use of the methods. Tables 3-1 and 3-2 below provide annual nutrient load export rates by land use category for impervious and pervious areas for phosphorus (PLERs) and nitrogen (NLER), respectively. The examples are applicable for both phosphorus and nitrogen. The permittee shall select the land use categories that most closely represents the actual uses of the drainage areas tributary to BMP. For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value. If the HSG is not known, assume HSG C conditions for the phosphorus and/or nitrogen load export rate. For drainage areas with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial/industrial land use category for the purpose of calculating phosphorus and/or nitrogen loads. Table 3-3 provides a crosswalk table of nutrient load export rate (PLER and NLER) land use categories in Tables 3-1 and 3-2, and the corresponding land use category codes used in NH GRANIT.

**Table 3-1: Average annual distinct phosphorus (P) load export rates for use in estimating P load reduction credits in the NH MS4 Permit**

| Phosphorus Source Category by Land Use | Land Surface Cover | P Load Export Rate, lbs./acre/year | P Load Export Rate, kg/ha/yr. |
|---|---|---|---|
| Commercial (COM) and Industrial (IND) | Directly connected impervious | 1.78 | 2.0 |
| | Pervious | See* DevPERV | See* DevPERV |
| Multi-Family (MFR) and High-Density Residential (HDR) | Directly connected impervious | 2.32 | 2.6 |
| | Pervious | See* DevPERV | See* DevPERV |
| Medium -Density Residential (MDR) | Directly connected impervious | 1.96 | 2.2 |
| | Pervious | See* DevPERV | See* DevPERV |
| Low Density Residential (LDR) - "Rural" | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Highway (HWY) | Directly connected impervious | 1.34 | 1.5 |
| | Pervious | See* DevPERV | See* DevPERV |
| Forest (FOR) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | 0.13 | 0.13 |
| Open Land (OPEN) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Agriculture (AG) | Directly connected impervious | 1.52 | 1.7 |
| | Pervious | 0.45 | 0.5 |
| *Developed Land Pervious (DevPERV) – HSG A | Pervious | 0.03 | 0.03 |
| *Developed Land Pervious (DevPERV) – HSG B | Pervious | 0.12 | 0.13 |
| *Developed Land Pervious (DevPERV) – HSG C | Pervious | 0.21 | 0.24 |
| *Developed Land Pervious (DevPERV) – HSG C/D | Pervious | 0.29 | 0.33 |

| | | | |
|---|---|---|---|
| *Developed Land Pervious (DevPERV) – HSG D | Pervious | 0.37 | 0.41 |

Notes:

- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate.
- Agriculture includes row crops, actively managed hay fields, and pasture lands. Institutional land uses, such as government properties, hospitals and schools, are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

**Table 3-2: Average annual distinct nitrogen (N) load export rates for use in estimating N load reduction credits in the NH MS4 Permit**

| Nitrogen Source Category by Land Use | Land Surface Cover | N Load Export Rate, lbs./acre/year | N Load Export Rate, kg/ha/yr. |
|---|---|---|---|
| Commercial (COM) and Industrial (IND) | Directly connected impervious | 15.0 | 16.9 |
| | Pervious | See* DevPERV | See* DevPERV |
| All Residential | Directly connected impervious | 14.1 | 15.8 |
| | Pervious | See* DevPERV | See* DevPERV |
| Highway (HWY) | Directly connected impervious | 10.5 | 11.8 |
| | Pervious | See* DevPERV | See* DevPERV |
| Forest (FOR) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | 0.5 | 0.6 |
| Open Land (OPEN) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | See* DevPERV | See* DevPERV |
| Agriculture (AG) | Directly connected impervious | 11.3 | 12.7 |
| | Pervious | 2.6 | 2.9 |
| *Developed Land Pervious (DevPERV) – HSG A | Pervious | 0.3 | 0.3 |
| *Developed Land Pervious (DevPERV) – HSG B | Pervious | 1.2 | 1.3 |
| *Developed Land Pervious (DevPERV) – HSG C | Pervious | 2.4 | 2.7 |
| *Developed Land Pervious (DevPERV) – HSG C/D | Pervious | 3.1 | 3.5 |
| *Developed Land Pervious (DevPERV) – HSG D | Pervious | 3.6 | 4.1 |

Notes:

- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate.
- Agriculture includes row crops. Actively managed hay fields and pasture lands. Institutional land uses such as government properties, hospitals and schools are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

**Table 3-3. Crosswalk of land use groups for NH MS4 P Load calculations to land use codes in NH GRANIT**

| Description of Land Use (LU) Groups for Calculating P Load Using PLERs | NH GRANIT LU Category Codes [1] |
|---|---|
| Commercial | 1210-1290, 1442, 1146, 1520-30, 1590, 1610-90, and 1790 |
| Industrial, | 1300, 1370, 1410-20, 1460-80, 1510, and 1580 |
| High Density Residential | 1110, 1120 and1140 |
| Medium Density Residential | 1130 and 1150 |
| Low Density Residential | 1190 |
| Highway/Freeway | 1440-45, 1447-50 and 1490 |
| Forest | 3000, 4000, 6000, 190 |
| Open Land | 1710-90, 1800 |
| Agriculture | 2000 and 2900 |

[1]NH GRANIT land use categories can be found at the following link (See Table 1, page 4): http://www.granit.unh.edu/resourcelibrary/GRANITresources/standards/LUStandards-I93-061107.pdf

**BMP Load:** To estimate the annual phosphorus and/or nitrogen load reduction for a given stormwater BMP, it is first necessary to estimate the amount of annual stormwater phosphorus and/or nitrogen load that will be directed to the BMP (BMP Load).

For a given BMP:

1) Determine the total drainage area to the BMP;

2) Distribute the total drainage area into impervious and pervious subareas by land use category as defined by Tables 3-1, 3-2 and 3-3;

3) Calculate the nutrient load for each land use-based impervious and pervious subarea by multiplying the subarea by the appropriate nutrient load export rate (i.e., PLER or NLER) provided in Tables 3-1 and 3-2; and

4) Determine the total annual phosphorus and/or nitrogen loads to the BMP by summing the calculated impervious and pervious subarea phosphorus and/or nitrogen loads.

**Example 3-1 to determine phosphorus and nitrogen loads to a proposed BMP:** A permittee is proposing a surface stormwater infiltration system that will treat runoff from an industrial site within the LPCP area that has a total drainage area of 12.87 acres comprised of 10.13 acres of impervious cover (e.g., roadways, parking areas and rooftops), 1.85 acres of landscaped pervious area and 0.89 acres of wooded area both with HSG C soils. The drainage area information for the proposed BMP is:

| BMP Subarea ID | Land Use Category | Cover Type | Area (acres) | PLER (lb/acre/yr)* | NLER (lb/acre/yr)** |
|---|---|---|---|---|---|
| 1 | Industrial | impervious | 10.13 | 1.78 | 15.0 |
| 2 | Landscaped (HSG C) | pervious | 1.85 | 0.21 | 2.4 |
| 3 | Forest (HSG C) | pervious | 0.89 | 0.12 | 0.5 |

*From Table 3-1
**From Table 3-2

The phosphorus load to the proposed BMP (BMP Load $_P$) is calculated as:

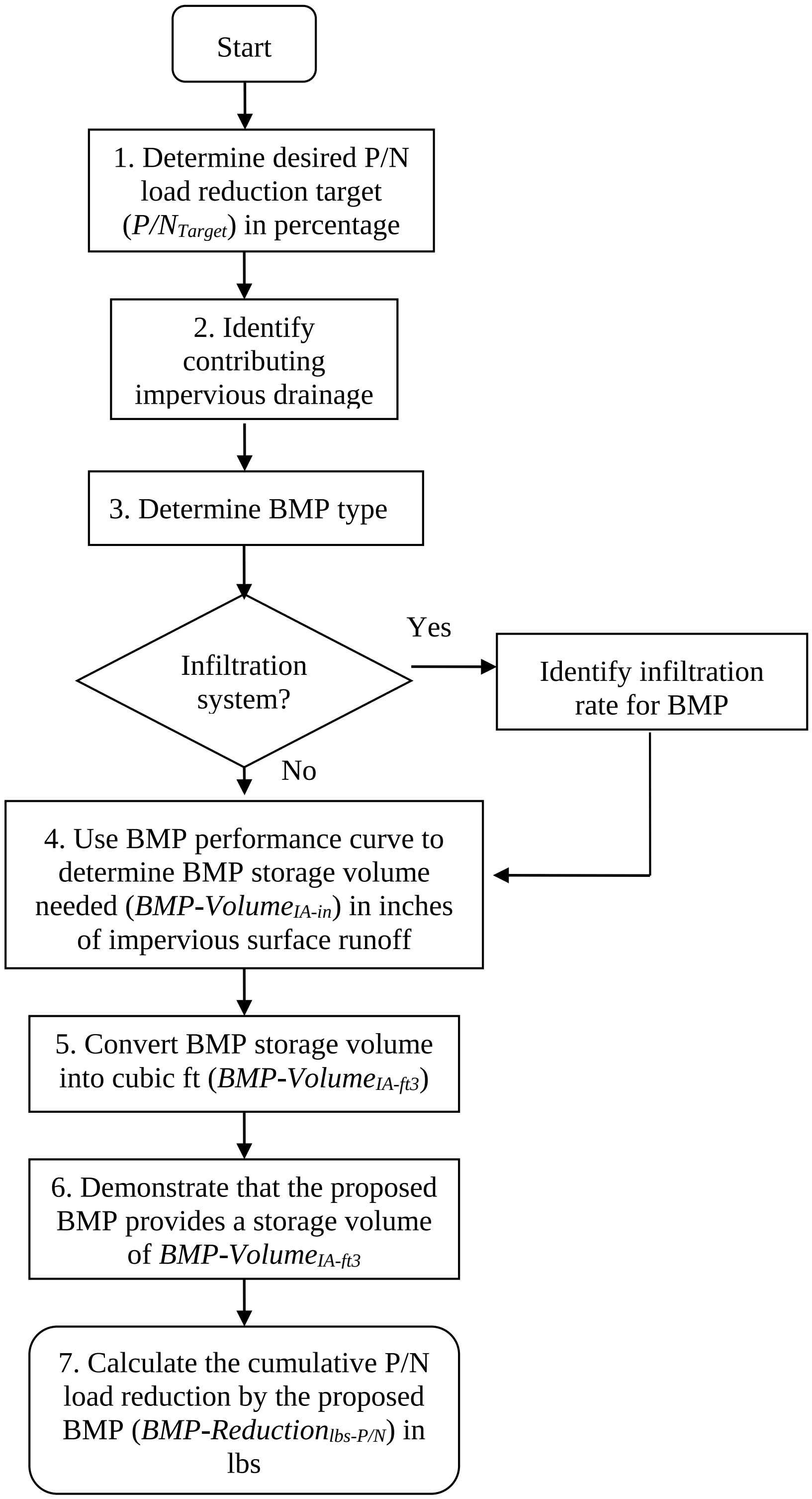
BMP Load $_P$ $= (IA_{Ind} \times PLER_{Ind}) + (PA_{Ind} \times PLER_{Ind}) + (PA_{FOREST} \times PLER_{For})$
$= (10.13 \times 1.78) + (1.85 \times 0.21) + (0.89 \times 0.12)$
**= 18.53 lbs P/year**

The nitrogen load to the proposed BMP (BMP Load $_N$) is calculated as:

BMP Load $_N$ $= (IA_{Ind} \times NLER_{Ind}) + (PA_{Ind} \times NLER_{Ind}) + (PA_{FOREST} \times NLER_{For})$
$= (10.13 \times 15.0) + (1.85 \times 2.4) + (0.89 \times 0.5)$
**= 156.9 lbs N/year**

**(1) Method to determine the design volume of a structural BMP to achieve a known phosphorus and/or nitrogen (P/N) load reduction target when the contributing drainage area is 100% impervious:**

Flow Chart 1 illustrates the steps to determine the design volume of a structural BMP to achieve a known phosphorus and/or nitrogen (P/N) load reduction target when the contributing drainage area is 100% impervious.




**Flow Chart 1: Method to determine BMP design volume to achieve a known phosphorous load reduction when contributing drainage area is 100% impervious.**

**1)** Determine the desired cumulative phosphorus and/or nitrogen load reduction target ($P/N_{target}$) in percentage for the structural BMP;

**2)** Determine the contributing impervious drainage area (IA) in acres to the structural BMP;

**3)** Determine the structural BMP type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the BMP in the Watershed;

**4)** Using the cumulative phosphorus and/or nitrogen removal performance curves for the selected structural BMP (Figures 3-1 through 3-20), determine the storage volume for the BMP (BMP-Volume $_{IA\text{-}in}$), in inches of runoff, needed to treat runoff from the contributing IA to achieve the reduction target;

**5)** Calculate the corresponding BMP storage volume in cubic feet (BMP-Volume $_{IA\text{-}ft^3}$) using BMP-Volume $_{IA\text{-}in}$ determined from step 4 and equation 3-1:

BMP-Volume $_{IA\text{-}ft^3}$ = IA (acre) x BMP-Volume $_{IA\text{-}in}$ x 3630 $ft^3$/ac-in **(Equation 3-1)**

**6)** Provide supporting calculations using the dimensions and specifications of the proposed structural BMP showing that the necessary storage volume capacity, BMP-Volume $_{IA\text{-}ft^3}$, determined from step 5 will be provided to achieve the P/N $_{Target}$; and

**7)** Calculate the cumulative P/N load reduction in pounds of P/N (BMP-Reduction $_{lbs\text{-}P/N}$) for the structural BMP using the BMP Load (as calculated from the procedure in Attachment 1 to Appendix F) and P/N $_{target}$ by using equation 3-2:

BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P/N $_{target}$ /100) **(Equation 3-2)**

**Example 3-2 to determine design storage volume capacity of a structural BMP for a 100% impervious drainage area to achieve a known phosphorus load reduction target*:**
*Note: The approach used in this example is for phosphorus and is equally applicable for nitrogen.

A permittee is considering a surface infiltration practice to capture and treat runoff from 2.57 acres (1.04 ha) of commercial impervious area in the LPCP area that will achieve a 70% reduction in average annual phosphorus load. The infiltration practice would be located adjacent to the impervious area. The permittee has measured an infiltration rate (IR) of 0.39 inches per hour (in/hr) in the vicinity of the proposed infiltration practice. Determine the:

**A)** Design storage volume needed for an surface infiltration practice to achieve a 70% reduction in annual phosphorus load from the contributing drainage area (BMP-Volume $_{IA\text{-}ft^3}$); and

**B)** Cumulative phosphorus reduction in pounds that would be accomplished by the BMP (BMP-Reduction $_{lbs\text{-}P}$)

**<u>Solution:</u>**

**1)** Phosphorus load reduction target (P $_{target}$) = 70%

**<u>Solution continued:</u>**

**2)** Contributing impervious drainages area (IA) = 2.57 acres;

**3)** BMP type is a surface infiltration practice (i.e., basin) with an infiltration rate (IRBMP type is a surface infiltration practice (i.e., basin) with an infiltration rate (IR) of 0.39 in/hr

**4)** The performance curve for the infiltration basin (i.e., surface infiltration practice), Figure 3-8, IR = 0.27 in/hr is used to determine the design storage volume of the BMP (BMP-Volume $_{IA\text{-}in}$) needed to treat runoff from the contributing IA and achieve a P $_{target}$ = 70%. The curve for an infiltration rate of 0.27 in/hr is chosen because 0.27 in/hr is the nearest simulated IR that is less than the field measured IR of 0.39 in/hr. From Figure 3-8, the BMP-Volume $_{IA\text{-}in}$ for a P $_{target}$ = 70% is 0.36 in.

**5)** The BMP-Volume $_{IA\text{-}in}$ is converted to cubic feet (BMP-Volume $_{IA\text{-}ft^3}$) using Equation 3-1:

BMP-Volume $_{IA\text{-}ft^3}$ = IA (acre) x BMP-Volume $_{IA\text{-}in}$ x 3,630 $ft^3$/acre-in
BMP-Volume $_{IA\text{-}ft^3}$ = 2.57 acre x 0.36 in x 3,630 $ft^3$/acre-in
= **3,359 $ft^3$**

**6)** A narrow trapezoidal infiltration basin with the following characteristics is proposed to achieve the P $_{Target}$ of 70%. As indicated in Table 3-5, the Design Storage Volume (DSV) of a surface infiltration practice is equal to the volume of surface ponding:

$$DSV = (L \times ((W_{bottom}+W_{top@Dmax})/2) \times D)$$ (Table 3-5: Surface Infiltration)

| Length (ft) | Design Depth (ft) | Side Slopes | Bottom area ($ft^2$) | Pond surface area ($ft^2$) | Design Storage Volume ($ft^3$) |
|---|---|---|---|---|---|
| 355 | 1.25 | 3:1 | 1,387 | 4,059 | 3,404 |

The proposed DSV of 3,404 $ft^3$ exceeds the BMP-Volume $_{IA\text{-}ft^3}$ needed, 3,359 $ft^3$ and therefore is sufficient to achieve the P Target of 70%.

**7)** The cumulative phosphorus load reduction in pounds of phosphorus for the infiltration practice (BMP-Reduction $_{lbs\text{-}P}$) is calculated using Equation 3-2. The BMP Load is first determined using the method described above.

BMP Load = IA x impervious cover PLER for commercial use (see Table 3-1)
= 2.57 acres x 1.78 lbs/acre/yr
= 4.58 lbs/yr

BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100)
BMP-Reduction $_{lbs\text{-}P}$ = 4.58 lbs/yr x (70/100)
= **3.21 lbs/yr**

**Solution continued:**

**Alternate Solution:** Alternatively, the permittee could determine the design storage volume needed for an IR = 0.39 in/hr by performing interpolation of the results from the surface infiltration performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr as follows (replacing steps 3 and 4 on the previous page):

Using the performance curves for the infiltration basin (i.e., surface infiltration practice), Figures 3-8, IR = 0.27 in/hr and 3-9, IR = 0.52 in/hr, interpolate between the curves to determine the design storage volume of the BMP (BMP-Volume $_{IA\text{-}in}$) needed to treat runoff from the contributing IA and achieve a P $_{target}$ = 70%.

First calculate the interpolation adjustment factor (IAF) to interpolate between the infiltration basin performance curves for infiltration rates of 0.27 and 0.52 in/hr:

$$IAF = (0.39 - 0.27)/ (0.52 – 0.27) = 0.48$$

From the two performance curves, develop the following table to estimate the general magnitude of the needed storage volume for an infiltration swale with an IR = 0.39 in/hr and a P $_{target}$ of 70%.

**Table Example 3-1-1: Interpolation Table for determining design storage volume of infiltration basin with IR = 0.39 in/hr and a phosphorus load reduction target of 70%**

| BMP Storage Volume | % Phosphorus Load Reduction IR = 0.27 in/hr ($PR_{IR=0.27}$) | % Phosphorus Load Reduction IR = 0.52 in/hr ($PR_{IR=0.52}$) | Interpolated % Phosphorus Load Reduction IR = 0.39 in/hr ($PR_{IR=0.39}$) **$PR_{IR=0.39}$= IAF($PR_{IR=0.52}$ – $PR_{IR=0.27}$) + $PR_{IR=0.27}$** |
|---|---|---|---|
| 0.3 | 64% | 67% | 65% |
| 0.4 | 74% | 77% | 75% |
| 0.5 | 79% | 82% | 80% |

As indicated from Table Example 3-1, the BMP-Volume $_{IA\text{-}in}$ for $PR_{IR=0.39}$ of 70% is between 0.3 and 0.4 inches and can be determined by interpolation:

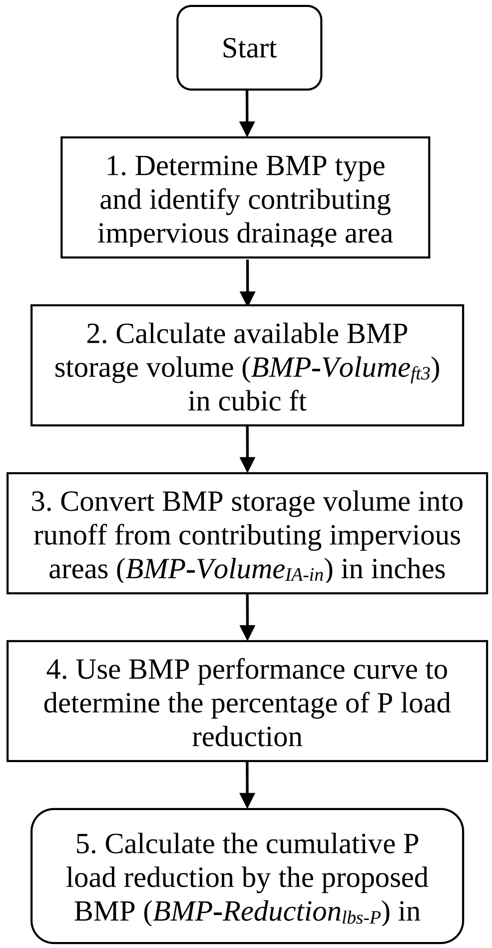
$$\text{BMP-Volume}_{IA\text{-}in} = (70\% - 65\%)/ (75\% - 65\%) \times (0.4 \text{ in} – 0.3 \text{ in}) + 0.3 \text{ in}$$
$$= 0.35 \text{ inches}$$

**5 alternative)** Convert the resulting BMP-Volume $_{IA\text{-}in}$ to cubic feet (BMP-Volume $_{IA\text{-}ft^3}$) using equation 3-1:

$$\text{BMP-Volume}_{IA\text{-}ft^3} = 2.57 \text{ acre} \times 0.35 \text{ in} \times 3{,}630 \text{ ft}^3\text{/acre-in}$$
$$\mathbf{= 3{,}265\ ft^3}$$

**(2) <u>Method to determine the phosphorus and/or nitrogen (N/P) load reduction credit for a structural BMP with a known design storage volume when the contributing drainage area is 100% impervious:</u>**

Flow Chart 2 illustrates the steps to determine the phosphorus and/or nitrogen (N/P) load reduction for a structural BMP with a known design volume when the contributing drainage area is 100% impervious.




**Flow Chart 2: Method to determine the phosphorus and/or nitrogen load reduction for a BMP with a known design volume when contributing drainage area is 100% impervious.**

1) Identify the structural BMP type and contributing impervious drainage area (IA);

2) Document the available storage volume ($ft^3$) of the structural BMP (BMP-Volume $_{ft^3}$) using the BMP dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

3) Convert BMP-Volume $_{ft^3}$ into inches of runoff from the contributing impervious area (BMP-Volume $_{IA\text{-}in}$) using equation 3-3:

   BMP-Volume $_{IA\text{-}in}$ = BMP-Volume $_{ft^3}$/ IA (acre) x 12 in/ft x 1 acre/43560 $ft^2$ **(Equation 3-3)**

4) Determine the % P/N load reduction for the structural BMP (BMP Reduction $_{\%-P}$) using the appropriate BMP performance curve (Figures 3-1 through 3-20) and the BMP-Volume $_{IA-in}$ calculated in step 3; and

5) Calculate the cumulative P/N load reduction in pounds for the structural BMP (BMP Reduction $_{lbs-P/N}$) using the BMP Load as calculated from the procedure described above and the percent P/N load reduction determined in step 4 by using equation 3-4:

BMP Reduction $_{lbs-P/N}$ = BMP Load x (BMP Reduction $_{\%-P/N}$/100) **(Equation 3-4)**

**Example 3-2: Determine the nitrogen load reduction for a structural BMP with a known storage volume capacity when the contributing drainage area is 100% impervious*:**
*The approach used in this example is for nitrogen and is equally applicable for phosphorus.

A permittee is considering an Enhanced Bio-filtration w/ISR system to treat runoff from 1.49 acres of high density residential (HDR) impervious area. Site constraints would limit the enhanced bio-filtration system to have a surface area of 1200 ft$^2$ and the system would have to be located next to the impervious drainage area to be treated. The design parameters for the enhanced bio-filtration w/ ISR system are presented in Table Example 3-2-1.

**Table Example 3-2-1: Design parameters for bio-filtration system for Example 3-2**

| Components of representation | Parameters | Value |
|---|---|---|
| Ponding | Maximum depth | 0.5 ft |
| | Surface area | 1200 ft$^2$ |
| | Vegetative parameter[a] | 85-95% |
| Soil mix | Depth | 2.0 ft |
| | Porosity | 0.35 |
| | Hydraulic conductivity | 4 inches/hour |
| Gravel layer | Depth | 2.0 ft |
| | Porosity | 0.45 |
| Orifice #1 | Diameter | 0.08 ft |

[a] Refers to the percentage of surface covered with vegetation

Determine the:

**A)** Percent nitrogen load reduction (BMP Reduction $_{\%-N}$) for the specified enhanced bio-filtration w/ISR system and contributing impervious HDR drainage area; and

**B)** Cumulative nitrogen reduction in pounds that would be accomplished by the system (BMP-Reduction $_{lbs-N}$)

**Solution:**

1) The BMP is an enhanced bio-filtration w/ISR system that will treat runoff from 1.49 acres of HDR impervious area (IA = 1.49 acre);

2) The available storage volume capacity (ft$^3$) of the enhanced bio-filtration system (BMP-Volume $_{BMP-ft^3}$) is determined using the surface area of the system, depth of ponding, and the porosities of the filter media and subsurface gravel ISR:

**Solution continued:**

BMP-Volume $_{BMP\text{-}ft^3}$ = (surface area x pond maximum depth) + (surface area x ((soil mix depth x soil layer porosity) + (gravel layer depth x gravel layer porosity))
= (1,200 $ft^2$ x 0.5 ft) + (1,200 $ft^2$ x ((2.0 x 0.35) + (2.0 x 0.45))
= 600 + 1920
= 2,520 $ft^3$

**3)** The available storage volume capacity of the enhanced bio-filtration system in inches of runoff from the contributing impervious area (BMP-Volume $_{IA\text{-}in}$) is calculated using equation 3-3:

BMP-Volume $_{IA\text{-}in}$ = (BMP-Volume $_{ft^3}$/ IA (acre) x 12 in/ft x 1 acre/43560 $ft^2$
BMP-Volume $_{IA\text{-}in}$ = (2520 $ft^3$/1.49 acre) x 12 in/ft x 1 acre/43560 $ft^2$
= 0.47 in

**4)** Using the enhanced bio-filtration performance curve shown in Figure 3-15, a **61%** nitrogen load reduction (BMP Reduction %-N) is determined for the system with a design storage capacity of 0.47 inches for treating runoff from 1.49 acres of impervious area; and

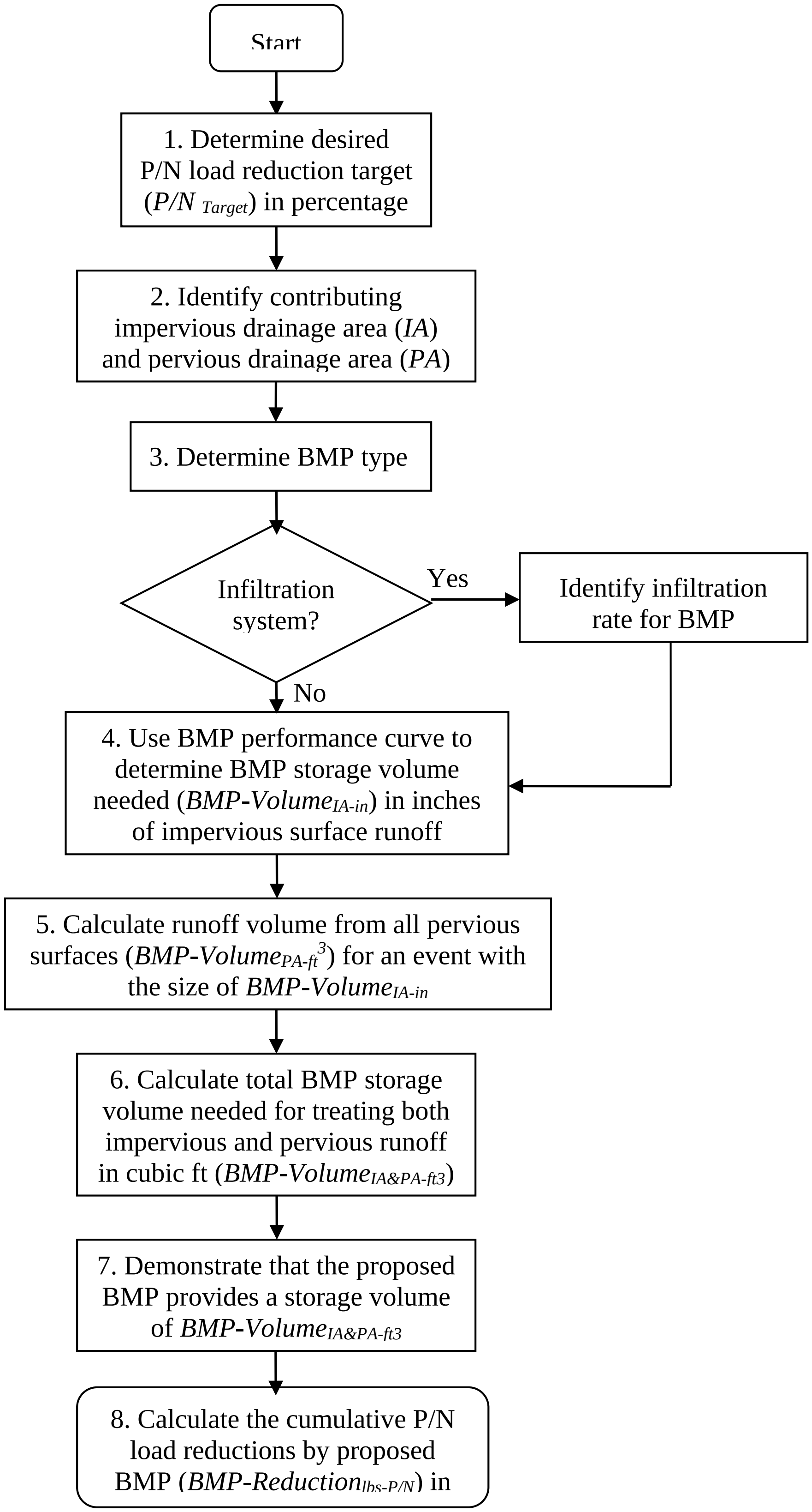
**5)** Calculate the cumulative nitrogen load reduction in pounds of for the enhanced bio-filtration w/ISR system (BMP Reduction $_{lbs\text{-}N}$) using the BMP Load as calculated from the procedure described above and the BMP Reduction $_{\%\text{-}N}$ determined in step 4 by using equation 3-4. First, the BMP Load is determined as specified above:

BMP Load $_N$ = IA x impervious cover nitrogen export loading rate for HDR (see Table 3-2)
= 1.49 acres x 15.8 lbs/acre/yr
= 23.5 lbs/yr

BMP Reduction $_{lbs\text{-}N}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
BMP Reduction $_{lbs\text{-}N}$ = 23.5 lbs/yr x (61/100)
= **14.4 lbs/yr**

**(3) Method to determine the design storage volume of a structural BMP to achieve a known phosphorus and/or nitrogen load reduction target when the contributing drainage area has impervious and pervious surfaces:**

Flow Chart 3 illustrates the steps to determine the design storage volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces.


Start
1. Determine desired P/N load reduction target ($P/N_{Target}$) in percentage
2. Identify contributing impervious drainage area ($IA$) and pervious drainage area ($PA$)
3. Determine BMP type
Infiltration system?
Yes
Identify infiltration rate for BMP
No
4. Use BMP performance curve to determine BMP storage volume needed ($BMP\text{-}Volume_{IA\text{-}in}$) in inches of impervious surface runoff
5. Calculate runoff volume from all pervious surfaces ($BMP\text{-}Volume_{PA\text{-}ft^3}$) for an event with the size of $BMP\text{-}Volume_{IA\text{-}in}$
6. Calculate total BMP storage volume needed for treating both impervious and pervious runoff in cubic ft ($BMP\text{-}Volume_{IA\&PA\text{-}ft3}$)
7. Demonstrate that the proposed BMP provides a storage volume of $BMP\text{-}Volume_{IA\&PA\text{-}ft3}$
8. Calculate the cumulative P/N load reductions by proposed BMP ($BMP\text{-}Reduction_{lbs\text{-}P/N}$) in

**Flow Chart 3: Method to determine the design storage volume of a BMP to reach a known P/N load reduction when both impervious and pervious drainage areas are present.**

1) Determine the desired cumulative P/N load reduction target ($P/N_{target}$) in percentage for the structural BMP;
2) Characterize the contributing drainage area to the structural BMP by identifying the following information for the impervious and pervious surfaces:
   **Impervious area (IA)** - Area (acre) and land use (e.g., commercial)
   **Pervious area (PA) –** Area (acre), land use and hydrologic soil group (HSG).
3) Determine the structural BMP type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the BMP in the Watershed;
4) Using the cumulative P/N removal performance curve for the selected structural BMP, determine the storage volume capacity of the BMP in inches needed to treat runoff from the contributing impervious area ($\text{BMP-Volume}_{\text{IA-in}}$);
5) Using Equation 3-5 below and the pervious area runoff depth information from Table 3-4, below, determine the total volume of runoff from the contributing pervious drainage area in cubic feet ($\text{BMP Volume}_{\text{PA-ft}^3}$) for a rainfall size equal to the sum of BMP $\text{Volume}_{\text{IA-in}}$, determined in step 4. The runoff volume for each distinct pervious area must be determined;
   $\text{BMP-Volume}_{\text{PA ft}^3} = \sum (\text{PA x (runoff depth) x } 3{,}630 \text{ ft}^3/\text{acre-in})_{(\text{PA1, PAn})}$ **(Equation 3-5)**

> Table 3-4 provides values of runoff depth from pervious areas for various rainfall depths and HSGs. Soils are assigned to an HSG on the basis of their permeability. HSG A is the most permeable, and HSG D is the least permeable. HSG categories for pervious areas in the drainage area shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the drainage area. If the HSG condition is not known, a HSG C soil condition should be assumed.

6) Using equation 3-6 below, calculate the BMP storage volume in cubic feet ($\text{BMP-Volume}_{\text{IA\&PA-ft}^3}$) needed to treat the runoff depth from the contributing impervious (IA) and pervious areas (PA);

   $\text{BMP-Volume}_{\text{IA\&PA-ft}^3} = \text{BMP Volume}_{\text{PA-ft}^3} + (\text{BMP Volume}_{\text{IA-in}} \text{ x IA (acre) x } 3{,}630 \text{ ft}^3/\text{acre-in})$ **(Equation 3-6)**

7) Provide supporting calculations using the dimensions and specifications of the proposed structural BMP showing that the necessary storage volume determined in step 6, $\text{BMP-Volume}_{\text{IA\&PA-ft}^3}$, will be provided to achieve the $P/N_{Target}$; and
8) Calculate the cumulative phosphorus load reduction in pounds of phosphorus ($\text{BMP-Reduction}_{\text{lbs-P/N}}$) for the structural BMP using the BMP Load (as calculated in example 1) and the $P/N_{target}$ by using equation 3-2:

   $\text{BMP-Reduction}_{\text{lbs-P/N}} = \text{BMP Load x } (P_{target}/100)$ **(Equation 3-2)**

**Table 3- 4: Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups (HSGs)**

| Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups | | | | | |
|---|---|---|---|---|---|
| Rainfall Depth, Inches | Runoff Depth, inches | | | | |
| | Pervious HSG A | Pervious HSG B | Pervious HSG C | Pervious HSG C/D | Pervious HSG D |
| 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.20 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 |
| 0.40 | 0.00 | 0.00 | 0.03 | 0.05 | 0.06 |
| 0.50 | 0.00 | 0.01 | 0.05 | 0.07 | 0.09 |
| 0.60 | 0.01 | 0.02 | 0.06 | 0.09 | 0.11 |
| 0.80 | 0.02 | 0.03 | 0.09 | 0.13 | 0.16 |
| 1.00 | 0.03 | 0.04 | 0.12 | 0.17 | 0.21 |
| 1.20 | 0.04 | 0.05 | 0.14 | 0.27 | 0.39 |
| 1.50 | 0.08 | 0.11 | 0.39 | 0.55 | 0.72 |
| 2.00 | 0.14 | 0.22 | 0.69 | 0.89 | 1.08 |

Notes: Runoff depths derived from combination of volumetric runoff coefficients from Table 5 of *Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices*, (Pitt, 1999), and using the Stormwater Management Model (SWMM) in continuous model mode for hourly precipitation data for Boston, MA, 1998-2002.

**Example 3-3: Determine the design storage volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces*:**

*The approach used in this example for phosphorus is equally applicable for nitrogen.

A permittee is considering a gravel wetland system to treat runoff from a high-density residential (HDR) site. The site is 7.5 acres of which 4.0 acres are impervious surfaces and 3.50 acres are pervious surfaces. The pervious area is made up of 2.5 acres of lawns in good condition surrounding cluster housing units and 1.0 acre of stable unmanaged woodland. Soils information indicates that all of the woodland and 0.5 acres of the lawn is hydrologic soil group (HSG) B and the other 2.0 acres of lawn are HSG C. The permittee wants to size the gravel wetland system to achieve a cumulative phosphorus load reduction ($P_{Target}$) of 55% from the entire 7.5 acres.

Determine the:

**A)** Design storage volume needed for a gravel wetland system to achieve a 55% reduction in annual phosphorus load from the contributing drainage area (BMP-Volume $_{IA\&PA\text{-}ft^3}$); and

**B)** Cumulative phosphorus reduction in pounds that would be accomplished by the BMP (BMP-Reduction $_{lbs\text{-}P}$)

**Example 3-3 continued:**
**Solution:**

**1)** The BMP type is gravel wetland system.

**2)** The phosphorus load reduction target ($P_{Target}$) = 55%.

**3)** Using the cumulative phosphorus removal performance curve for the gravel wetland system shown in Figure 3-14, the storage volume capacity in inches needed to treat runoff from the contributing impervious area (BMP $Volume_{IA\text{-}in}$) is 0.71 in;

Using equation 3-5 and the pervious runoff depth information from Table 3-4, the volume of runoff from the contributing pervious drainage area in cubic feet (BMP $Volume_{PA-ft^3}$) for a rainfall size equal to 0.71 in is summarized in Table Example 3-3-A. As indicated from Table 3-4, the runoff depth for a rainfall size equal to 0.71 inches is between 0.6 and 0.8 inches and can be determined by interpolation (example shown for runoff depth of HSG C):

Runoff depth (HSG C) = (0.71 – 0.6)/(0.8 – 0.6) x (0.09 in – 0.06 in) + 0.06 in
= 0.07 inches

**Table Example 3-3-A: Runoff contributions from pervious areas for HDR site**

| ID | Type | Pervious Area (acre) | HSG | Runoff (in) | Runoff = (runoff) x PA (acre-in) | Runoff = Runoff (acre-in) x 3630 $ft^3$/acre-in ($ft^3$) |
|---|---|---|---|---|---|---|
| PA1 | Grass | 2.00 | C | 0.07 | 0.14 | 508 |
| PA2 | Grass | 0.50 | B | 0.01 | 0.0 | 0.0 |
| PA3 | Woods | 1.00 | B | 0.01 | 0.0 | 0.0 |
| **Total** | ----- | **3.50** | ----- | ----- | **0.14** | **508** |

**4)** Using equation 3-6, determine the BMP storage volume in cubic feet (BMP-$Volume_{IA\&PA\text{-}ft^3}$) needed to treat 0.71 inches of runoff from the contributing impervious area (IA) and the runoff of 0.14 acre-in from the contributing pervious areas, determined in step 5 is:

BMP $Volume_{IA\&PA\text{-}ft^3}$ = BMP $Volume_{PA\ ac\text{-}in}$ + (BMP $Volume_{IA\text{-}in}$ x IA (acre)) x 3,630 $ft^3$/acre-in)
BMP $Volume_{IA\&PA\text{-}ft^3}$ = (508 $ft^3$+ ((0.71 in x 4.00 acre) x 3,630 $ft^3$/acre-in)
= 10,817 $ft^3$

**5)** Table Example 3-3-B provides design details for of a potential gravel wetland system

**Solution continued:**

**Table Example 3-3-B: Design details for gravel wetland system**

| Gravel Wetland System Components | Design Detail | Depth (ft) | Surface Area ($ft^2$) | Volume ($ft^3$) |
|---|---|---|---|---|
| **Sediment Forebay** | **10% of Treatment Volume** | | | |
| Pond area | ---- | 1.33 | 896 | 1,192 |
| **Wetland Cell #1** | **45% of Treatment Volume** | --------------- | ------------------- | --------------- |
| Pond area | ---- | 2.00 | 1,914 | 3,828 |
| Gravel layer | porosity = 0.4 | 2.00 | 1,914 | 1,531 |
| **Wetland Cell #2** | **45% of Treatment Volume** | --------------- | ------------------ | --------------- |
| Pond area | ---- | 2.00 | 1,914 | 3,828 |
| Gravel layer | porosity = 0.4 | 2.00 | 1,914 | 1,531 |

The total design storage volume for the proposed gravel wetland system identified in Table Example 3-3-C is 11,910 $ft^3$. This volume is greater than 11,834 $ft^3$ ((BMP-Volume $_{IA\&PA\text{-}ft}{}^3$), calculated in step 4) and is therefore sufficient to achieve a P $_{Target}$ of 55%.

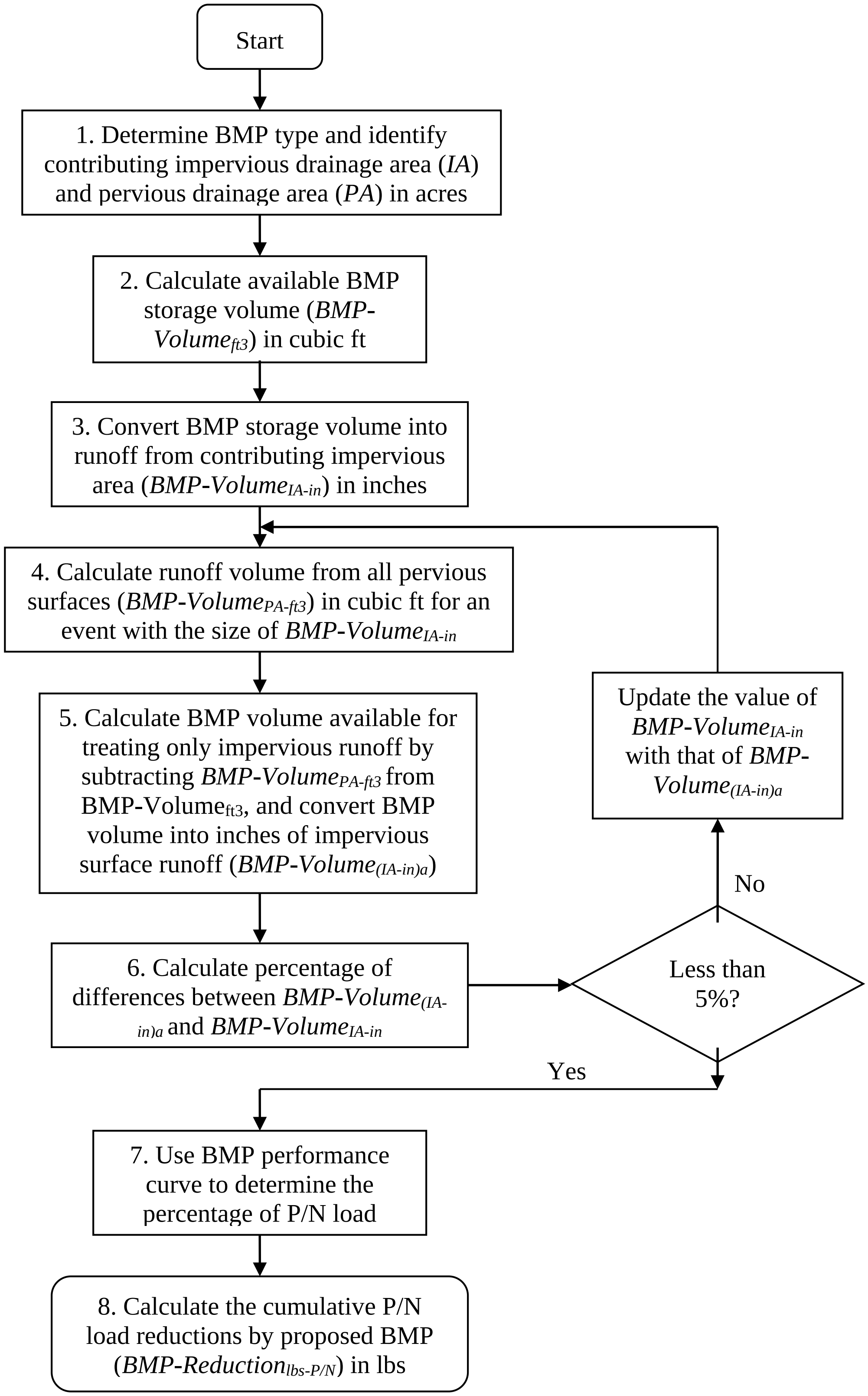
**6)** The cumulative phosphorus load reduction in pounds of phosphorus (BMP-Reduction $_{lbs\text{-}P}$) for the proposed gravel wetland system is calculated by using equation 3-2 with the BMP Load and the P $_{target}$ = 55%.

BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100) (**Equation 3-2**)

Using Table 3-1, the BMP Load is calculated:
BMP Load = (IA x PLER $_{IC\ HDR}$) + (PA lawn $_{HSG\ B}$ x PLER $_{HSG\ B}$) + (PA lawn $_{HSG\ C}$ x PLER $_{HSG\ C}$) + (PA forest x PA PLER $_{For}$)
= (4.00 acre x 2.32 lbs/acre/yr) + (0.50 acres x 0.12 lbs/acre/yr) + (2.00 acre x 0.21 lbs/acre/yr) + (1.00 acres x 0.13)
= 9.68 lbs/yr
BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100)
BMP-Reduction $_{lbs\text{-}P}$ = 9.68 lbs/yr x 55/100
= **5.32 lbs/yr**

**(4) Method to determine the phosphorus and/or nitrogen load reduction for a structural BMP with a known storage volume when the contributing drainage area has impervious and pervious surfaces:**

Flow Chart 4 illustrates the steps to determine the phosphorus and/or nitrogen (P/N) load reduction for a structural BMP with a known storage volume when the contributing drainage area has impervious and pervious surfaces.


Start
1. Determine BMP type and identify contributing impervious drainage area (IA) and pervious drainage area (PA) in acres
2. Calculate available BMP storage volume (BMP-Volume$_{ft3}$) in cubic ft
3. Convert BMP storage volume into runoff from contributing impervious area (BMP-Volume$_{IA-in}$) in inches
4. Calculate runoff volume from all pervious surfaces (BMP-Volume$_{PA-ft3}$) in cubic ft for an event with the size of BMP-Volume$_{IA-in}$
5. Calculate BMP volume available for treating only impervious runoff by subtracting BMP-Volume$_{PA-ft3}$ from BMP-Volume$_{ft3}$, and convert BMP volume into inches of impervious surface runoff (BMP-Volume$_{(IA-in)a}$)
6. Calculate percentage of differences between BMP-Volume$_{(IA-in)a}$ and BMP-Volume$_{IA-in}$
Less than 5%?
No
Update the value of BMP-Volume$_{IA-in}$ with that of BMP-Volume$_{(IA-in)a}$
Yes
7. Use BMP performance curve to determine the percentage of P/N load
8. Calculate the cumulative P/N load reductions by proposed BMP (BMP-Reduction$_{lbs-P/N}$) in lbs

**Flow Chart 4: Method to determine the P/N load reduction for a BMP with known storage volume when both pervious and impervious drainage areas are present.**

**1)** Identify the type of structural BMP and characterize the contributing drainage area to the structural BMP by identifying the following information for the impervious and pervious surfaces:

**Impervious area (IA) –** Area (acre) and land use (e.g., commercial)

**Pervious area (PA) –** Area (acre), land use, and hydrologic soil group (HSG

**2)** Determine the available storage volume ($ft^3$) of the structural BMP (BMP-Volume $_{ft^3}$) using the BMP dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

**3)** To estimate the P/N load reduction of a BMP with a known storage volume capacity, it is first necessary to determine the portion of available BMP storage capacity (BMP-Volume $_{ft^3}$) that would treat the runoff volume generated from the contributing impervious area (IA) for a rainfall event with a depth of *i* inches (in). This will require knowing the corresponding amount of runoff volume that would be generated from the contributing pervious area (PA) for the same rainfall event (depth of *i* inches). Using equation 3-6a below, solve for the BMP capacity that would be available to treat runoff from the contributing imperious area for the unknown rainfall depth of *i* inches (see equation 3-6b):

$$\text{BMP-Volume}_{\text{ft}^3} = \text{BMP-Volume}_{(\text{IA-ft}^3)i} + \text{BMP-Volume}_{(\text{PA-ft}^3)i} \quad \textbf{(Equation 3-6a)}$$

Where:

BMP-Volume $_{ft^3}$= the available storage volume of the BMP;

BMP-Volume $_{(IA\text{-}ft^3)i}$ = the available storage volume of the BMP that would fully treat runoff generated from the contributing impervious area for a rainfall event of size *i* inches; and

BMP-Volume $_{(PA\text{-}ft^3)i}$ = the available storage volume of the BMP that would fully treat runoff generated from the contributing pervious area for a rainfall event of size *i* inches

Solving for BMP-Volume $_{(IA\text{-}ft^3)i}$:

$$\text{BMP-Volume}_{(\text{IA-ft}^3)i} = \text{BMP-Volume}_{\text{ft}^3} - \text{BMP-Volume}_{(\text{PA-ft}^3)i} \quad \textbf{(Equation 3-6b)}$$

To determine BMP-Volume $_{(IA\text{-}ft^3)i}$, requires performing an iterative process of refining estimates of the rainfall depth used to calculate runoff volumes until the rainfall depth used results in the sum of runoff volumes from the contributing IA and PA equaling the available BMP storage capacity (BMP-Volume $_{ft^3}$). For the purpose of estimating BMP performance, it will be considered adequate when the IA runoff depth (in) is within 5% IA runoff depth used in the previous iteration.

For the first iteration (1), convert the BMP-Volume $_{ft^3}$ determined in step 2 into inches of runoff from the contributing impervious area (BMP Volume $_{(IA\text{-}in)1}$) using equation 3-7a.

BMP-Volume $_{(IA\text{-}in)1}$ = (BMP-Volume$_{ft^3}$/ IA (acre)) x (12 in/ft /43,560 $ft^2$/acre) **(Equation 3-7a)**;

For iterations 2 through n (2…n), convert the BMP Volume $_{(IA\text{-}ft^3)2\ldots n}$, determined in step 6) below, into inches of runoff from the contributing impervious area (BMP Volume $_{(IA\text{-}in)2\ldots n}$) using equation 3-7b.

BMP-Volume $_{(IA\text{-}in)2\ldots n}$ = (BMP-Volume $_{(IA\text{-}ft^3)2\ldots n}$ / IA (acre)) x (12 in/ft /43,560 $ft^2$/acre) **(Equation 3-7b)**;

**4)** For 1 to n iterations, use the pervious runoff depth information from Table 3-4 (repeated below) and equation 3-8 to determine the total volume of runoff ($ft^3$) from the contributing PA (BMP Volume $_{PA\text{-}ft^3}$) for a rainfall size equal to the sum of BMP-Volume $_{(IA\text{-}in)1}$, determined in step 3. The runoff volume for each distinct pervious area must be determined.

BMP Volume $_{(PA\text{-}ft^3)1\ldots n}$ = ∑ ((PA x (runoff depth) $_{(PA1,\, PA2..PAn)}$ x (3,630 $ft^3$/acre-in) **(Equation 3-8)**

Table 3-4 provides values of runoff depth from pervious areas for various rainfall depths and HSGs. Soils are assigned to an HSG on the basis of their permeability. HSG A is the most permeable, and HSG D is the least permeable. HSG categories for pervious areas in the drainage area shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the drainage area. If the HSG condition is not known, a HSG C soil condition should be assumed.

**Table 3- 4: Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups (HSGs)** (reprinted for ease of use in example)

| Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups | | | | | |
|---|---|---|---|---|---|
| | Runoff Depth, inches | | | | |
| Rainfall Depth, Inches | Pervious HSG A | Pervious HSG B | Pervious HSG C | Pervious HSG C/D | Pervious HSG D |
| 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.20 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 |
| 0.40 | 0.00 | 0.00 | 0.03 | 0.05 | 0.06 |
| 0.50 | 0.00 | 0.01 | 0.05 | 0.07 | 0.09 |
| 0.60 | 0.01 | 0.02 | 0.06 | 0.09 | 0.11 |
| 0.80 | 0.02 | 0.03 | 0.09 | 0.13 | 0.16 |
| 1.00 | 0.03 | 0.04 | 0.12 | 0.17 | 0.21 |

| | | | | | |
|---|---|---|---|---|---|
| **1.20** | **0.04** | **0.05** | **0.14** | **0.27** | **0.39** |
| **1.50** | **0.08** | **0.11** | **0.39** | **0.55** | **0.72** |
| **2.00** | **0.14** | **0.22** | **0.69** | **0.89** | **1.08** |

Notes: Runoff depths derived from combination of volumetric runoff coefficients from Table 5 of *Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices*, (Pitt, 1999), and using the Stormwater Management Model (SWMM) in continuous model mode for hourly precipitation data for Boston, MA, 1998-2002.

**5)** For iteration 1, estimate the portion of BMP Volume that is available to treat runoff from only the IA by subtracting BMP-Volume $_{PA\text{-}ft^3}$, determined in step 4, from BMP-Volume $_{ft^3}$, determined in step 2, and convert to inches of runoff from IA (see equations 3-9a and 3-9b):

$$\text{BMP-Volume}_{(IA\text{-}ft^3)2} = ((\text{BMP-Volume}_{ft^3} - \text{BMP Volume}_{(PA\text{-}ft^3)1}) \quad \textbf{(Equation 3-9a)}$$

$$\text{BMP-Volume}_{(IA\text{-}in)2} = (\text{BMP-Volume}_{(IA\text{-}ft^3)2}/\text{IA (acre)}) \times (12 \text{ in/ft} \times 1 \text{ acre}/43{,}560 \text{ ft}^2) \quad \textbf{(Equation 3-9b)}$$

If additional iterations (i.e., 2 through n) are needed, estimate the portion of BMP volume that is available to treat runoff from only the IA (BMP-Volume $_{(IA\text{-}in)3..n+1}$) by subtracting BMP Volume $_{(PA\text{-}ft^3)2..n}$, determined in step 4, from BMP Volume $_{(IA\text{-}ft^3)3..n+1}$, determined in step 5, and by converting to inches of runoff from IA using equation 3-9b):

**6)** For iteration a (an iteration between 1 and n+1), compare BMP Volume $_{(IA\text{-}in)a}$ to BMP Volume $_{(IA\text{-}in)a-1}$ determined from the previous iteration (a-1). If the difference in these values is greater than 5% of BMP Volume $_{(IA\text{-}in)a}$ then repeat steps 4 and 5, using BMP Volume $_{(IA\text{-}in)a}$ as the new starting value for the next iteration (a+1). If the difference is less than or equal to 5 % of BMP Volume $_{(IA\text{-}in)a}$ then the permittee may proceed to step 7;

**7)** Determine the % P/N load reduction for the structural BMP (BMP Reduction $_{\%\text{-}P/N}$) using the appropriate BMP performance curve and the BMP-Volume $_{(IA\text{-}in)n}$ calculated in the final iteration of steps 5 and 6; and

**8)** Calculate the cumulative P/N load reduction in pounds for the structural BMP (BMP Reduction $_{lbs\text{-}P/N}$) using the BMP Load as calculated Example 3-1 above and the percent P/N load reduction (BMP Reduction $_{\%\text{-}P/N}$ ) determined in step 7 by using equation 3-4:

$$\text{BMP Reduction}_{lbs\text{-}P/N} = \text{BMP Load} \times (\text{BMP Reduction}_{\%\text{-}P/N}/100) \quad \textbf{(Equation 3-4)}$$

**Example 3-4: Determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area has impervious and pervious surfaces:***

*The approach used in this example for phosphorus is equally applicable for nitrogen.

A permittee is considering an infiltration basin to capture and treat runoff from a portion of the medium density residential area (MDR). The contributing drainage area is 16.55 acres and has 11.75 acres of impervious area and 4.8 acres of pervious area (PA) made up mostly of lawns and landscaped areas that is 80% HSG D and 20% HSG C. An infiltration basin with the following specifications can be placed at the down-gradient end of the contributing drainage area where soil testing results indicates an infiltration rate (IR) of 0.28 in/hr:

**Table Example 3-4-A: Infiltration basin characteristics**

| Structure | Bottom area (acre) | Top surface area (acre) | Maximum pond depth (ft) | Design storage volume ($ft^3$) | Infiltration Rate (in/hr) |
|---|---|---|---|---|---|
| Infiltration basin | 0.65 | 0.69 | 1.65 | 48,155 | 0.28 |

Determine the:

**A)** Percent phosphorus load reduction (BMP Reduction $_{\%-P}$) for the specified infiltration basin and the contributing impervious and pervious drainage area; and

**B)** Cumulative phosphorus reduction in pounds that would be accomplished by the BMP (BMP-Reduction $_{lbs-P}$)

**Solution:**

**1)** A surface infiltration basin is being considered. Information for the contributing impervious (IA) and pervious (PA) areas are summarized in Tables Example 3-4-A and Example 3-4-B, respectively.

**Table Example 3-4-B: Impervious area characteristics**

| ID | Land use | Area (acre) |
|---|---|---|
| IA1 | MDR | 11.75 |

**Table Example 3-4-C: Pervious area characteristics**

| ID | Area (acre) | Hydrologic Soil Group (HSG) |
|---|---|---|
| PA1 | 3.84 | D |
| PA2 | 0.96 | C |

**2)** The available storage volume ($ft^3$) of the infiltration basin (BMP-Volume $_{ft^3}$) is determined from the design details and basin dimensions; BMP-Volume $_{ft^3}$ = 48,155 $ft^3$.

**3)** To determine what the BMP design storage volume is in terms of runoff depth (in) from IA, an iterative process is undertaken:

**Solution Iteration 1**

For the first iteration (1), the BMP-Volume$_{ft^3}$ is converted into inches of runoff from the contributing impervious area (BMP Volume $_{(IA\text{-}in)1}$) using equation 3-7a.

BMP Volume $_{(IA\text{-}in)1}$ = (48,155 ft$^2$/ 11.75 acre) x (12 in/ft /43,560 ft$^2$/acre)
= 1.13 in

**4-1)** The total volume of runoff (ft$^3$) from the contributing PA (BMP Volume $_{PA\text{-}ft^3}$) for a rainfall size equal to the sum of BMP Volume $_{(IA\text{-}in)1}$ determined in step 3 is determined for each distinct pervious area identified in Table Example 3-4-C using the information from Table 3-4 and equation 3-5. Interpolation was used to determine runoff depths.

BMP Volume $_{(PA\text{-}ft^3)1}$ = ((3.84 acre x (0.33 in) + (0.96 acre x (0.13 in)) x 3,630 ft$^3$/acre-in
= 5052 ft$^3$

**5-1)** For iteration 1, the portion of BMP Volume that is available to treat runoff from only the IA is estimated by subtracting the BMP Volume $_{(PA\text{-}ft^3)1}$, determined in step 4-1, from BMP Volume$_{ft^3}$, determined in step 2, and converted to inches of runoff from IA:

BMP Volume $_{(IA\text{-}ft^3)\,2}$ = 48,155 ft$^3$ – 5052 ft$^3$
= 43,103 ft$^3$

BMP Volume $_{(IA\text{-}in)\,2}$ = (43,103 ft$^3$/11.75 acre) x (12 in/ft x 1 acre/43,560 ft$^2$)
= 1.01 in

**6-1)** The % difference between BMP Volume $_{(IA\text{-}in)\,2}$, 1.01 in, and BMP Volume $_{(IA\text{-}in)1}$, 1.13 in is determined and found to be significantly greater than 5%:

% Difference = ((1.13 in – 1.01 in)/1.01 in) x 100
= 12%

Therefore, steps 4 through 6 are repeated starting with BMP Volume $_{(IA\text{-}in)\,2}$ = 1.01 in.

**Solution Iteration 2**

**4-2)** BMP-Volume $_{(PA\text{-}ft^3)2}$ = ((3.84 acre x 0.21 in) + (0.96 acre x 0.12 in)) x 3,630 ft$^3$/acre-in
= 3,345 ft$^3$

**5-2)** BMP-Volume $_{(IA\text{-}ft^3)\,3}$ = 48,155 ft$^3$ – 3,345 ft$^3$
= 44,810 ft$^3$

BMP-Volume $_{(IA\text{-}in)\,3}$ = (44,810 ft$^3$/11.75 acre) x (12 in/ft x 1 acre/43,560 ft$^2$)
= 1.05 in

**6-2)** % Difference = ((1.05 in – 1.01 in)/1.05 in) x 100
= 4%

The difference of 4% is acceptable.

**7)** The % phosphorus load reduction for the infiltration basin (BMP Reduction $_{\%\text{-}P}$) is determined by using the infiltration basin performance curve for an infiltration rate of 0.27 in/hr and the treatment volume (BMP-Volume $_{\text{Net IA-in}}$ = 1.05 in) calculated in step 5-2 and is **BMP Reduction $_{\%\text{-}P}$ = 93%**.

The performance curve for IR = 0.27 is used rather than interpolating between the performance curves for IR = 0.27 in/hr and 0.52 in/hr to estimate performance for IR = 0.28 in/hr. An evaluation of the performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr for a design storage volume of 1.05 in indicate a small difference in estimated performance (BMP Reduction $_{\%\text{-}P}$ = 93% for IR = 0.27 in/hr and BMP Reduction $_{\%\text{-}P}$ = 95% for IR = 0.52 in/hr).

**8)** The cumulative phosphorus load reduction in pounds of phosphorus (BMP-Reduction $_{\text{lbs-P}}$) for the proposed infiltration basin is calculated by using equation 3-2 with the BMP Load and the P $_{\text{target}}$ of 93%.

BMP-Reduction $_{\text{lbs-P}}$ = BMP Load x (P $_{\text{target}}$ /100) **(Equation 3-2)**

Using Table 3-1, the BMP load is calculated:
BMP Load = (IA x impervious cover phosphorus export loading rate for industrial)
+ (PA $_{\text{HSG D}}$ x pervious cover phosphorus export loading rate for HSG D)
+ (PA $_{\text{HSG C}}$ x pervious cover phosphorus export loading rate for HSG C)

BMP Load = (11.75 acre x 1.96 lbs/acre/yr) + (3.84 acre x 0.37 lbs/acre/yr)
+ (0.96 acre x 0.21 lbs/acre/yr)
= 24.65 lbs/yr

BMP-Reduction $_{\text{lbs-P}}$ = 24.65 lbs/yr x 93/100 = **22.92 lbs/yr**

**Example 3-5: Determine the phosphorus and nitrogen load reductions for disconnecting impervious area using storage with delayed release:**

A commercial operation has an opportunity to divert runoff from 0.75 acres of impervious roof top to a 5000 gallon (668.4 $ft^3$) storage tank for temporary storage and subsequent release to 0.09 acres of pervious area (PA) with HSG C soils.
Determine the:

A) Percent phosphorus and nitrogen load reduction rates (BMP Reduction $_{\%\text{-}P\&N}$) for the specified impervious area (IA) disconnection and storage system assuming release times of 1, 2 and 3 days for the stored volumes to discharge to the pervious area; and
B) Cumulative phosphorus and nitrogen load reductions in pounds that would be accomplished by the system (BMP-Reduction $_{\text{lbs-P\&N}}$) for the three storage release times, 1, 2 and 3 days.

**Solution:**

1. Determine the storage volume in units of inches of runoff depth from contributing impervious area:
   Storage Volume $_{IA\text{-}in}$ = (668.4 ft$^3$/(0.75 acre x 43.560 ft$^2$/acre)) x 12 inch/ft
   = 0.25 inches

2. Determine the ratio of the contributing impervious area to the receiving pervious area:
   IA:PA = 0.75 acres/0.09 acres
   = 8.3
3. Using Table 3-26 or Figure 3-23 for a IA:PA ratio of 8:1, determine the phosphorus and nitrogen load reduction rates for a storage volume of 0.25 inches that discharges to HSG C with release rates of 1, 2 and 3 days: Using interpolation the reduction rates are shown in Table 3-5-A:

**Table Example 3-5-A: P&N Reduction Rates**

| **Percent Phosphorus & Nitrogen load reduction for IA disconnection with storage to PA HSG C** | | | |
|---|---|---|---|
| Storage Volume $_{IA\text{-}in}$ | Storage release rate, days | | |
| | 1 | 2 | 3 |
| 0.25 | 39% | 42% | 43% |

4. The cumulative phosphorus and nitrogen load reductions in pounds of phosphorus for the IA disconnection with storage (BMP-Reduction $_{lbs\text{-}P/N}$) is calculated using Equation 3-2. The BMP Loads for phosphorus and nitrogen are first determined using the method presented in Example 3-1.
   **<u>Phosphorus:</u>**
   BMP Load $_P$ = IA (acre) x PLER $_{IC\text{-}Com}$ (see Table 3-1)
   = 0.75 acres x 1.78 lbs/acre/yr
   = 1.34 lbs/yr
   BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
   BMP Reduction $_{lbs\text{-}P}$ = 1.34 lbs/yr x (39/100)
   = **0.53 lbs/yr**
   Table Example 3-5-B presents the BMP Reduction $_{lbs\text{-}P}$ for each of the release rates:

**Table Example 3-5-B: P Reduction Loads**

| **Phosphorus load reduction for IA disconnection with storage to PA HSG C, lbs** | | | |
|---|---|---|---|
| Storage Volume $_{IA\text{-}in}$ | Storage release rate, days | | |
| | 1 | 2 | 3 |
| 0.25 | 0.53 | 0.56 | 0.58 |

   **<u>Nitrogen:</u>**
   BMP Load $_N$ = IA (acre) x NLER $_{IC\text{-}Com}$ (see Table 3-2)
   = 0.75 acres x 15.0 lbs/acre/yr
   = 11.3 lbs/yr
   BMP Reduction $_{lbs\text{-}N}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
   BMP Reduction $_{lbs\text{-}N}$ = 11.3 lbs/yr x (39/100)
   BMP Reduction $_{lbs\text{-}N}$ = **4.4 lbs/yr**

Table Example 3-5-C presents the BMP Reduction $_{lbs-N}$ for each of the release rates:

**Table Example 3-5-C: N Reduction Loads**

| **Nitrogen load reduction for IA disconnection with storage to PA HSG C, lbs** | | | |
|---|---|---|---|
| Storage Volume IA-in | Storage release rate, days | | |
| | 1 | 2 | 3 |
| 0.25 | 4.4 | 4.7 | 4.9 |

**Example 3-6: Determine the phosphorus load reduction for disconnecting impervious area with and without soil augmentation in the receiving pervious area:***

*The approach used in this example for phosphorus is equally applicable for nitrogen

The same commercial property as in Example 3-5 wants to evaluate disconnecting drainage from the 0.75 acre impervious roof top and discharging it directly to 0.09 acres of pervious area (PA) with HSG C.  Also, the property has the opportunity to purchase a small adjoining area (0.06 acres), also HSG C, to increase the size of the receiving PA from 0.09 to 0.15 acres and to allow the property owner to avoid having to install a drainage structure to capture overflow runoff from the PA. The property owner has been informed that the existing PA soil can be tilled and augmented with soil amendments to support denser vegetative growth and improve hydrologic function to approximate HSG B.

Determine the:

A) Percent phosphorus load reduction rates (BMP Reduction $_{\%-P}$) for the specified impervious area (IA) disconnection to both the 0.09 and 0.15 acre receiving PAs with and without soil augmentation; and
B) Cumulative phosphorus reductions in pounds that would be accomplished by the IA disconnection for the various scenarios (BMP-Reduction $_{lbs-P}$).

**Solution:**

1. Determine the ratio of the contributing impervious area to the receiving pervious area:

   IA:PA = 0.75 acres/0.09 acres
   = 8.3
   IA:PA = 0.75 acres/0.15 acres
   = 5.0

2. Using Table 3-31 and Figure 3-41 for a IA:PA ratios of 8:1 and 5:1, respectively, determine the phosphorus load reduction rates for IA disconnections to HSG C and HSG B:

**Table Example 3-6-A: Reduction Rates**

| **Percent Phosphorus load reduction rates for IA disconnection** | | |
|---|---|---|
| **Receiving PA** | **IA:PA** | |
| | 8:1 | 5:1 |
| HSG C | 7% | 14% |
| HSG B (soil augmentation) | 14% | 22% |

3. The cumulative phosphorus load reduction in pounds of phosphorus for the IA disconnection with storage (BMP-Reduction $_{\text{lbs-P}}$) is calculated using Equation 3-2. The BMP Load was calculated in example 3-5 and is 1.34 lbs/yr.

   BMP Reduction $_{\text{lbs-P}}$ = BMP Load x (BMP Reduction $_{\text{\%-P}}$/100)
   For PA of 0.09 acres HSG C the BMP Reduction $_{\text{lbs-P}}$ is calculated as follows:
   BMP Reduction $_{\text{lbs-P(0.09ac- HSG C)}}$ = 1.34 lbs/yr x (7/100)
   = **0.09 lbs/yr**
   Table Example 3-6-B presents the BMP Reduction $_{\text{lbs-P}}$ for each of the scenarios:

**Table Example 3-6-B: Reduction**

| **Pounds Phosphorus load reduction for IA disconnection, lbs/yr** | | |
|---|---|---|
| **Receiving PA** | **Area of Receiving PA, acres** | |
| | **0.09** | **0.15** |
| HSG C | 0.09 | 0.19 |
| HSG B (soil augmentation) | 0.19 | 0.29 |

**Example 3-7: Determine the phosphorus load reduction for converting impervious area to permeable/pervious area:***
*The approach used in this example for phosphorus is equally applicable for nitrogen.

A municipality is planning upcoming road reconstruction work in medium density residential (MDR) neighborhoods, and has identified an opportunity to convert impervious surfaces to permeable/pervious surfaces by narrowing the road width of 3.7 miles (mi) of roadway from 32 feet (ft) to 28 ft and eliminating 3.2 miles of 4 ft wide paved sidewalk (currently there are sidewalks on both sides of the roadways targeted for restoration). The newly created permeable/pervious area will be tilled and treated with soil amendments to support vegetated growth in order to restore hydrologic function to at least HSG B.
Determine the:

A) Percent phosphorus load reduction rate (BMP Reduction $_{\text{\%-P}}$) for the conversion of impervious area (IA) to permeable/pervious area (PA); and

B) Cumulative phosphorus reduction in pounds that would be accomplished by the project (BMP-Reduction $_{lbs-P}$).

**Solution:**

1. Determine the area of IA to be converted to PA:

   New PA = (((3.7 mi x 4 ft) + (3.2 mi x 4 ft)) x 5280 ft/mi)/43,560 ft$^2$/acre
   = 3.35 acres

2. Using Table 3-32, the phosphorus load reduction rate for converting IA to HSG B is 94.1%
3. The BMP Load is first determined using the method described above.

   BMP Load = IA x phosphorus export loading rate for MDR IA (see Table 3-1)
   = 3.35 acres x 1.96 lbs/acre/yr
   = 6.57 lbs/yr

4. The cumulative phosphorus load reduction in pounds of phosphorus for the IA conversion (BMP-Reduction $_{lbs-P}$) is calculated using Equation 3-2.

   BMP Reduction $_{lbs-P}$ = BMP Load x (BMP Reduction $_{\%-P}$/100)
   BMP Reduction $_{lbs-P}$ = 6.57 lbs/yr x (94.1/100)
   = 6.18 lbs/yr

**Table 3-5 Method for determining stormwater control design volume (DSV) (i.e., capacity) using long-term cumulative performance curves**

| Stormwater Control Type | Description | Applicable Structural Stormwater Control Performance Curve | Equation for calculating Design Storage Capacity for Estimating Cumulative Reductions using Performances Curves |
|---|---|---|---|
| **Infiltration Trench** | Provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils. | Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = void space volumes of gravel and sand layers DSV = $(L \times W \times D_{stone} \times n_{stone}) + (L \times W \times D_{sand} \times n_{sand})$ |
| **Subsurface Infiltration** | Provides temporary storage of runoff using the combination of storage structures (e.g., galleys, chambers, pipes, etc.) and void spaces within the soil/sand/gravel mixture that is used to backfill the system for subsequent infiltration into the surrounding sub-soils. | Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = Water storage volume of storage units and void space volumes of backfill materials. Example for subsurface galleys backfilled with washed stone: DSV = $(L \times W \times D)_{galley} + (L \times W \times D_{stone} \times n_{stone})$ |
| **Surface Infiltration** | Provides temporary storage of runoff through surface ponding storage structures (e.g., basin or swale) for subsequent infiltration into the underlying soils. | Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = Water volume of storage structure before bypass. Example for linear trapezoidal vegetated swale DSV = $(L \times ((W_{bottom}+W_{top@Dmax})/2) \times D)$ |
| **Rain Garden/Bio-retention (no underdrains)** | Provides temporary storage of runoff through surface ponding and possibly void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils. | Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = Ponding water storage volume and void space volumes of soil filter media. Example for raingarden: DSV = $(A_{pond} \times D_{pond}) + (A_{soil} \times D_{soil} \times n_{soil\ mix})$ |
| **Tree Filter (no underdrain)** | Provides temporary storage of runoff through surface ponding and void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils. | Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = Ponding water storage volume and void space volumes of soil filter media. DSV = $(L \times W \times D_{ponding}) + (L \times W \times D_{soil} \times n_{soil\ mix})$ |
| **Bio-Filtration (w/underdrain)** | Provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity includes void spaces in the filter media and temporary ponding at the surface. After runoff has passed through the filter media it is collected by an under-drain pipe for discharge. Manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. | Bio-filtration | DSV = Ponding water storage volume and void space volume of soil filter media. Example of a linear biofilter: DSV = $(L \times W \times D_{ponding}) + (L \times W \times D_{soil} \times n_{soil})$ |
| **Enhanced Bio-filtration w/ Internal Storage Reservoir (ISR) (no infiltration)** | Based on design by the UNH Stormwater Center (UNHSC). Provides temporary storage of runoff for filtering through an engineered soil media, augmented for enhanced phosphorus removal, followed by detention and denitrification in a subsurface internal storage reservoir (ISR) comprised of gravel. An elevated outlet control at the top of the ISR is designed to provide a retention time of at least 24 hours in the system to allow for sufficient time for denitrification and nitrogen reduction to occur prior to discharge. The design storage capacity for using the cumulative performance curves is comprised of void spaces in the filter media, temporary ponding at the surface of the practice and the void spaces in the gravel ISR. | Enhanced Bio-filtration w/ISR | DSV = Ponding water storage volume and void space volume of soil filter media and gravel ISR. DSV = $(A_{bed} \times D_{ponding}) + (A_{bed} \times D_{soil} \times n_{soil}) + (A_{ISR} \times D_{gravel} \times n_{gravel})$ |
| **Gravel Wetland** | Provides temporary surface ponding storage of runoff in a vegetated wetland cell that is eventually routed to an underlying saturated gravel internal storage reservoir (ISR) for nitrogen treatment. Outflow is controlled by an elevated orifice that has its invert elevation equal to the top of the ISR layer and provides a retention time of at least 24 hours. | Gravel Wetland | DSV = pretreatment volume + ponding volume + void space volume of gravel ISR. DSV = $(A_{pretreatment} \times D_{preTreatment}) + (A_{wetland} \times D_{ponding}) + (A_{ISR} \times D_{gravel} \times n_{gravel})$ |
| **Porous Pavement with subsurface infiltration** | Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces of a subsurface gravel reservoir prior to infiltration into subsoils. | Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour) | DSV = void space volumes of gravel layer DSV = $(L \times W \times D_{stone} \times n_{stone})$ |
| **Porous pavement w/ impermeable underliner w/underdrain** | Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces prior to discharge by way of an underdrain. | Porous Pavement | Depth of Filter Course = $D_{FC}$ |
| **Sand Filter w/underdrain** | Provides filtering of runoff through a sand filter course and temporary storage of runoff through surface ponding and within void spaces of the sand and washed stone layers prior to discharge by way of an underdrain. | Sand Filter | DSV = pretreatment volume + ponding volume + void space volume of sand and washed stone layers. DSV = $(A_{pretreatment} \times D_{preTreatment}) + (A_{bed} \times D_{ponding}) + (A_{bed} \times D_{sand} \times n_{sand}) + (A_{bed} \times D_{stone} \times n_{stone})$ |
| **Wet Pond** | Provides treatment of runoff through routing through permanent pool. | Wet Pond | DSV= Permanent pool volume prior to high flow bypass DSV=$A_{pond} \times D_{pond}$ (does not include pretreatment volume) |
| **Extended Dry Detention Basin** | Provides temporary detention storage for the design storage volume to drain in 24 hours through multiple out let controls. | Dry Pond | DSV= Ponding volume prior to high flow bypass DSV=$A_{pond} \times D_{pond}$ (does not include pretreatment volume) |
| **Dry Water Quality Swale/Grass Swale** | Based on MA design standards. Provides temporary surface ponding storage of runoff in an open vegetated channel through permeable check dams. Treatment is provided by filtering of runoff by vegetation and check dams and infiltration into subsurface soils. | Water Quality Grass swale | DSV = Volume of swale at full design depth DSV=$L_{swale} \times W_{swale} \times D_{ponding\ swale}$ |

**Definitions: DSV**= Design Storage Volume = physical storage capacity to hold water; **VSV** = Void Space Volume; **L** = length, **W** = width, **D** = depth at design capacity before bypass, **n** = porosity fill material, **A**= average surface area for calculating volume; **Infiltration rate** = saturated soil hydraulic conductivity

**Table 3- 6: Infiltration Trench (IR = 0.17 in/hr) BMP Performance Table**

| Infiltration Trench (IR = 0.17 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 15% | 28% | 49% | 64% | 75% | 82% | 92% | 95% |
| **Cumulative Phosphorus Load Reduction** | 18% | 33% | 57% | 73% | 83% | 90% | 97% | 99% |
| **Cumulative Nitrogen Load Reduction** | 56% | 72% | 87% | 93% | 96% | 98% | 99% | 100% |

**Figure 3- 1: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.17 in/hr)**

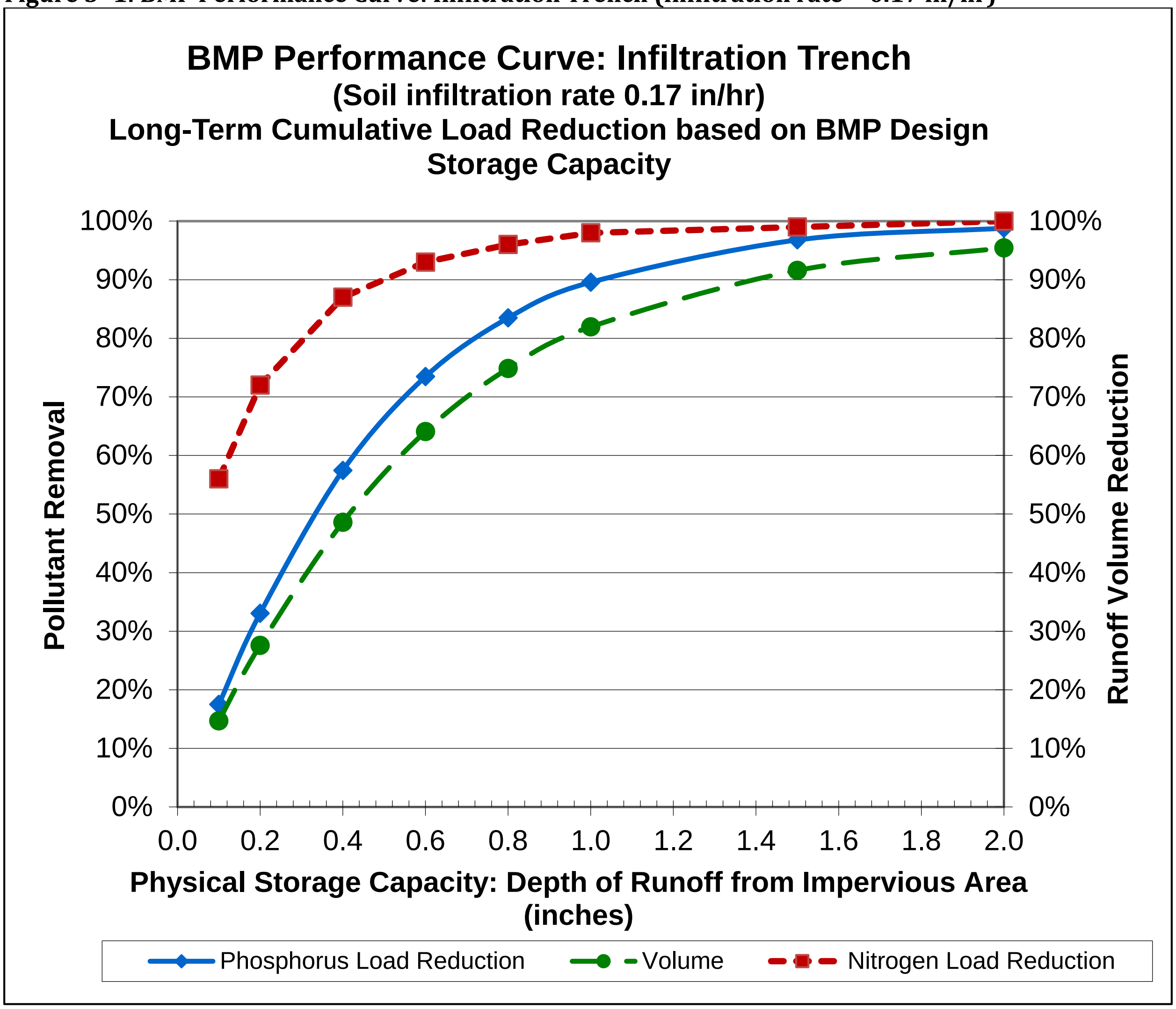


**Table 3- 7: Infiltration Trench (IR = 0.27 in/hr) BMP Performance Table**

| Infiltration Trench (IR = 0.27 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 17.8% | 32.5% | 55.0% | 70.0% | 79.3% | 85.2% | 93.3% | 96.3% |
| **Cumulative Phosphorus Load Reduction** | 20% | 37% | 63% | 78% | 86% | 92% | 97% | 99% |
| **Cumulative Nitrogen Load Reduction** | 57% | 74% | 88% | 94% | 97% | 98% | 99% | 100% |

**Figure 3- 2: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.27 in/hr)**

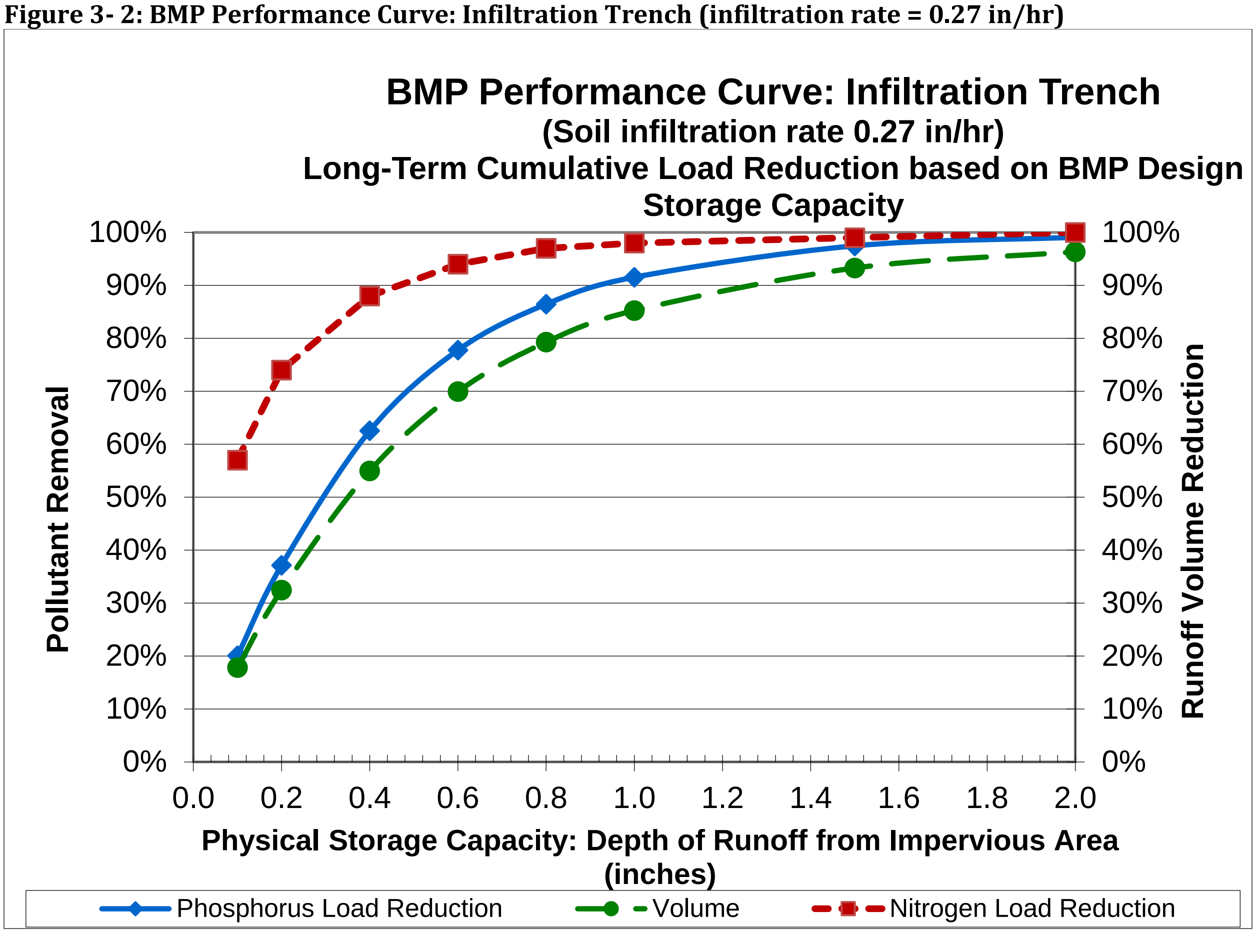


**Table 3- 8: Infiltration Trench (IR = 0.52 in/hr) BMP Performance Table**

| Infiltration Trench (IR = 0.52 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 22.0% | 38.5% | 61.8% | 75.7% | 83.7% | 88.8% | 95.0% | 97.2% |
| **Cumulative Phosphorus Load Reduction** | 23% | 42% | 68% | 82% | 89% | 94% | 98% | 99% |
| **Cumulative Nitrogen Load Reduction** | 59% | 76% | 90% | 95% | 98% | 99% | 100% | 100% |

**Figure 3- 3: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.52 in/hr)**

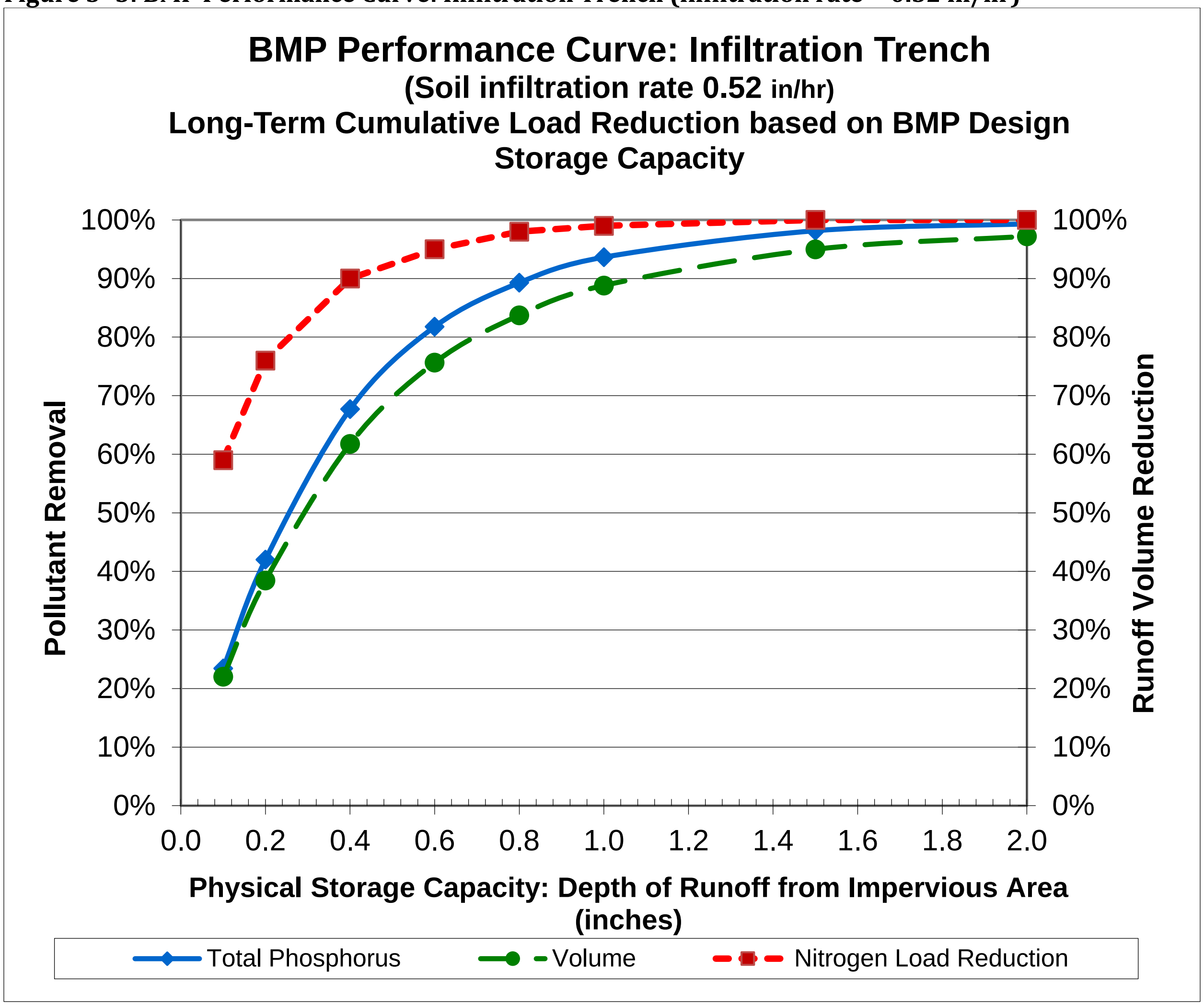


**Table 3- 9: Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table**

| Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 26.3% | 44.6% | 68.2% | 81.0% | 88.0% | 92.1% | 96.5% | 98.3% |
| **Cumulative Phosphorus Load Reduction** | 27% | 47% | 73% | 86% | 92% | 96% | 99% | 100% |
| **Cumulative Nitrogen Load Reduction** | 61% | 78% | 92% | 97% | 98% | 99% | 100% | 100% |

**Figure 3- 4: BMP Performance Curve: Infiltration Trench (infiltration rate = 1.02 in/hr)**

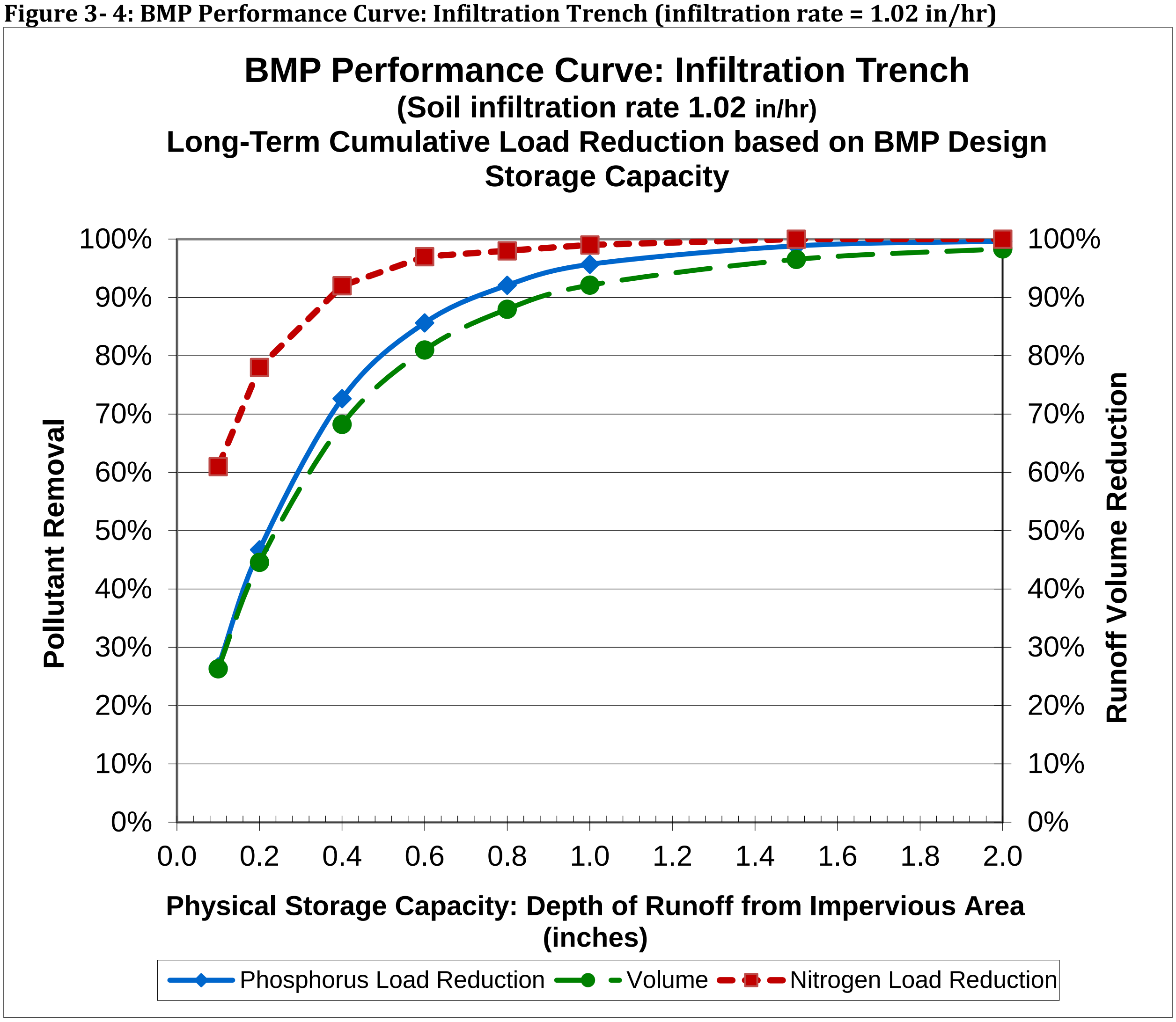


**Table 3- 10: Infiltration Trench (IR = 2.41 in/hr) BMP Performance Table**

| Infiltration Trench (IR = 2.41 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 34% | 55% | 78% | 88% | 93% | 96% | 99% | 100% |
| **Cumulative Phosphorus Load Reduction** | 33% | 55% | 81% | 91% | 96% | 98% | 100% | 100% |
| **Cumulative Nitrogen Load Reduction** | 65% | 83% | 95% | 98% | 99% | 100% | 100% | 100% |

**Figure 3- 5: BMP Performance Curve: Infiltration Trench (infiltration rate = 2.41 in/hr)**

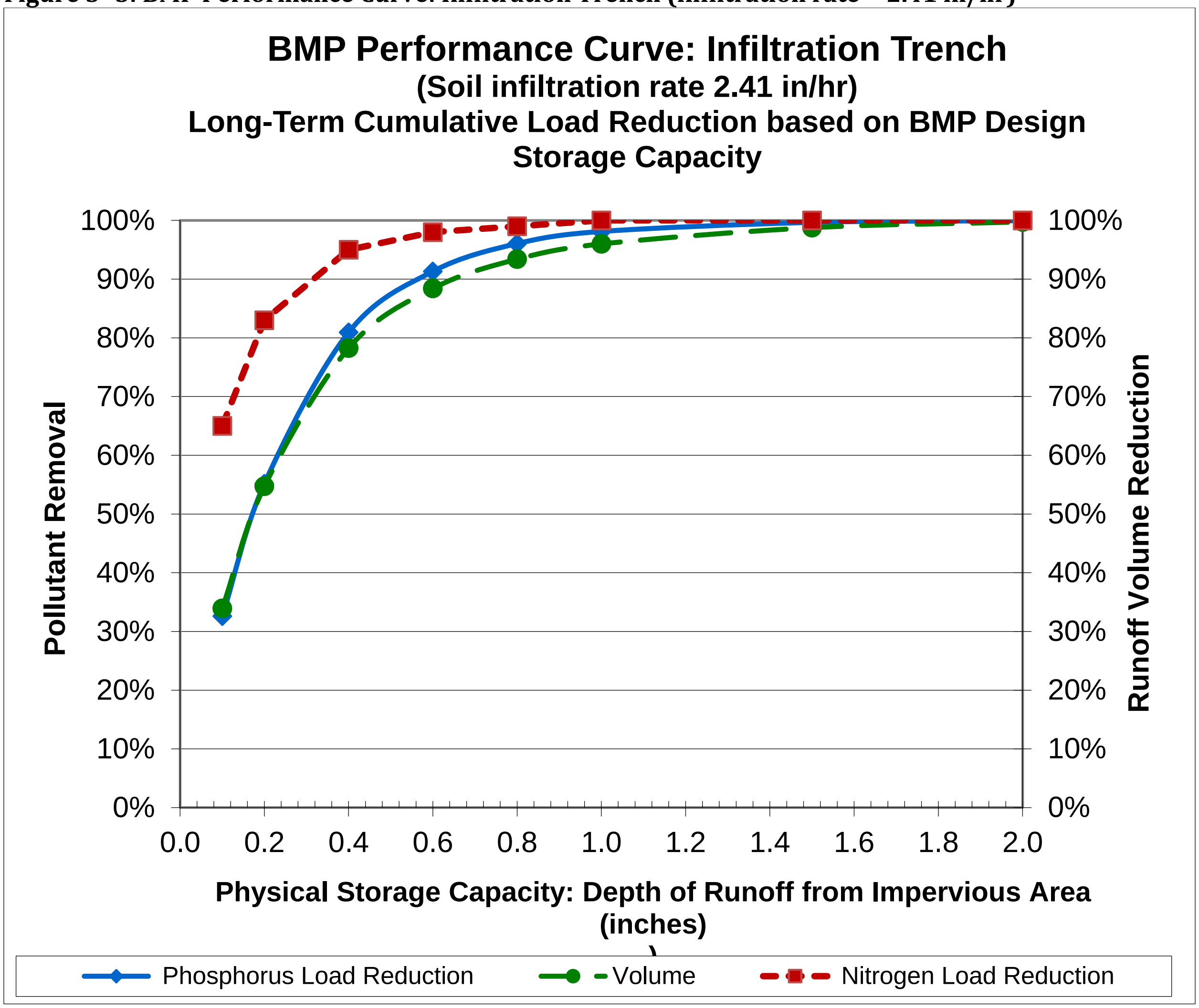


**Table 3- 11: Infiltration Trench (8.27 in/hr) BMP Performance Table**

| Infiltration Trench (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 53.6% | 76.1% | 92.6% | 97.2% | 98.9% | 99.5% | 100.0% | 100.0% |
| **Cumulative Phosphorus Load Reduction** | 50% | 75% | 94% | 98% | 99% | 100% | 100% | 100% |
| **Cumulative Nitrogen Load Reduction** | 76% | 92% | 98% | 100% | 100% | 100% | 100% | 100% |

**Figure 3- 6: BMP Performance Curve: Infiltration Trench (infiltration rate = 8.27 in/hr)**

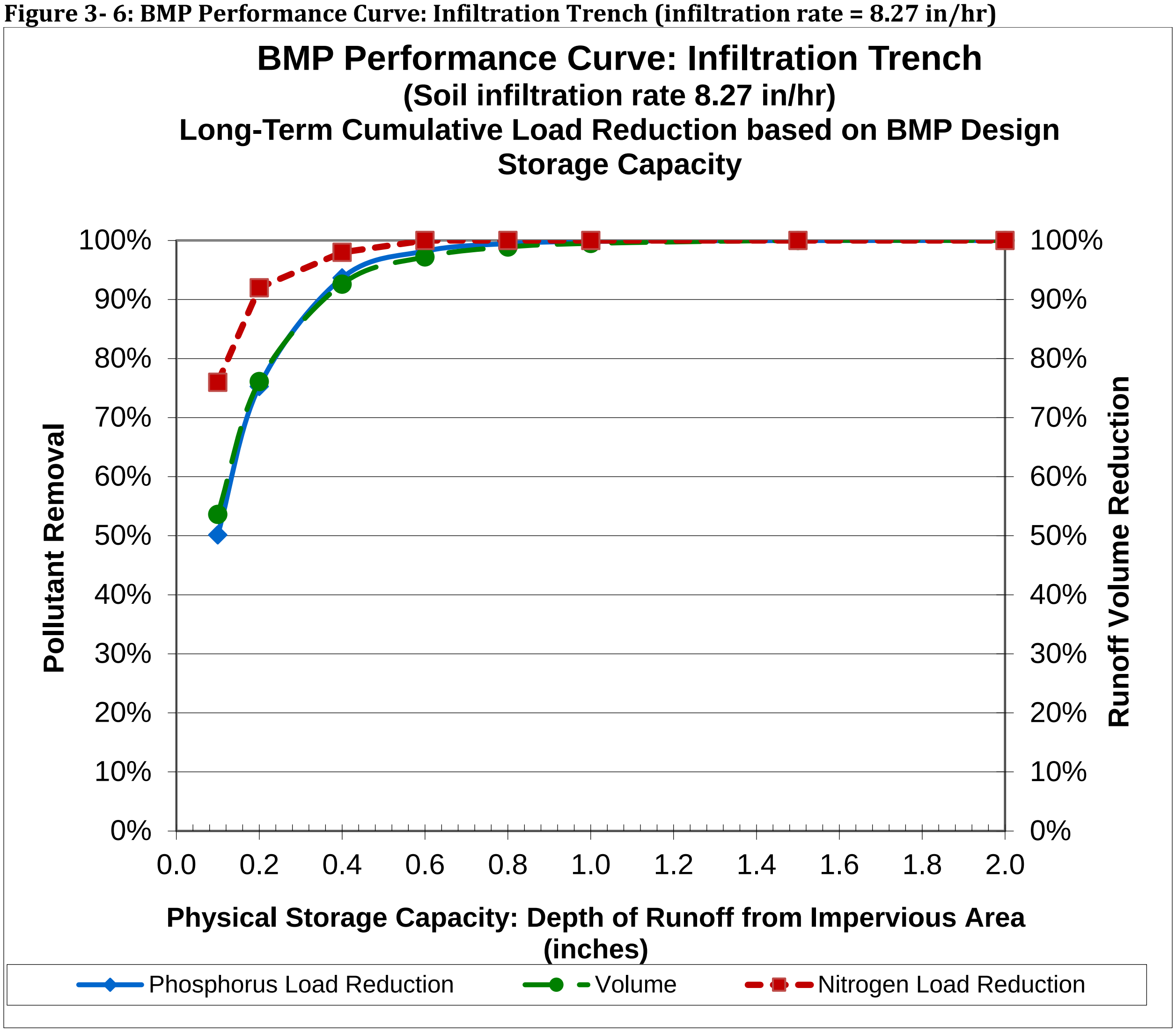


**Table 3- 12: Surface Infiltration (0.17 in/hr) BMP Performance Table**

| Surface Infiltration (0.17 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 13% | 25% | 44% | 59% | 71% | 78% | 89% | 94% |
| **Cumulative Phosphorus Load Reduction** | 35% | 52% | 72% | 82% | 88% | 92% | 97% | 99% |
| **Cumulative Nitrogen Load Reduction** | 52% | 69% | 85% | 92% | 96% | 98% | 99% | 100% |

**Figure 3- 7: BMP Performance Curve: Infiltration Basin (infiltration rate = 0.17 in/hr)**

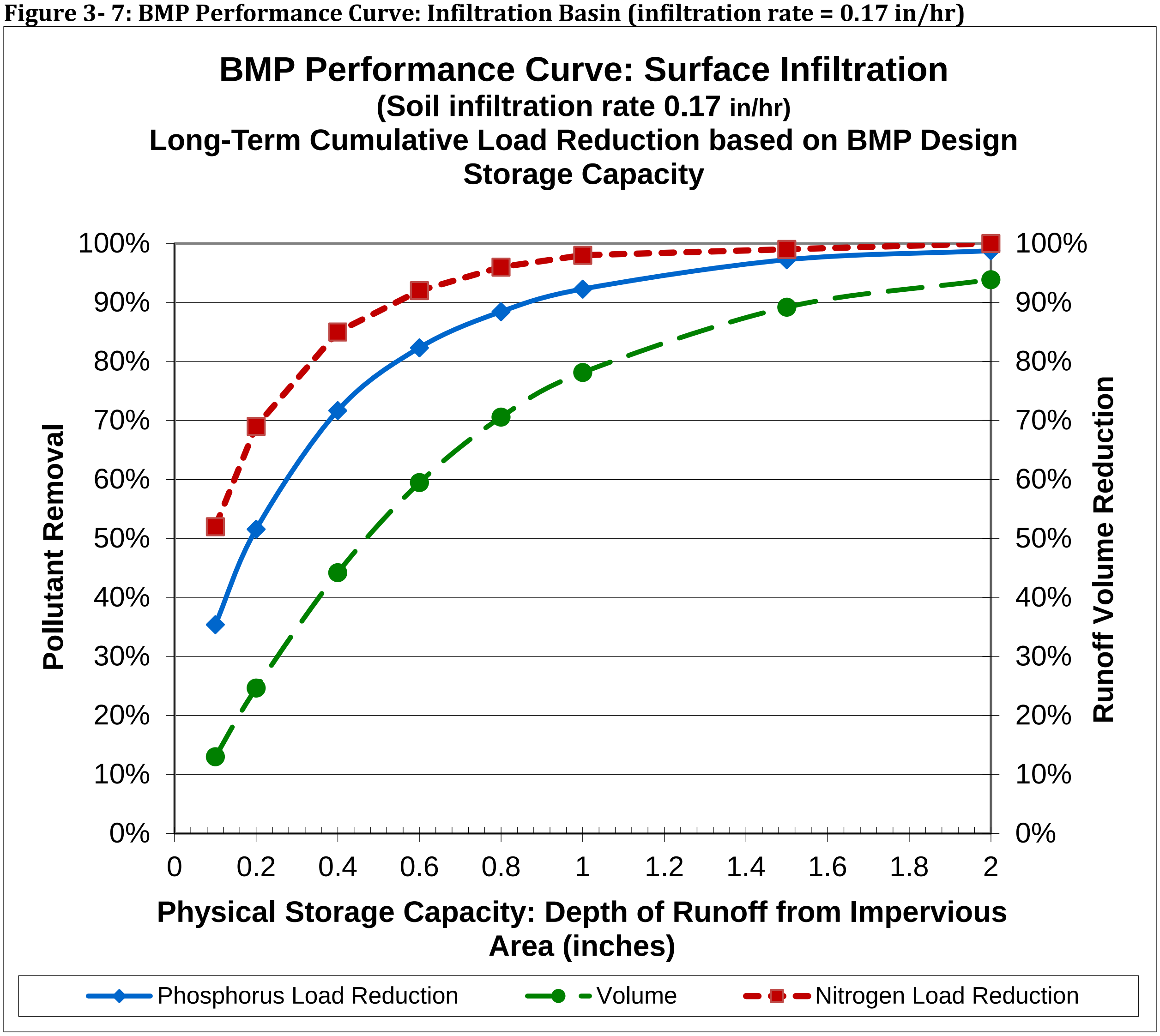


**Table 3- 13: Infiltration Basin (0.27 in/hr) BMP Performance Table**

| Surface Infiltration (0.27 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 16% | 30% | 51% | 66% | 76% | 82% | 91% | 95% |
| **Cumulative Phosphorus Load Reduction** | 37% | 54% | 74% | 85% | 90% | 93% | 98% | 99% |
| **Cumulative Nitrogen Load Reduction** | 54% | 71% | 87% | 93% | 97% | 98% | 99% | 100% |

**Figure 3- 8: BMP Performance Curve: Surface Infiltration (infiltration rate = 0.27 in/hr)**

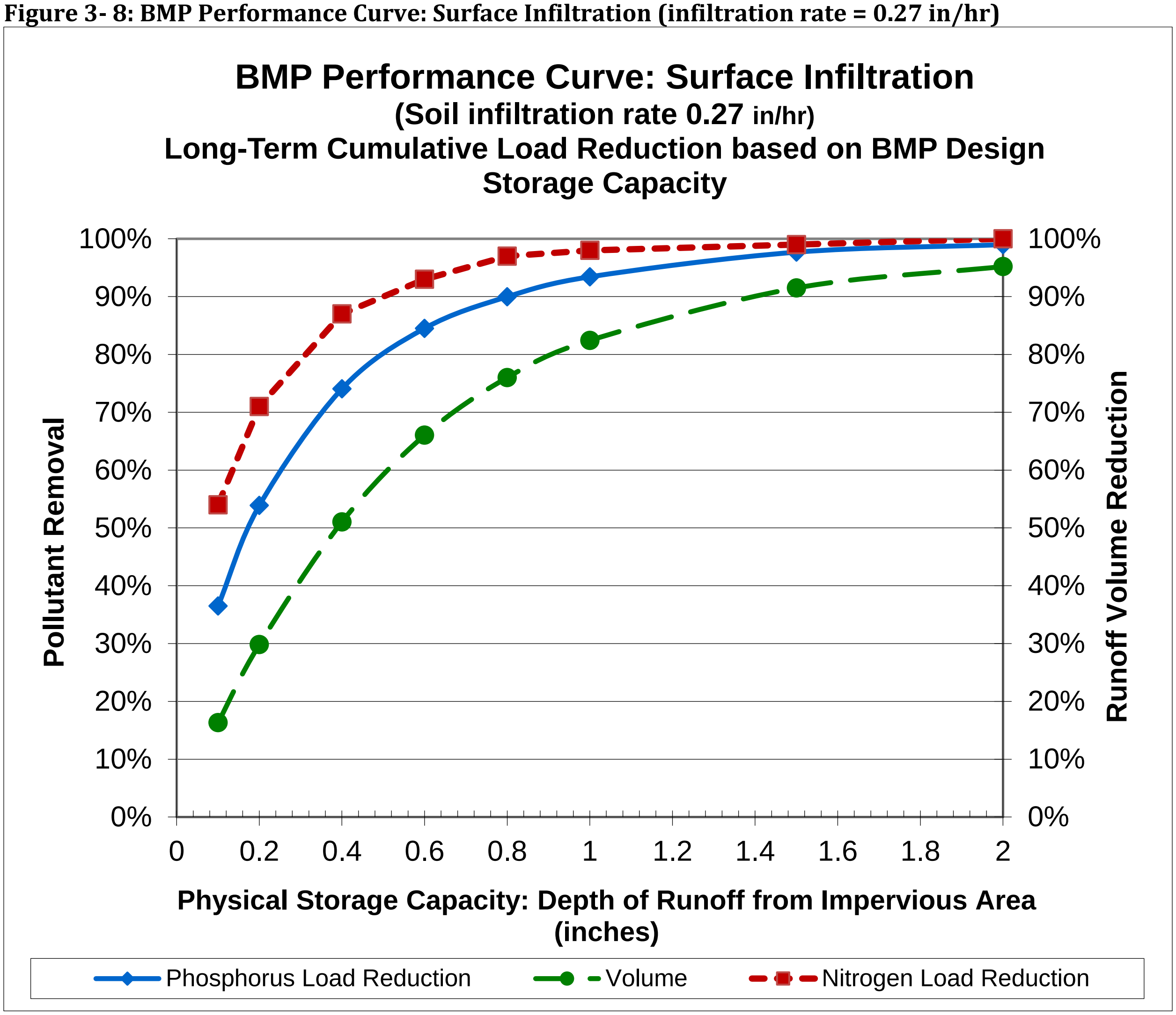


**Table 3- 14: Infiltration Basin (0.52 in/hr) BMP Performance Table**

| Surface Infiltration (0.52 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 20% | 36% | 58% | 73% | 81% | 87% | 94% | 97% |
| **Cumulative Phosphorus Load Reduction** | 38% | 56% | 77% | 87% | 92% | 95% | 98% | 99% |
| **Cumulative Nitrogen Load Reduction** | 56% | 74% | 89% | 94% | 98% | 99% | 100% | 100% |

**Figure 3- 9: BMP Performance Curve: Surface Infiltration (infiltration rate = 0.52 in/hr)**

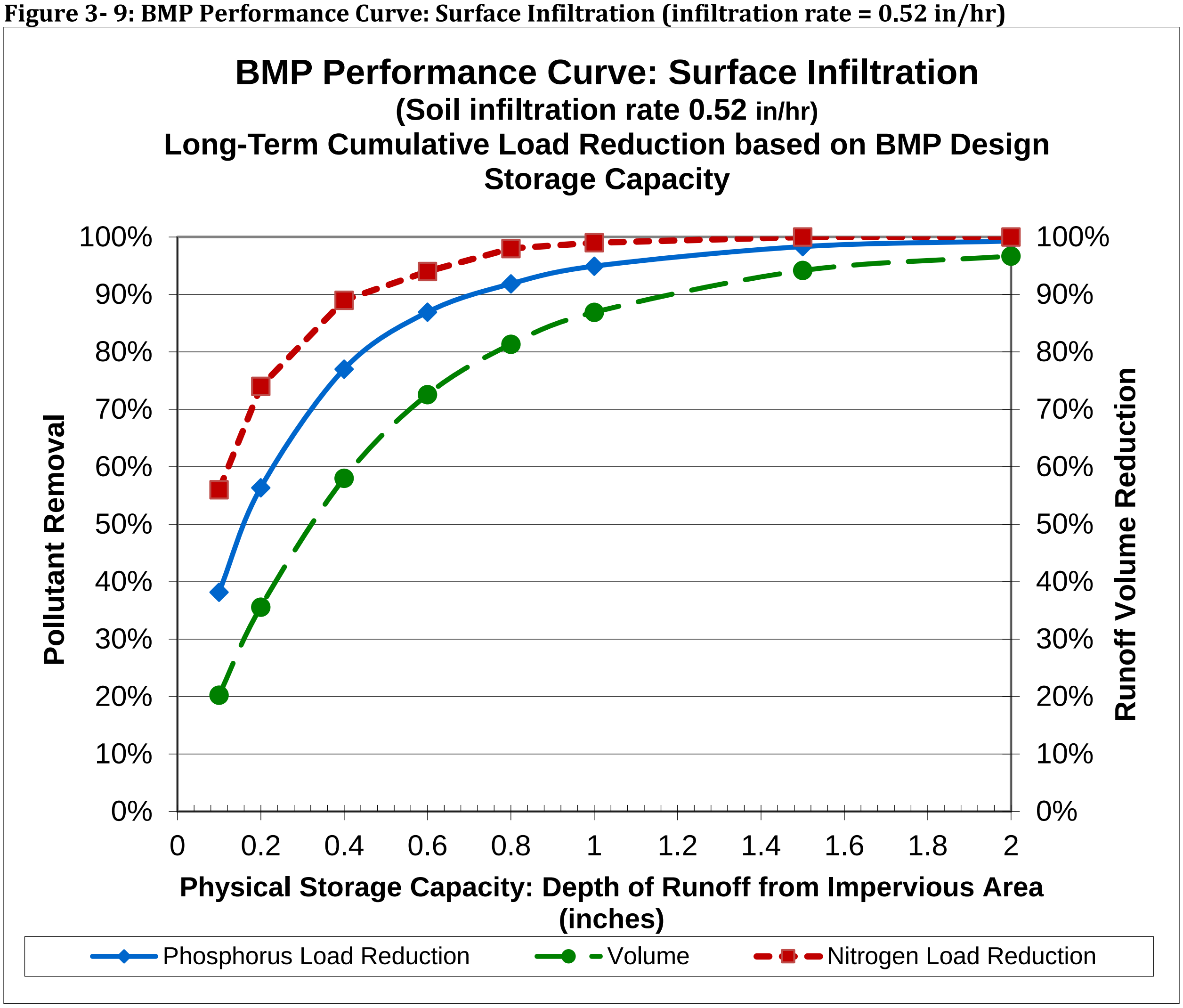


**Table 3-15: Infiltration Basin (1.02 in/hr) BMP Performance Table**

| Surface Infiltration (1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 24.5% | 42.0% | 65.6% | 79.4% | 86.8% | 91.3% | 96.2% | 98.1% |
| **Cumulative Phosphorus Load Reduction** | 41% | 60% | 81% | 90% | 94% | 97% | 99% | 100% |
| **Cumulative Nitrogen Load Reduction** | 59% | 77% | 92% | 96% | 98% | 100% | 100% | 100% |

**Figure 3- 10: BMP Performance Curve: Surface Infiltration (Soil infiltration rate = 1.02 in/hr)**

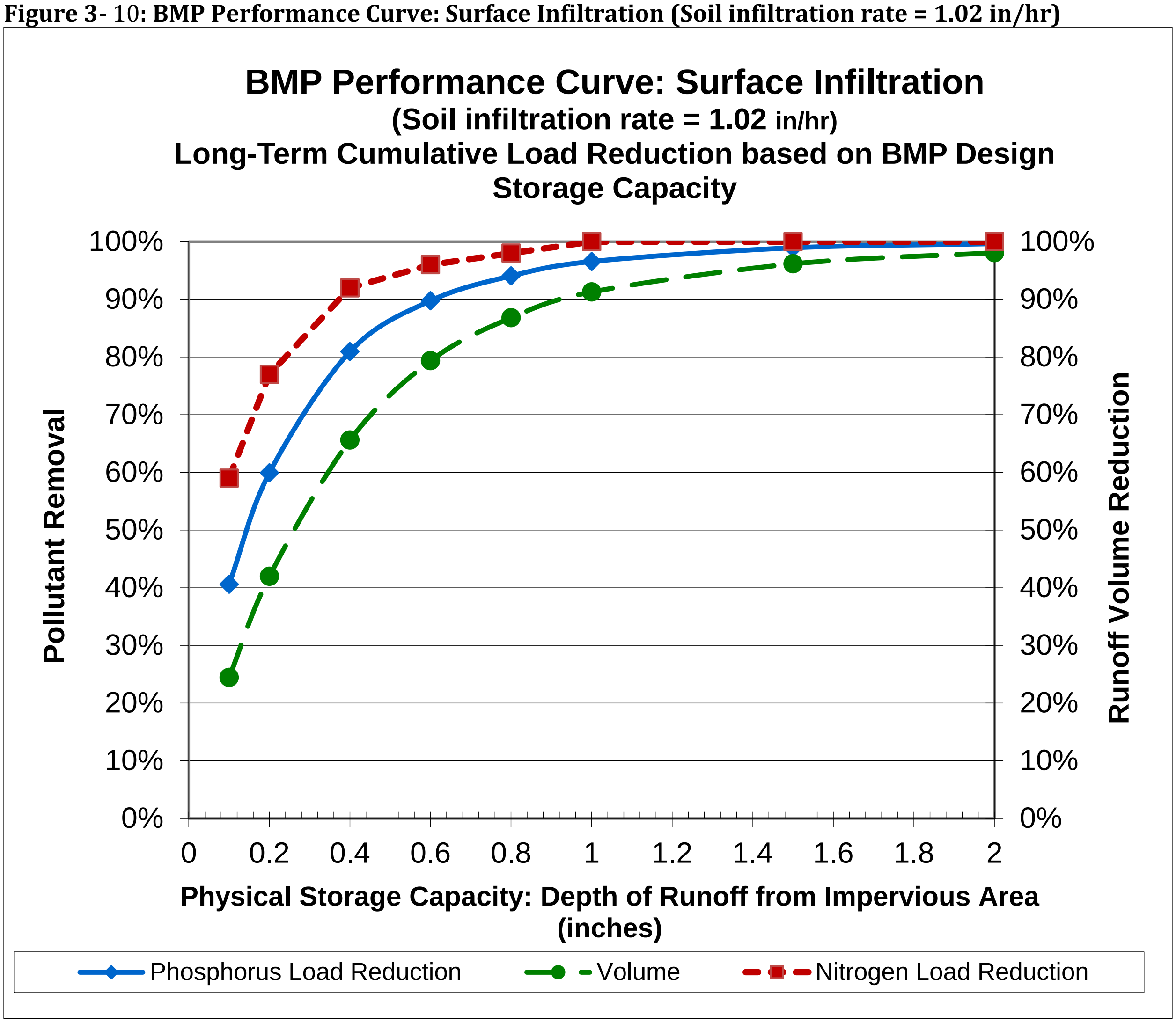


**Table 3- 16: Surface Infiltration (2.41 in/hr) BMP Performance Table**

| Surface Infiltration (2.41 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 32.8% | 53.8% | 77.8% | 88.4% | 93.4% | 96.0% | 98.8% | 99.8% |
| **Cumulative Phosphorus Load Reduction** | 46% | 67% | 87% | 94% | 97% | 98% | 100% | 100% |
| **Cumulative Nitrogen Load Reduction** | 64% | 82% | 95% | 98% | 99% | 100% | 100% | 100% |

**Figure 3- 11: BMP Performance Curve: Infiltration Basin (infiltration rate = 2.41 in/hr)**

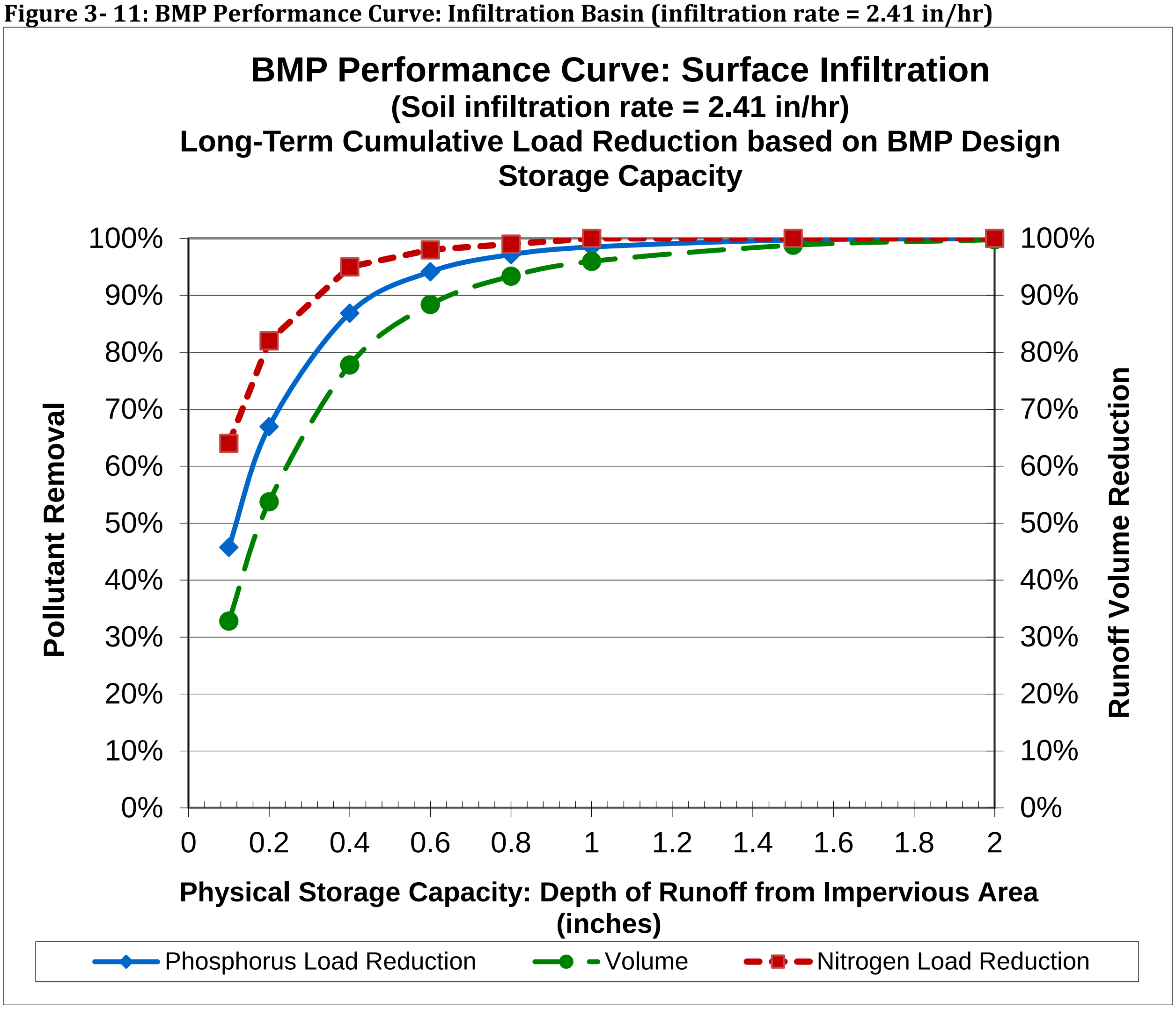


**Table 3- 17: Surface Infiltration (8.27 in/hr) BMP Performance Table**

| Surface Infiltration (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Runoff Volume Reduction** | 54.6% | 77.2% | 93.4% | 97.5% | 99.0% | 99.6% | 100.0% | 100.0% |
| **Cumulative Phosphorus Load Reduction** | 59% | 81% | 96% | 99% | 100% | 100% | 100% | 100% |
| **Cumulative Nitrogen Load Reduction** | 75% | 92% | 99% | 100% | 100% | 100% | 100% | 100% |

**Figure 3- 12: BMP Performance Curve: Surface Infiltration (infiltration rate = 8.27 in/hr)**

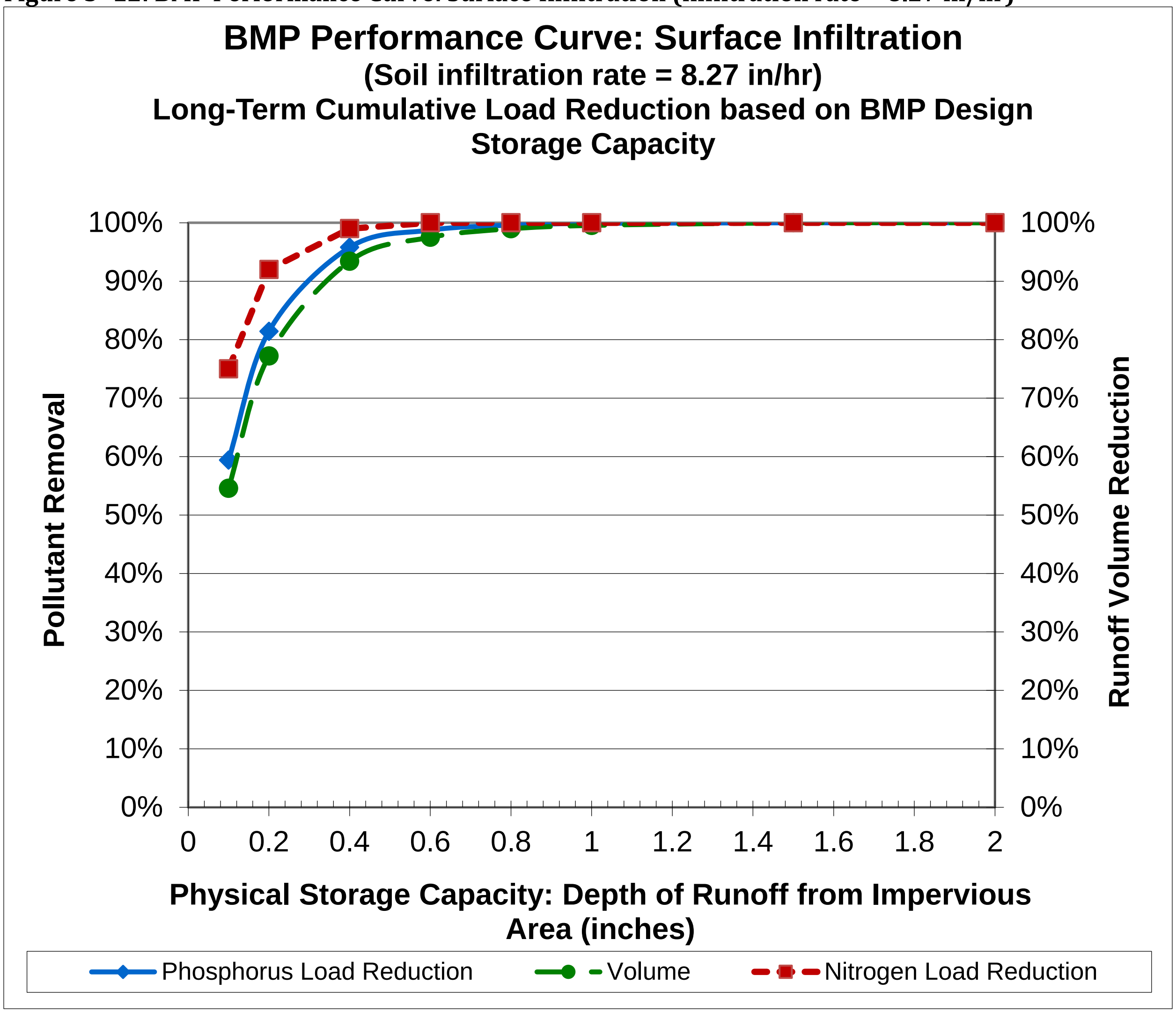


**Table 3-18: Bio-filtration BMP Performance Table**

| Bio-filtration BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Cumulative Phosphorus Load Reduction** | 19% | 34% | 53% | 64% | 71% | 76% | 84% | 89% |
| **Cumulative Nitrogen Load Reduction** | 9% | 16% | 23% | 28% | 31% | 32% | 37% | 40% |

**Figure 3- 13: BMP Performance Curve: Bio-filtration**

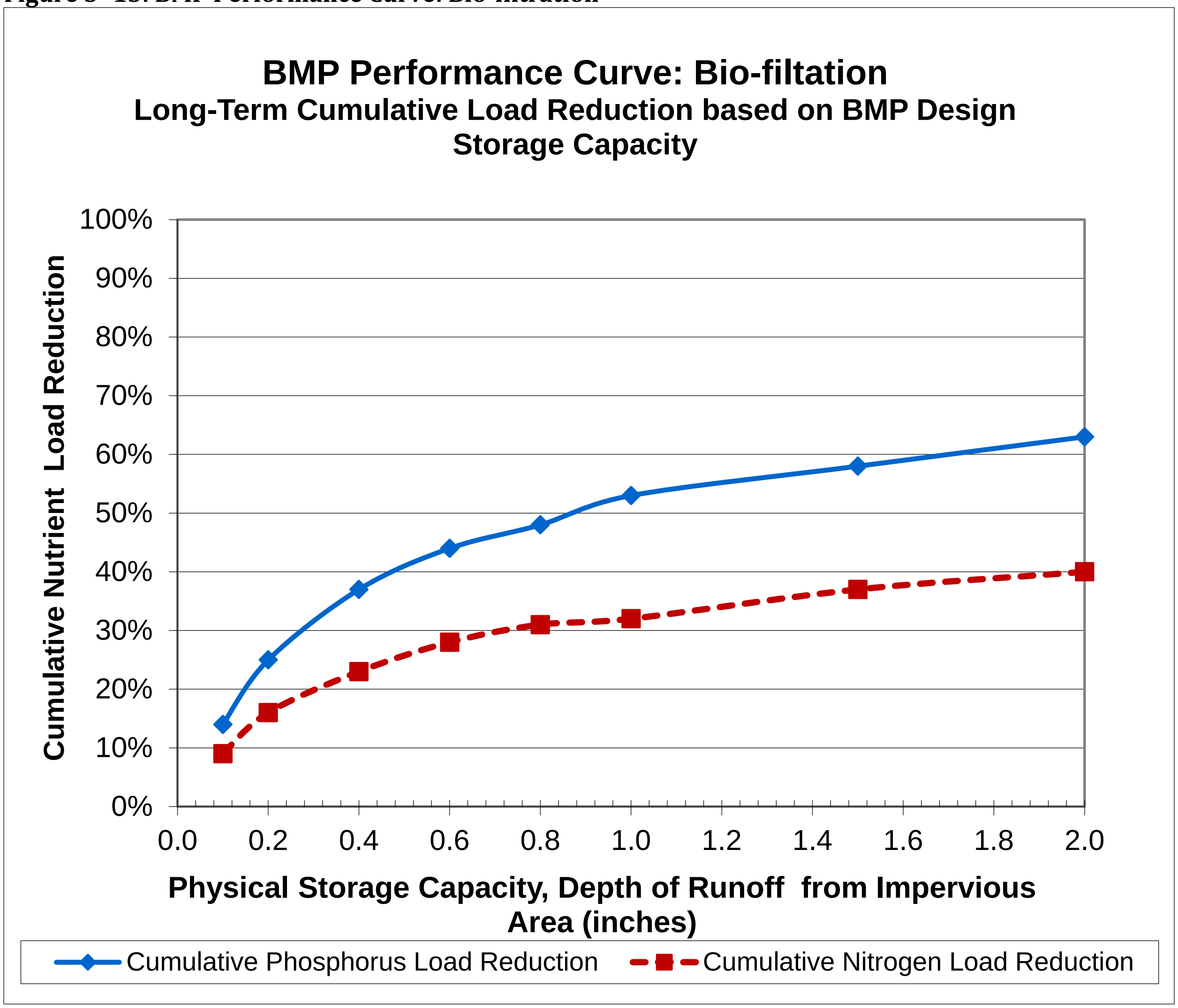


**Table 3- 19: Gravel Wetland BMP Performance Table**

| Gravel Wetland BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **BMP Capacity: Depth of Runoff from Impervious Area (inches)** | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
| **Cumulative Phosphorus Load Reduction** | 19% | 26% | 41% | 51% | 57% | 61% | 65% | 66% |
| **Cumulative Nitrogen Load Reduction** | 22% | 33% | 48% | 57% | 64% | 68% | 74% | 79% |

**Figure 3- 14: BMP Performance Curve: Gravel Wetland**

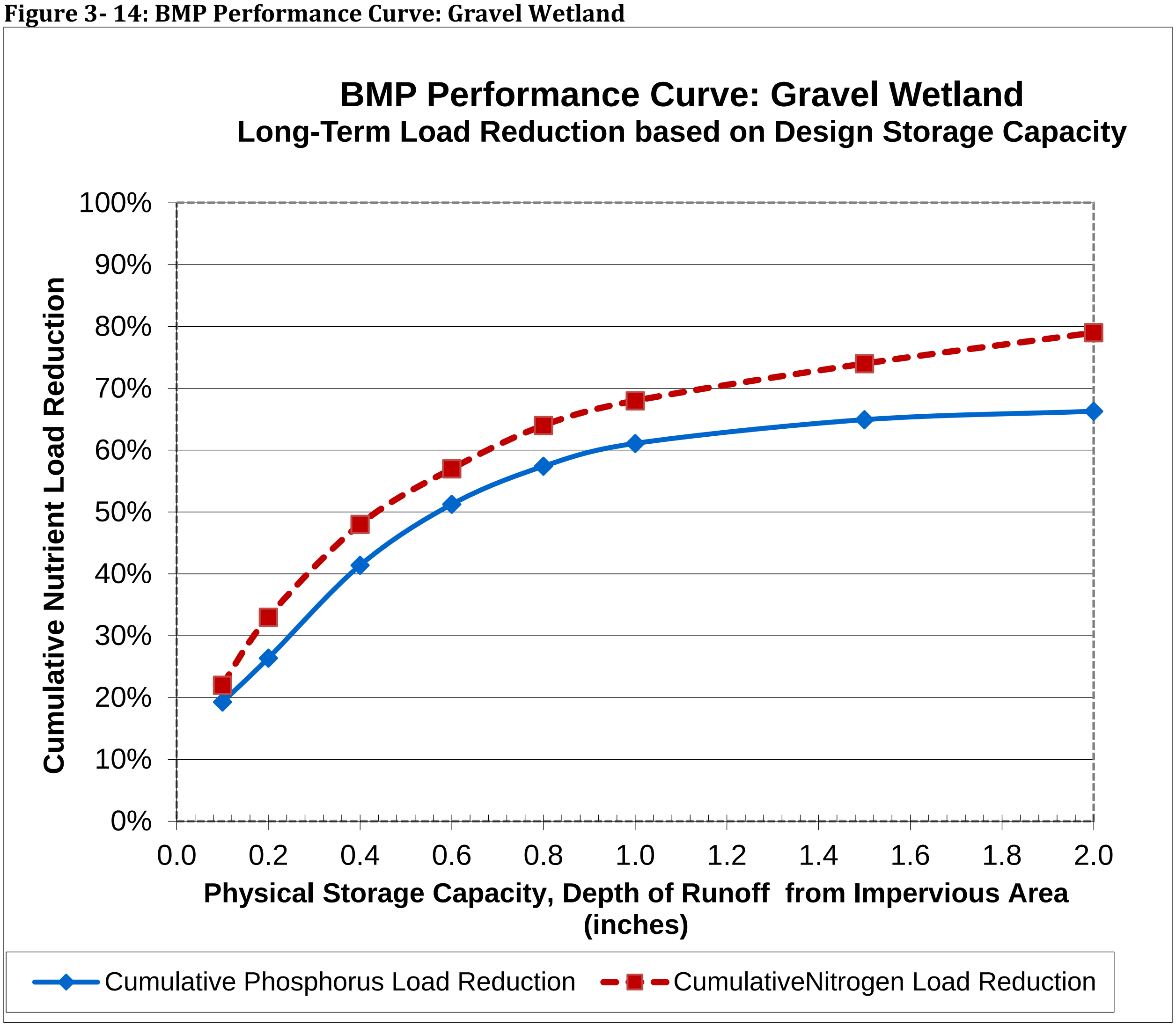



**Table 3- 20: Enhanced Bio-filtration* with Internal Storage Reservoir (ISR) BMP Performance Table**

| Enhanced Bio-filtration* w/ ISR BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction |
|---|

| BMP Capacity: Depth of Runoff from Impervious Area (inches) | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|---|---|---|---|
| **Cumulative Phosphorus Load Reduction** | 19% | 26% | 41% | 51% | 57% | 61% | 65% | 66% |
| **Cumulative Nitrogen Load Reduction** | 22% | 33% | 48% | 57% | 64% | 68% | 74% | 79% |

***Filter media augmented with phosphorus sorbing materials to enhance phosphorus removal.**

**Figure 3-15: BMP Performance Curve: Enhanced Bio-filtration with Internal Storage Reservoir (ISR) BMP Performance Table**

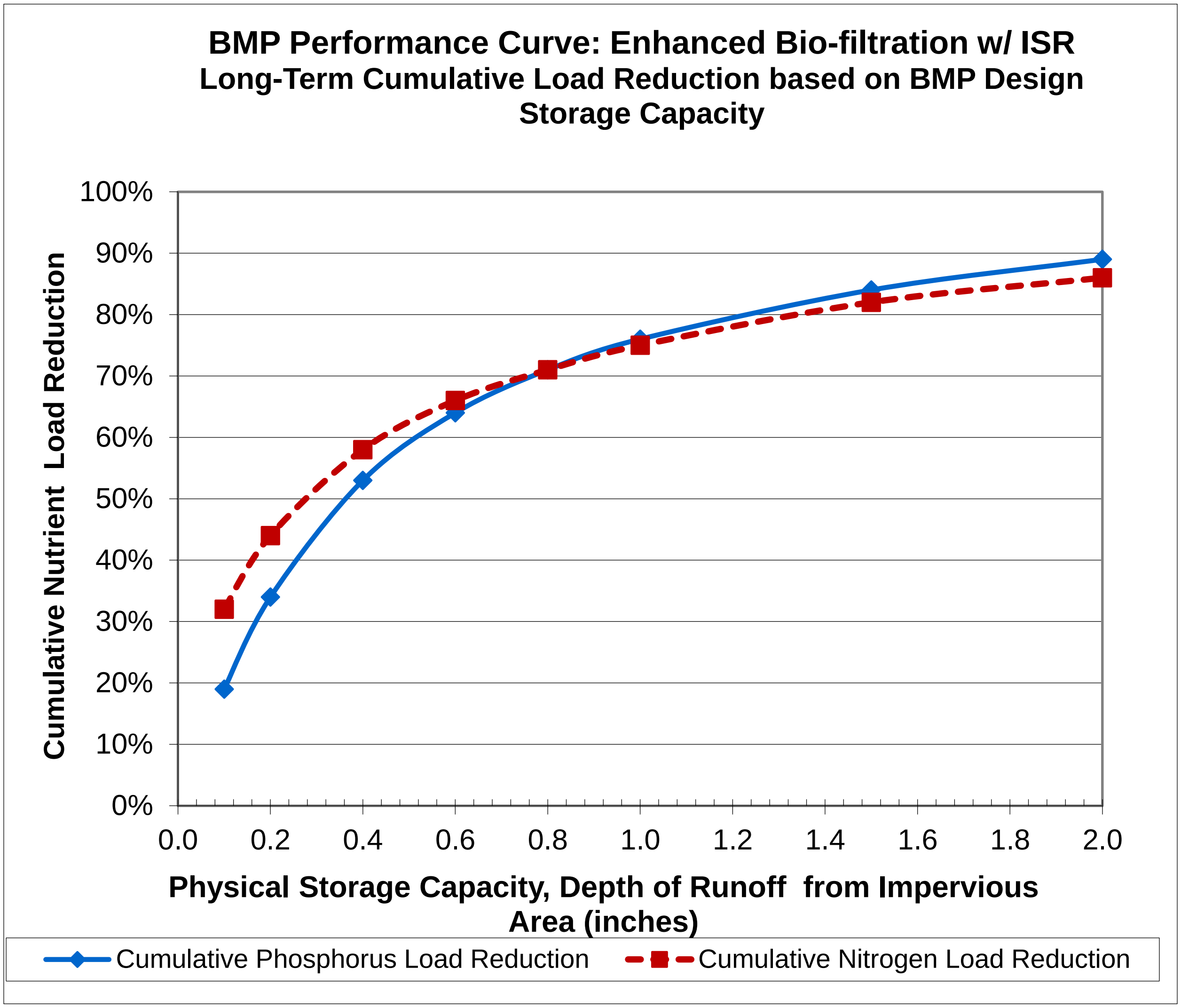



**Table 3-21: Sand Filter BMP Performance Table**

| Sand Filter BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction |
|---|

| BMP Capacity: Depth of Runoff from Impervious Area (inches) | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|---|---|---|---|
| Cumulative Phosphorus Load Reduction | 19% | 34% | 53% | 64% | 71% | 76% | 84% | 89% |
| Cumulative Nitrogen Load Reduction | 9% | 16% | 23% | 28% | 31% | 32% | 37% | 40% |

**Figure 3-16: BMP Performance Curve: Sand Filter**

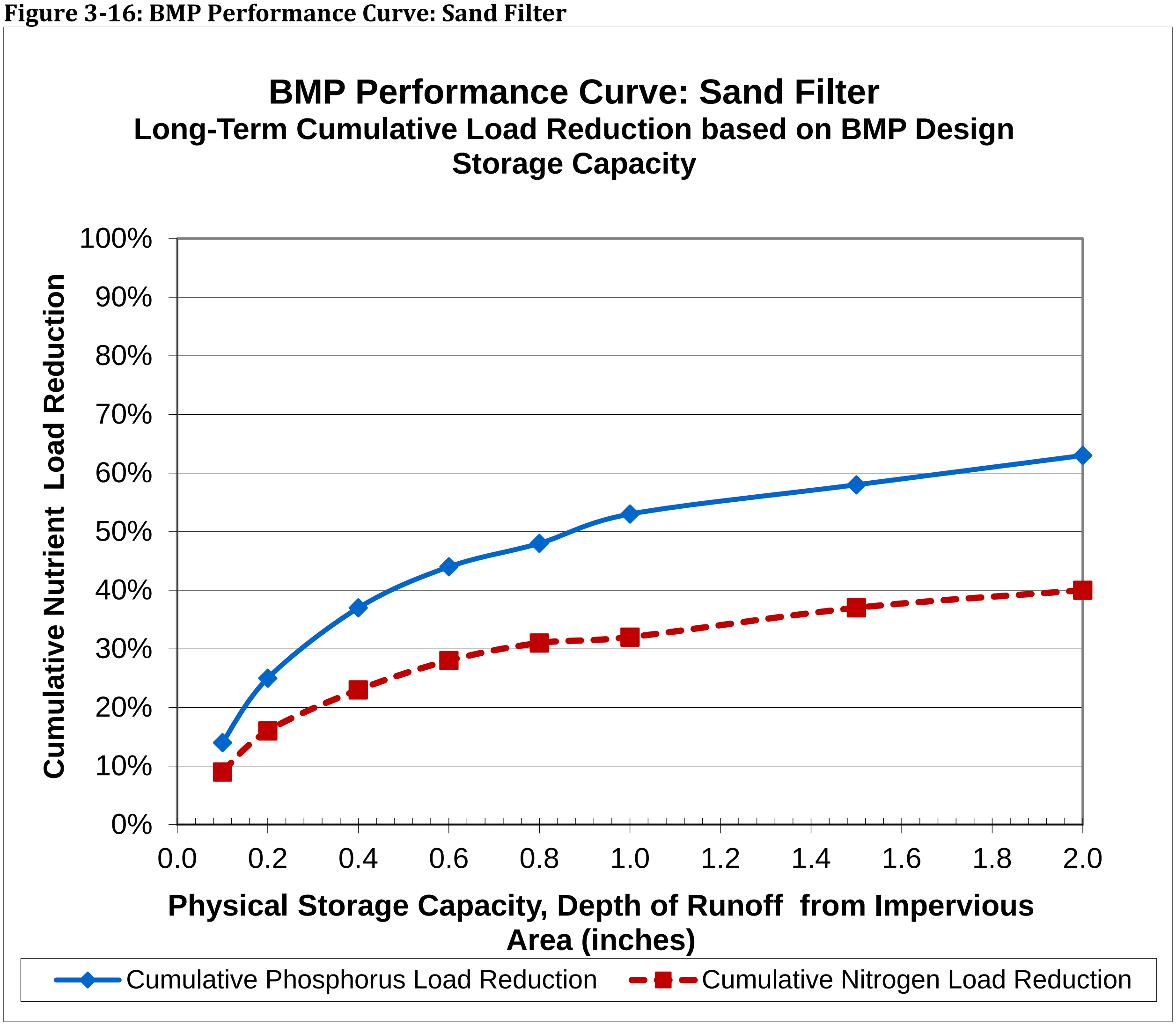



**Table 3- 22 Porous Pavement BMP Performance Table**

| Porous Pavement BMP Performance Table: Long-Term Phosphorus Load Reduction |
|---|

| BMP Capacity: Depth of Filter Course Area (inches) | 12.0 | 18.0 | 24.0 | 32.0 |
|---|---|---|---|---|
| Cumulative Phosphorus Load Reduction | 62% | 70% | 75% | 78% |
| Cumulative Nitrogen Load Reduction | 76% | 77% | 77% | 79% |

**Figure 3- 17: BMP Performance Curve: Porous Pavement**

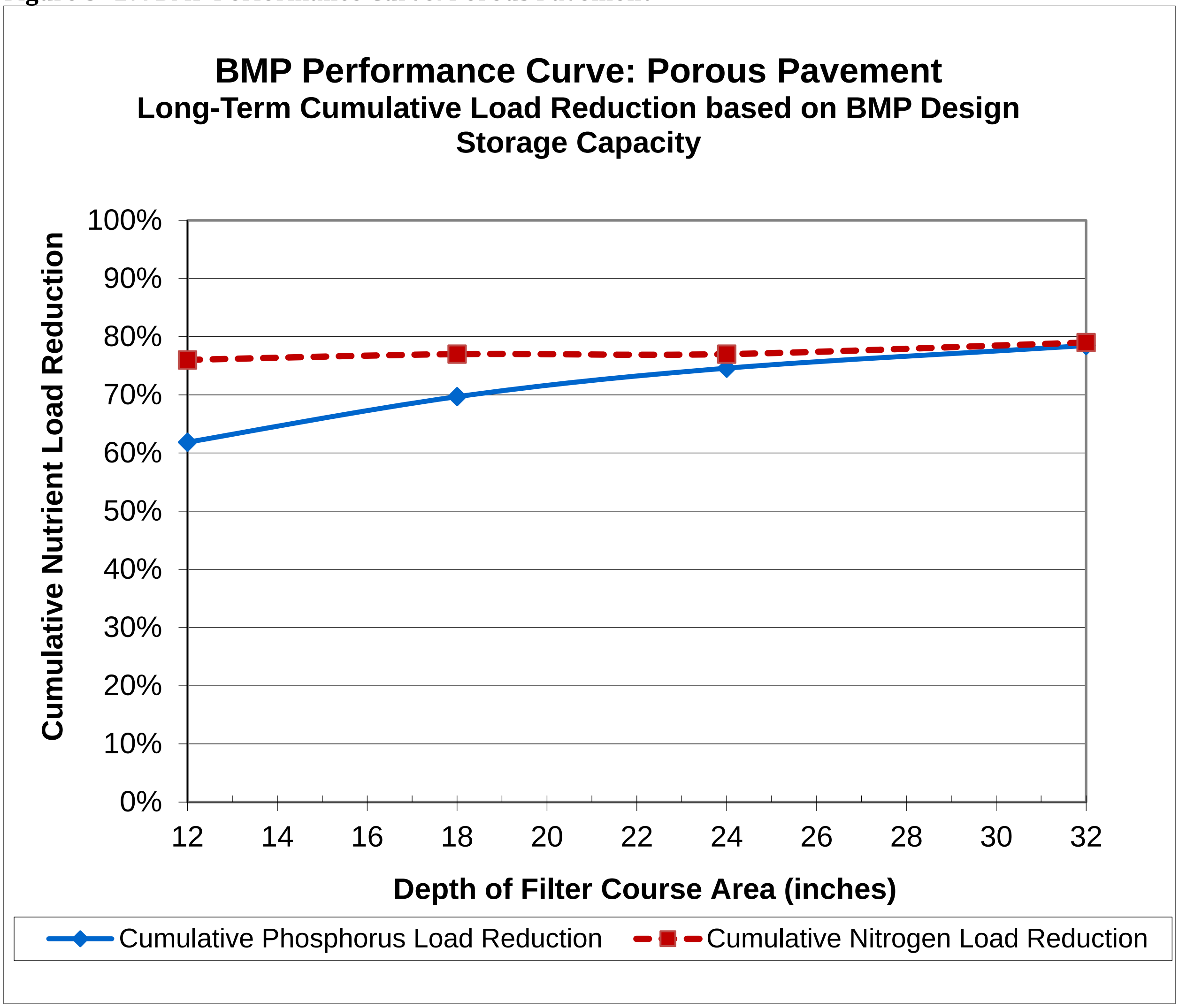



**Table 3- 23: Wet Pond BMP Performance Table**

| Wet Pond BMP Performance Table: Long-Term Phosphorus Load Reduction |
|---|

| BMP Capacity: Depth of Runoff from Impervious Area (inches) | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|---|---|---|---|
| **Cumulative Phosphorus Load Reduction** | 14% | 25% | 37% | 44% | 48% | 53% | 58% | 63% |
| **Cumulative Nitrogen Load Reduction** | 9% | 16% | 23% | 28% | 31% | 32% | 37% | 40% |

**Figure 3-18: BMP Performance Curve: Wet Pond**

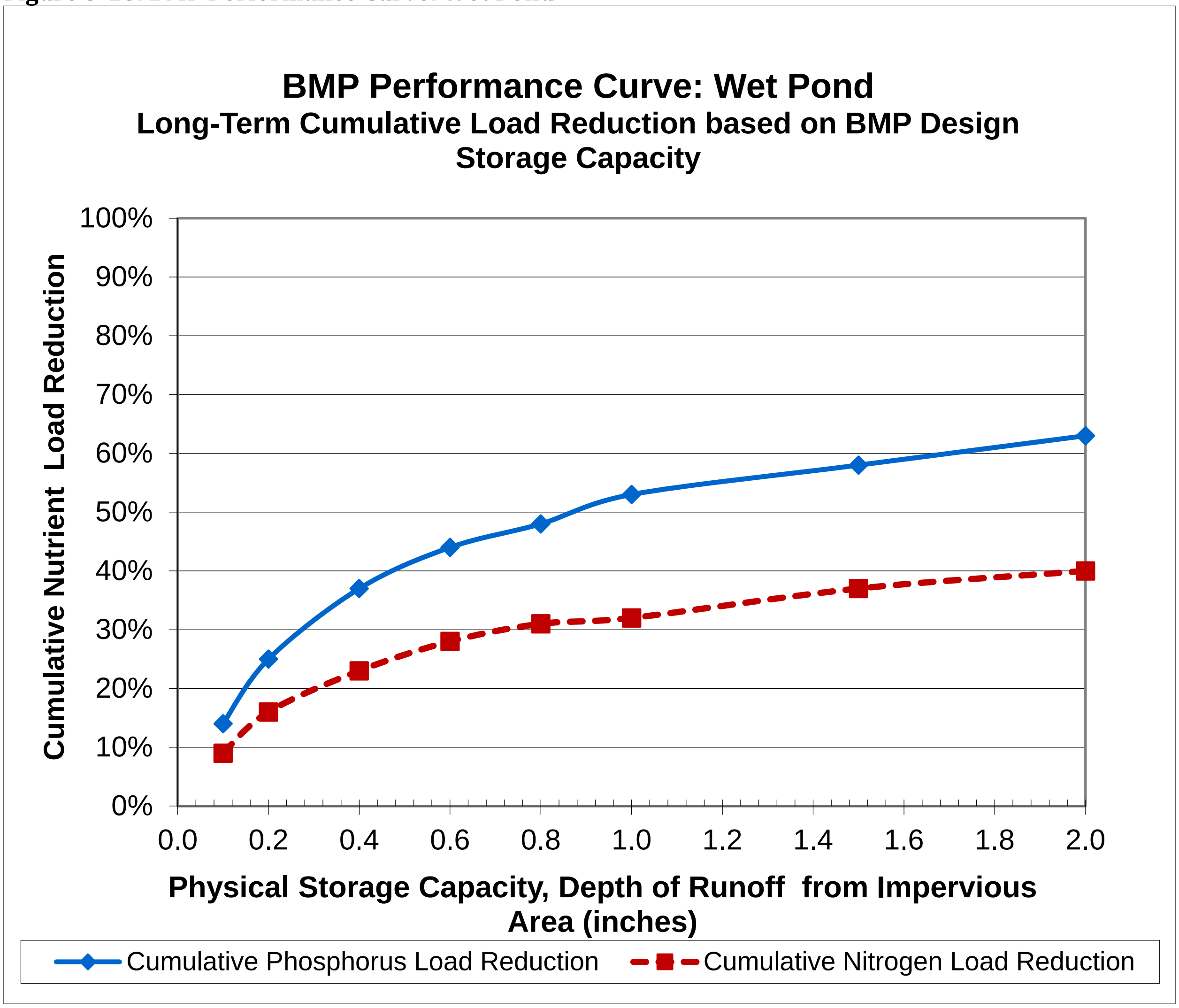



**Table 3-24: Dry Pond BMP Performance Table**

| Dry Pond BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction |
|---|

| BMP Capacity: Depth of Runoff from Impervious Area (inches) | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|---|---|---|---|
| Cumulative Phosphorus Load Reduction | 2% | 5% | 9% | 13% | 17% | 21% | 29% | 36% |
| Cumulative Nitrogen Load Reduction | 1% | 3% | 6% | 9% | 11% | 13% | 19% | 23% |

**Figure 3- 19: BMP Performance Curve: Dry Pond**

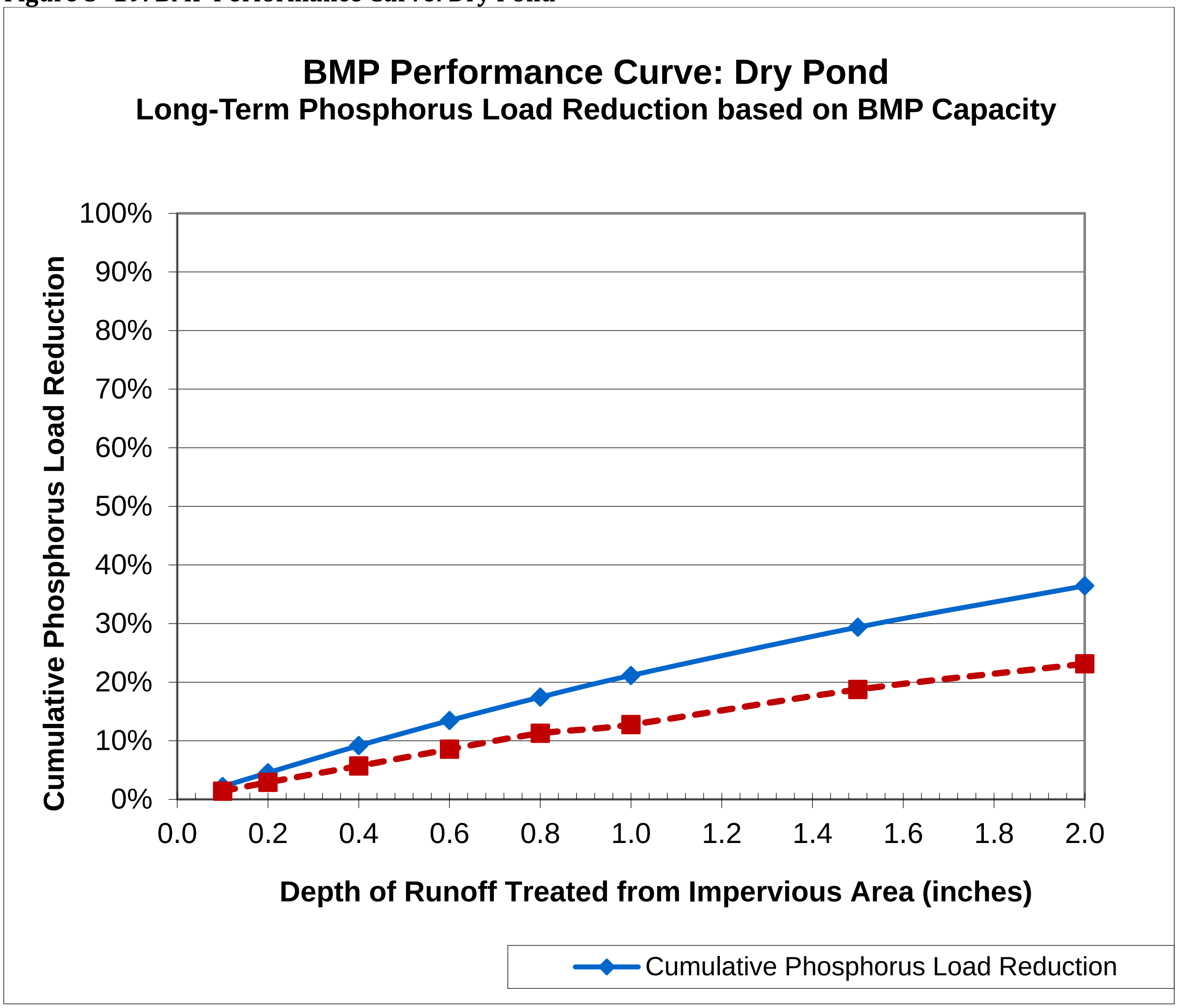



**Table 3- 25: Water Quality Grass Swale with Detention BMP Performance Table**

| Water Quality Grass Swale with Detention BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction |
|---|

| BMP Capacity: Depth of Runoff from Impervious Area (inches) | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|---|---|---|---|
| Phosphorus Load Reduction | 2% | 5% | 9% | 13% | 17% | 21% | 29% | 36% |
| Nitrogen Load Reduction | 1% | 3% | 6% | 9% | 11% | 13% | 19% | 23% |

**Figure 3-20: BMP Performance Curve: Water Quality Grass Swale with Detention**

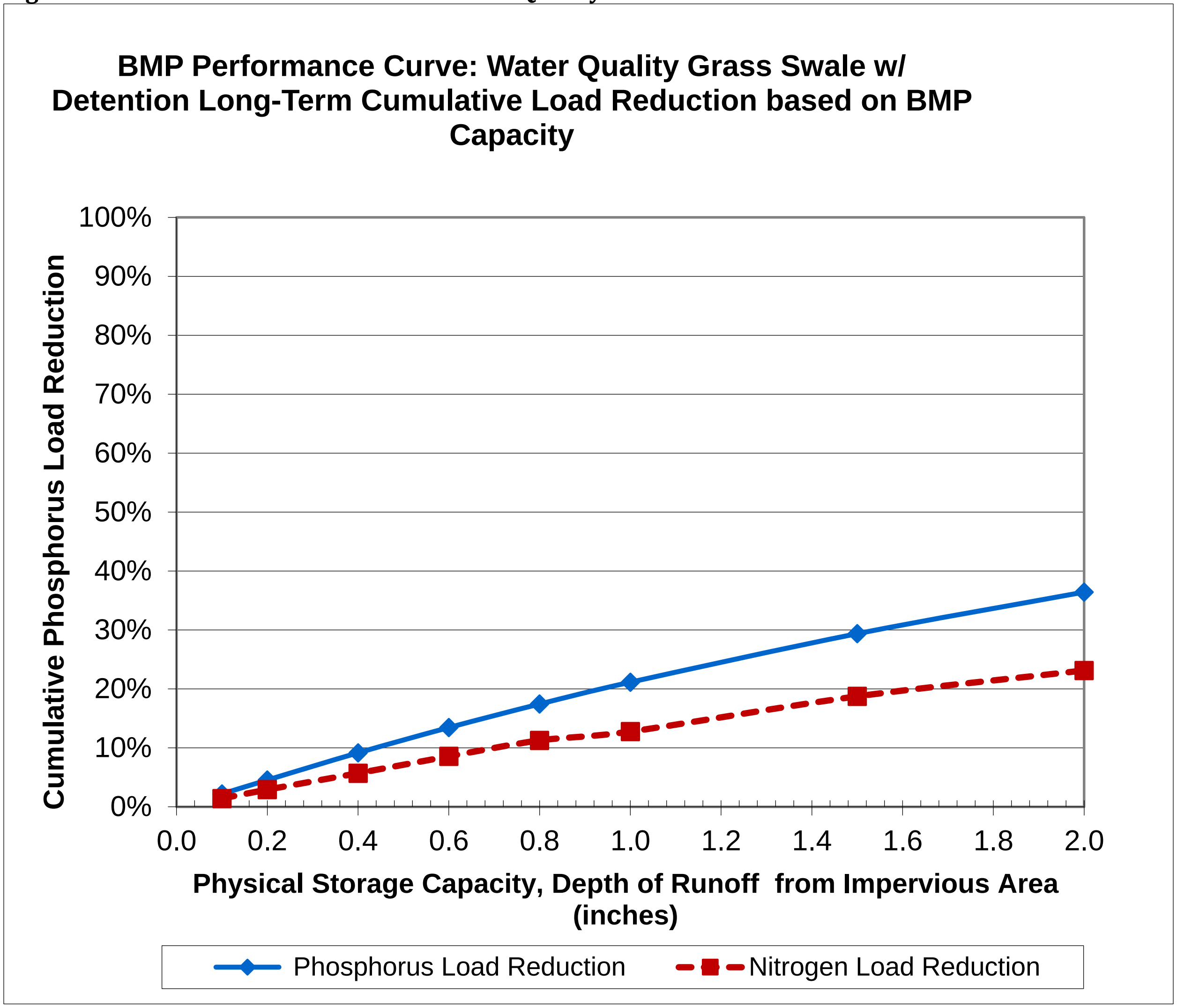



**Table 3- 26: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1**

| Impervious Area Disconnection through Storage : Impervious Area to Pervious Area Ratio = 8:1 | |
|---|---|
| | Total Runoff Volume (TP) Reduction Percentages |

| Storage volume to impervious area ratio | HSG A | | | HSG B | | | HSG C | | | HSG D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day |
| 0.1 in | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% | 22% | 22% | 21% |
| 0.2 in | 40% | 38% | 37% | 40% | 38% | 37% | 37% | 38% | 37% | 24% | 26% | 27% |
| 0.3 in | 52% | 50% | 49% | 52% | 50% | 49% | 40% | 46% | 49% | 24% | 26% | 27% |
| 0.4 in | 61% | 59% | 58% | 59% | 59% | 58% | 40% | 48% | 54% | 24% | 26% | 27% |
| 0.5 in | 67% | 66% | 64% | 62% | 66% | 64% | 40% | 48% | 56% | 24% | 26% | 27% |
| 0.6 in | 70% | 71% | 70% | 62% | 70% | 70% | 40% | 48% | 56% | 24% | 26% | 27% |
| 0.8 in | 71% | 78% | 77% | 62% | 73% | 77% | 40% | 48% | 56% | 24% | 26% | 27% |
| 1.0 in | 71% | 80% | 80% | 62% | 73% | 79% | 40% | 48% | 56% | 24% | 26% | 27% |
| 1.5 in | 71% | 81% | 87% | 62% | 73% | 81% | 40% | 48% | 56% | 24% | 26% | 27% |
| 2.0 in | 71% | 81% | 88% | 62% | 73% | 81% | 40% | 48% | 56% | 24% | 26% | 27% |

**Figure 3- 21: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG A Soils**

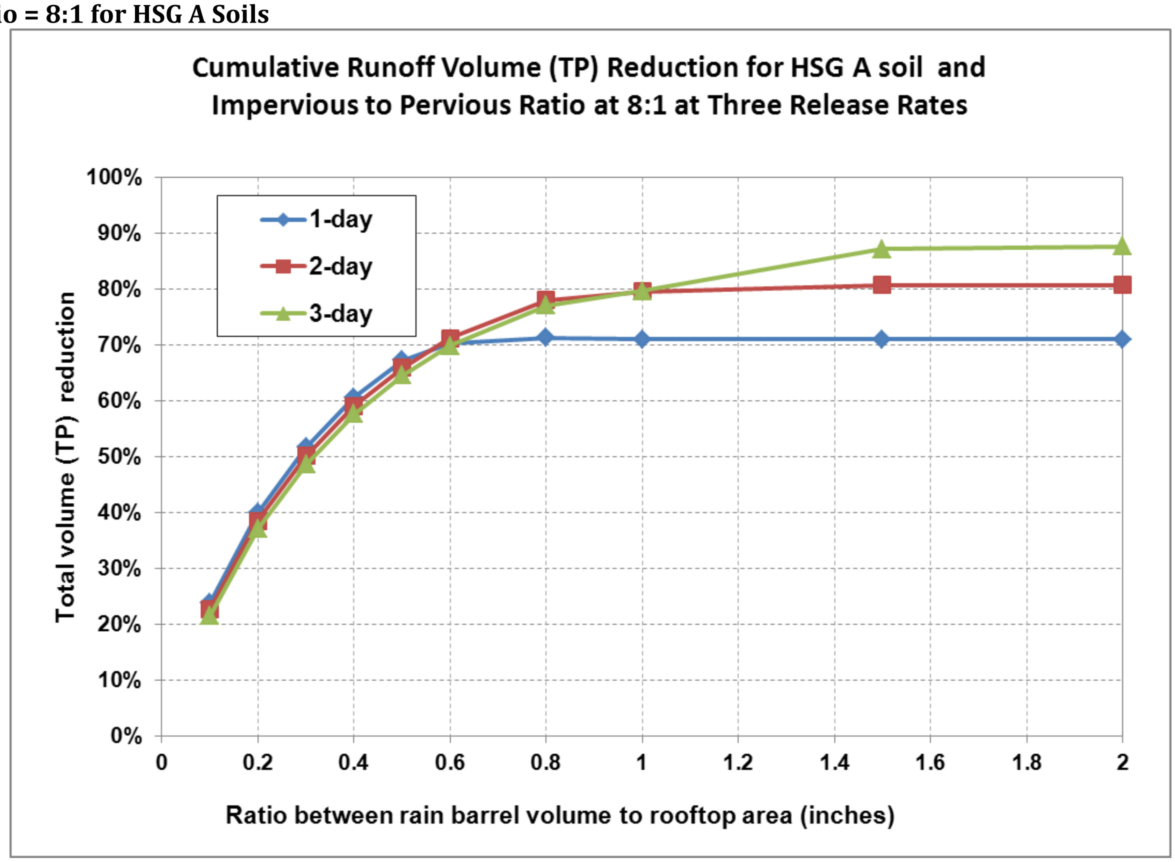


**Figure 3- 22: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG B Soils**

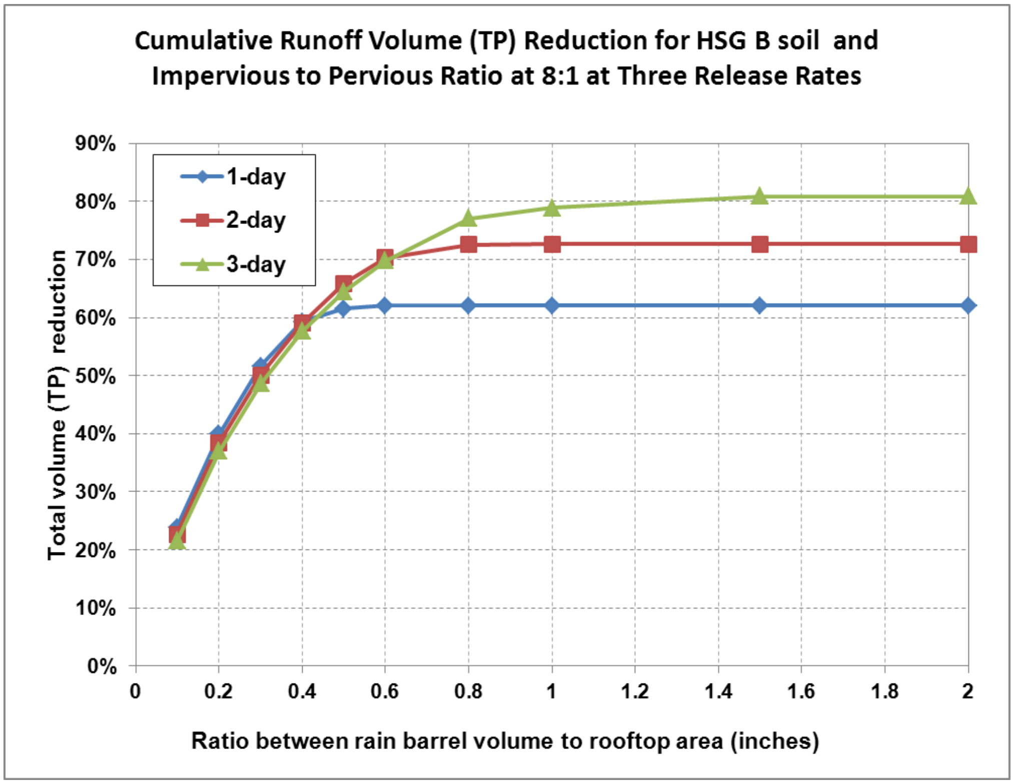



**Figure 3- 23: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG C Soils**

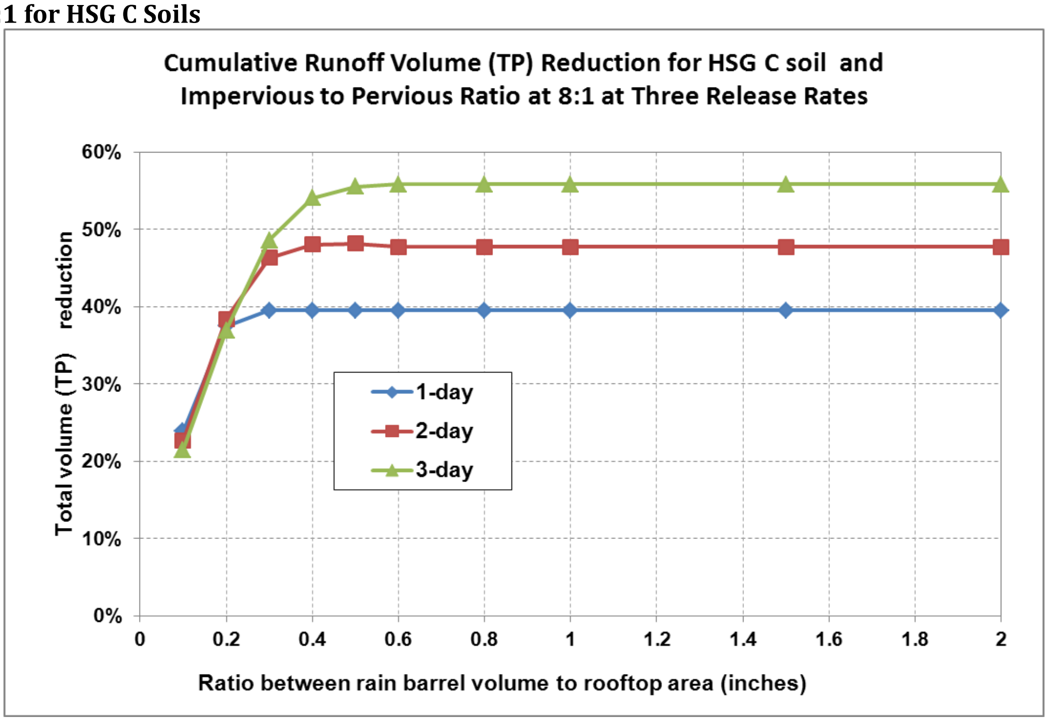


**Figure 3- 24: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG D Soils**

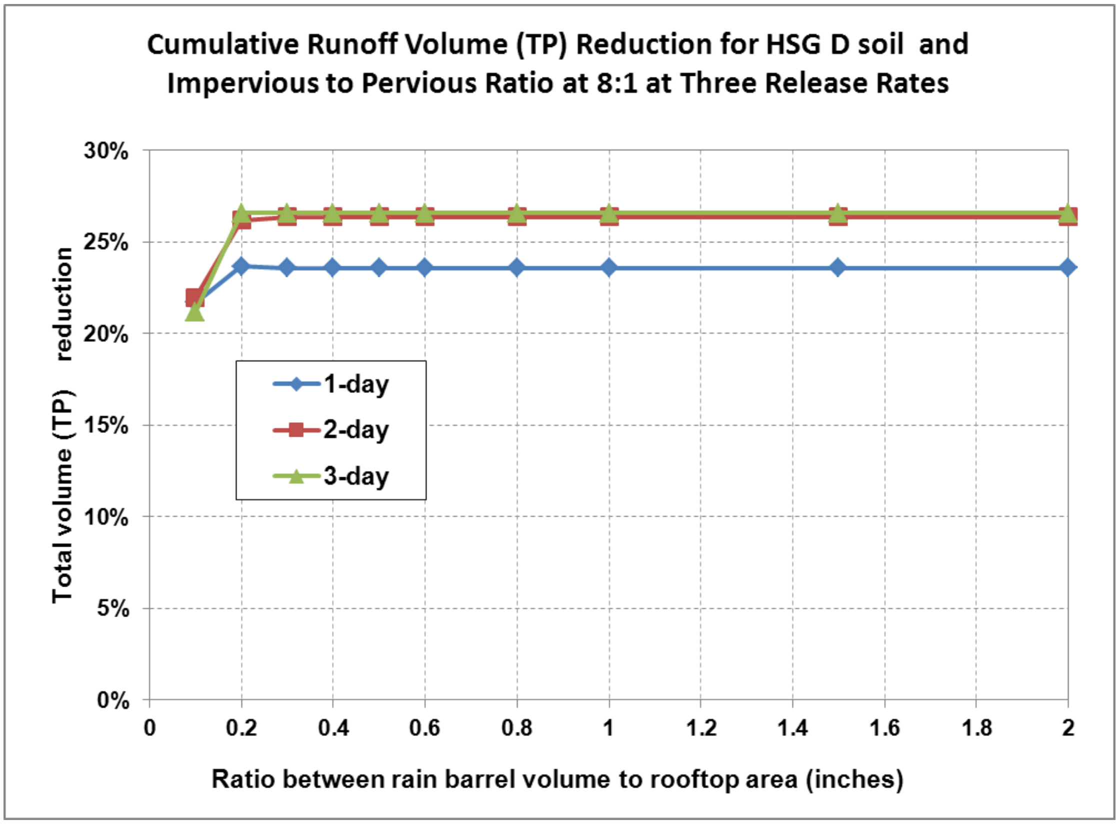



**Table 3- 27: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1**

| Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rain barrel volume to impervious area ratio | Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages | | | | | | | | | | | |
| | HSG A | | | HSG B | | | HSG C | | | HSG D | | |
| | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day |
| 0.1 in | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% | 23% | 23% | 22% |
| 0.2 in | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% | 28% | 30% | 33% |
| 0.3 in | 52% | 50% | 49% | 52% | 50% | 49% | 47% | 50% | 49% | 29% | 31% | 34% |
| 0.4 in | 61% | 59% | 58% | 61% | 59% | 58% | 48% | 55% | 58% | 29% | 31% | 34% |
| 0.5 in | 67% | 66% | 64% | 67% | 66% | 64% | 48% | 57% | 63% | 29% | 31% | 34% |
| 0.6 in | 73% | 71% | 70% | 70% | 71% | 70% | 48% | 57% | 65% | 29% | 31% | 34% |
| 0.8 in | 78% | 78% | 77% | 71% | 78% | 77% | 48% | 57% | 66% | 29% | 31% | 34% |
| 1.0 in | 79% | 81% | 80% | 71% | 79% | 80% | 48% | 57% | 66% | 29% | 31% | 34% |
| 1.5 in | 79% | 87% | 88% | 71% | 80% | 87% | 48% | 57% | 66% | 29% | 31% | 34% |
| 2.0 in | 79% | 87% | 91% | 71% | 80% | 87% | 48% | 57% | 66% | 29% | 31% | 34% |

**Figure 3- 25: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG A Soils**

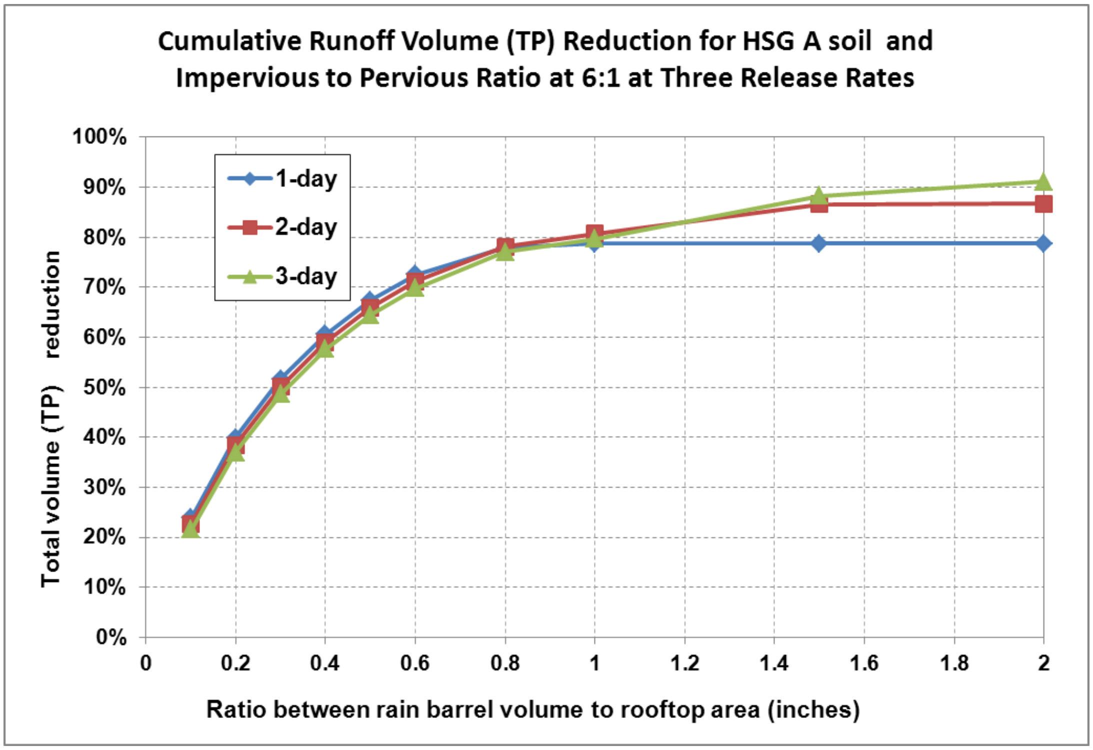



**Figure 3- 26: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG B Soils**

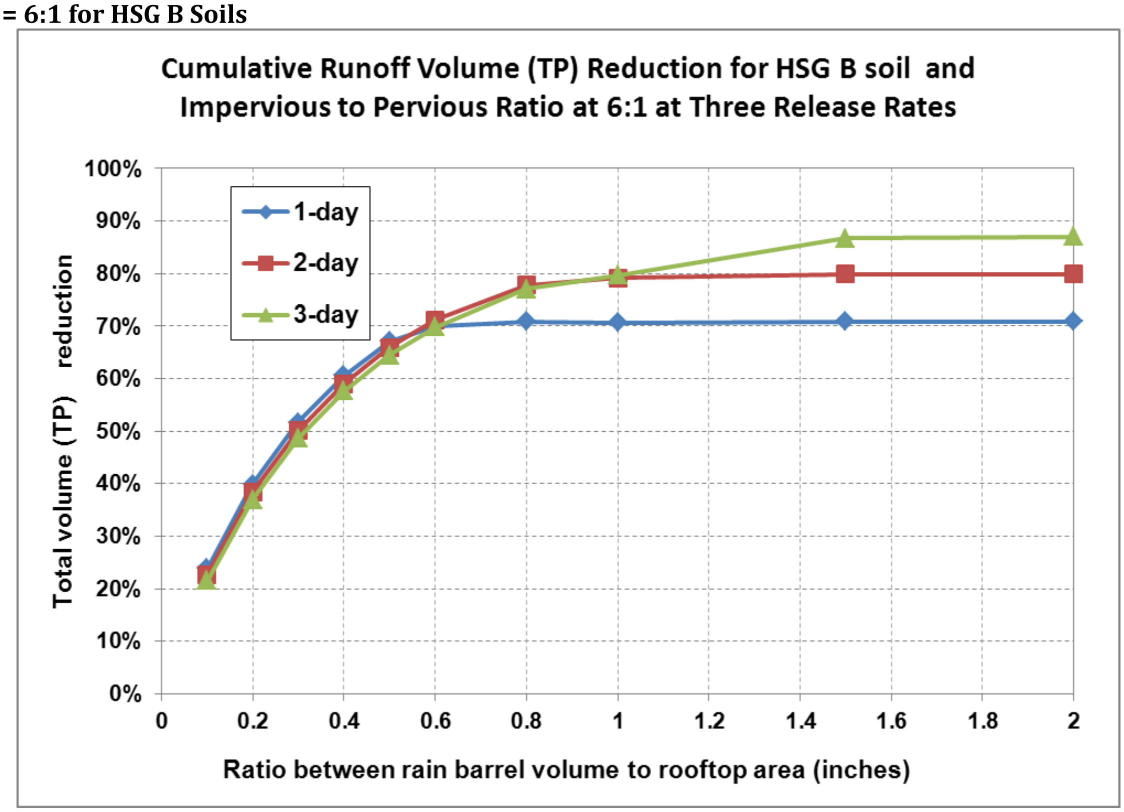


**Figure 3- 27: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG C Soils**

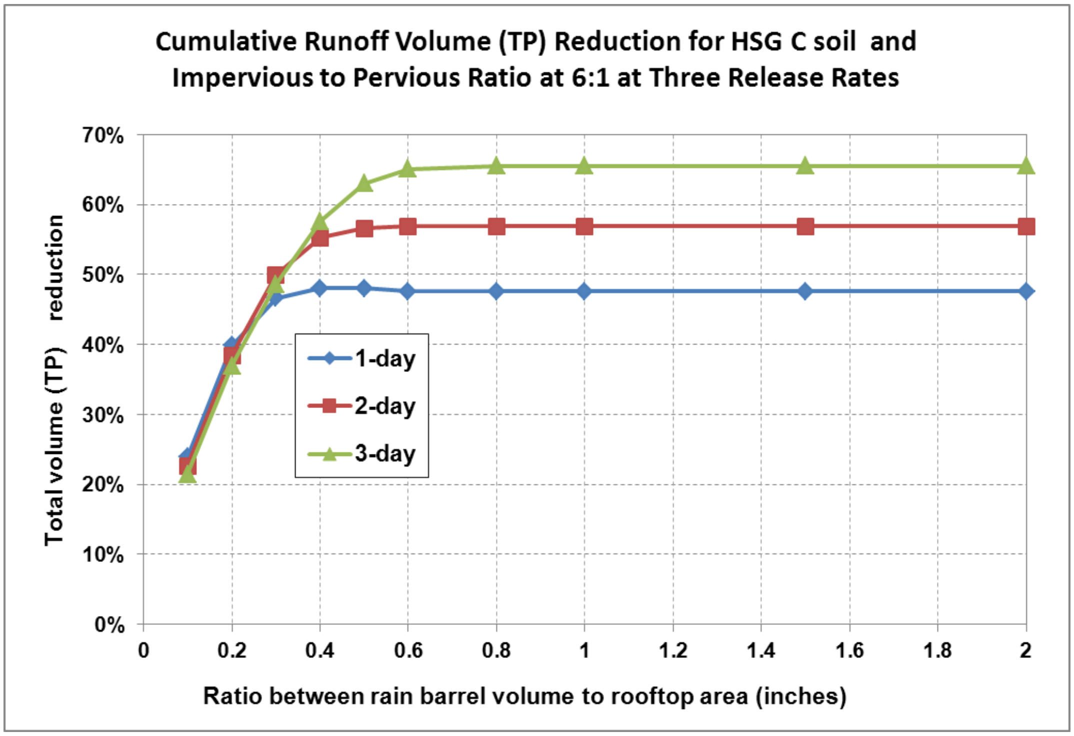



**Figure 3- 28: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG D Soils**

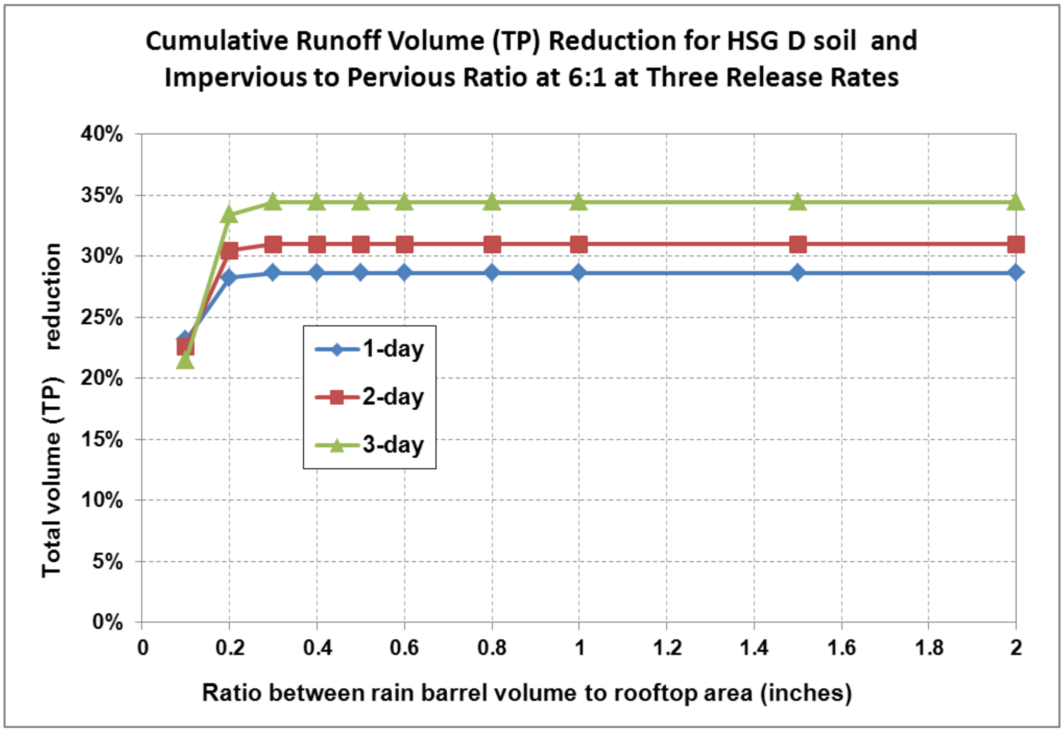


**Table 3- 28: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1**

| Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storage volume to impervious area ratio | Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages | | | | | | | | | | | |
| | HSG A | | | HSG B | | | HSG C | | | HSG D | | |
| | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day |
| 0.1 in | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% |
| 0.2 in | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% | 37% | 37% | 37% |
| 0.3 in | 52% | 50% | 49% | 52% | 50% | 49% | 52% | 50% | 49% | 39% | 42% | 45% |
| 0.4 in | 61% | 59% | 58% | 61% | 59% | 58% | 58% | 59% | 58% | 39% | 42% | 47% |
| 0.5 in | 67% | 66% | 64% | 67% | 66% | 64% | 60% | 65% | 64% | 40% | 42% | 47% |
| 0.6 in | 73% | 71% | 70% | 73% | 71% | 70% | 61% | 68% | 70% | 40% | 42% | 47% |
| 0.8 in | 79% | 78% | 77% | 79% | 78% | 77% | 61% | 69% | 75% | 40% | 42% | 47% |
| 1.0 in | 82% | 81% | 80% | 80% | 81% | 80% | 61% | 69% | 76% | 40% | 42% | 47% |
| 1.5 in | 87% | 89% | 88% | 80% | 87% | 88% | 61% | 69% | 76% | 40% | 42% | 47% |
| 2.0 in | 87% | 91% | 91% | 80% | 88% | 91% | 61% | 69% | 76% | 40% | 42% | 47% |

**Figure 3- 29: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG A Soils**

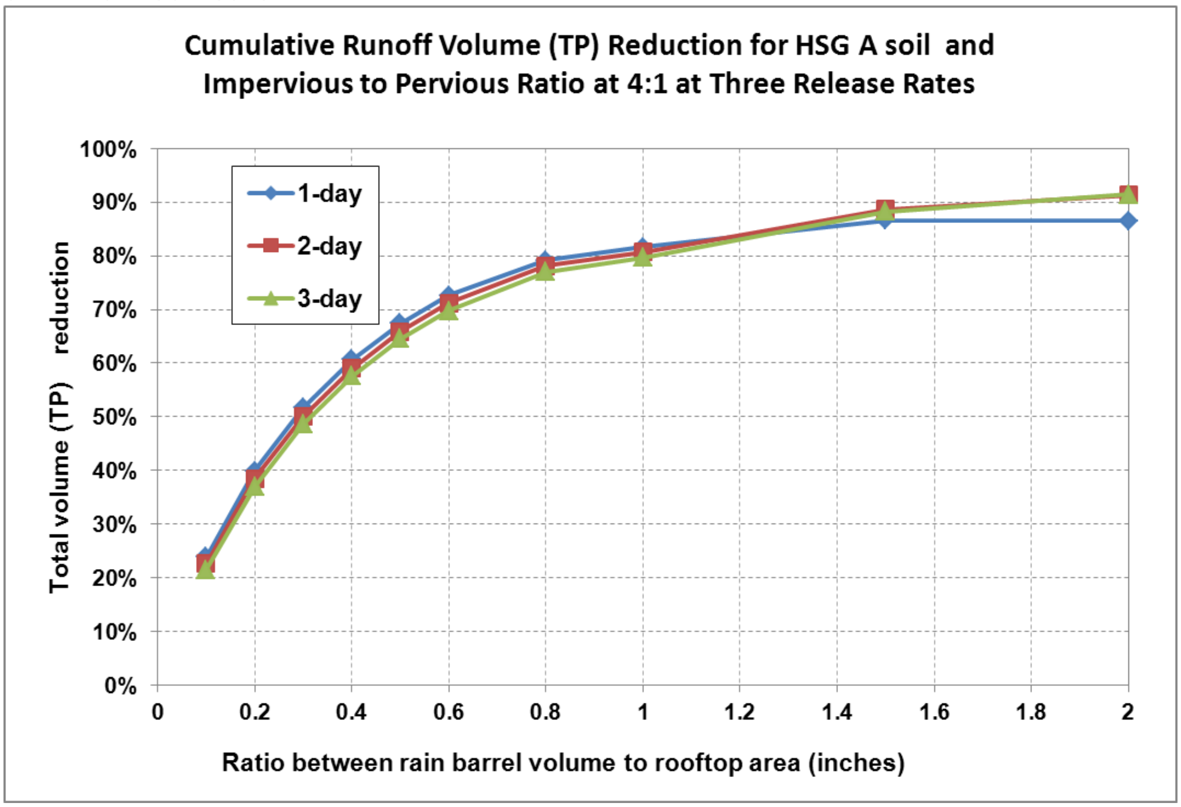


**Figure 3- 30: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG B Soils**

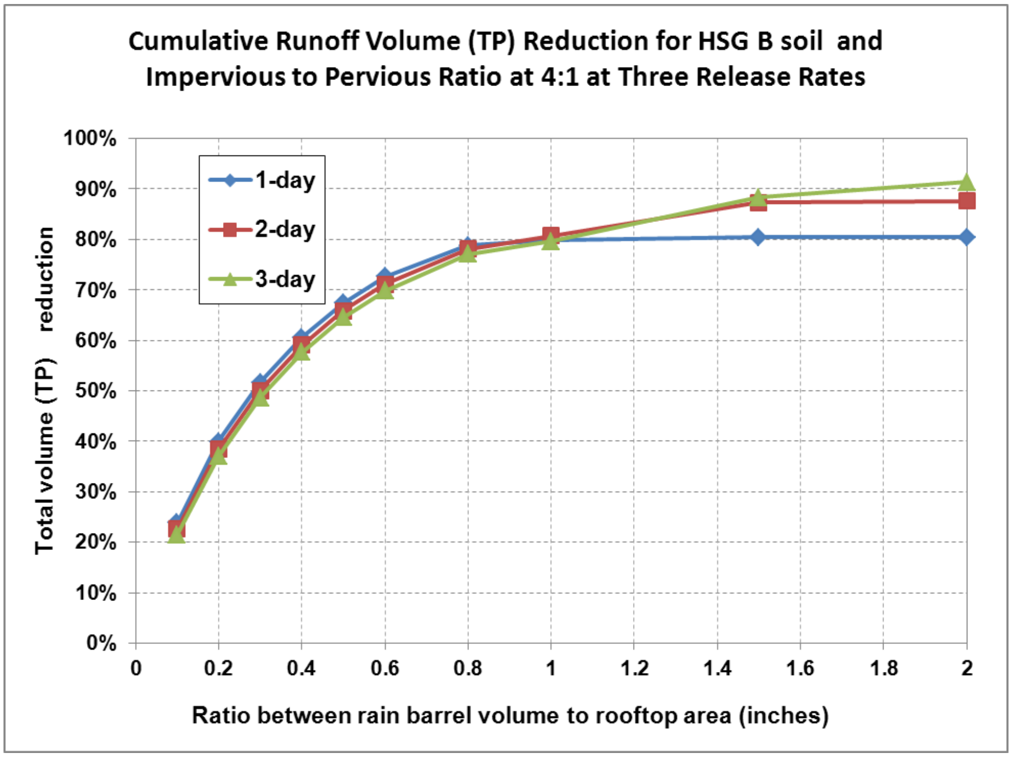



**Figure 3- 31: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG C Soils**

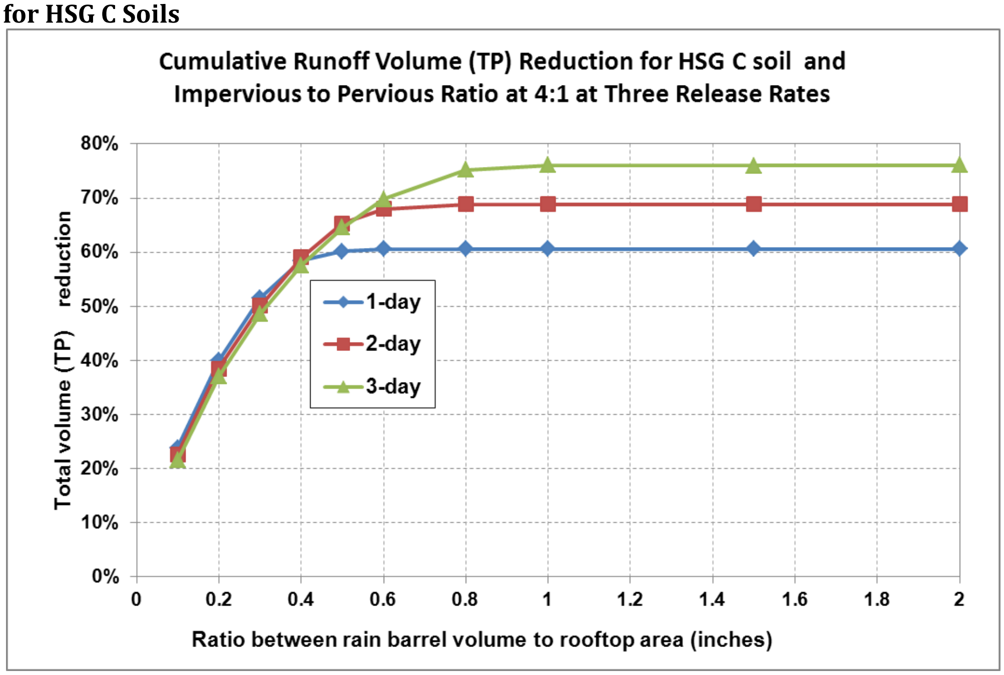


**Figure 3- 32: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG D Soils**

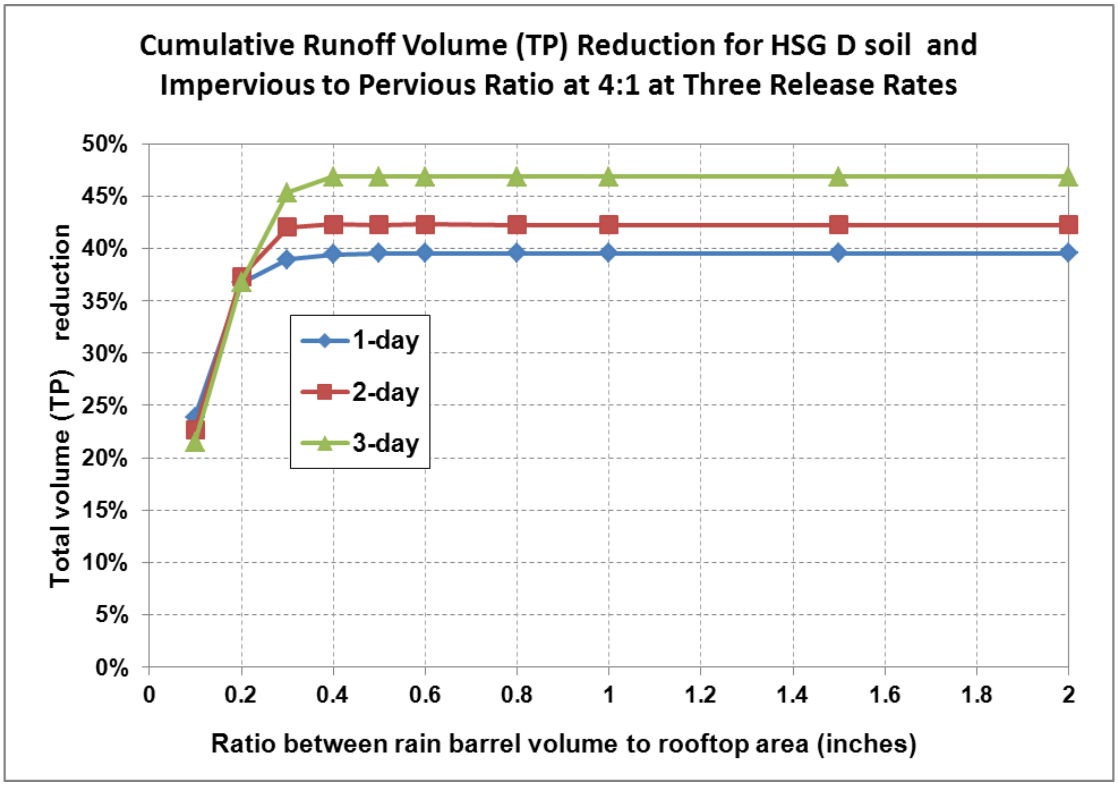



**Table 3- 29: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1**

| Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storage volume to impervious area ratio | Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages | | | | | | | | | | | |
| | HSG A | | | HSG B | | | HSG C | | | HSG D | | |
| | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day |
| 0.1 in | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% |
| 0.2 in | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% |
| 0.3 in | 52% | 50% | 49% | 52% | 50% | 49% | 52% | 50% | 49% | 51% | 50% | 49% |
| 0.4 in | 61% | 59% | 58% | 61% | 59% | 58% | 61% | 59% | 58% | 57% | 58% | 57% |
| 0.5 in | 67% | 66% | 64% | 67% | 66% | 64% | 67% | 66% | 64% | 59% | 62% | 63% |
| 0.6 in | 73% | 71% | 70% | 73% | 71% | 70% | 72% | 71% | 70% | 59% | 62% | 67% |
| 0.8 in | 79% | 78% | 77% | 79% | 78% | 77% | 77% | 78% | 77% | 59% | 62% | 67% |
| 1.0 in | 82% | 81% | 80% | 82% | 81% | 80% | 78% | 81% | 80% | 59% | 62% | 67% |
| 1.5 in | 89% | 89% | 88% | 89% | 89% | 88% | 78% | 84% | 88% | 59% | 62% | 67% |
| 2.0 in | 92% | 92% | 91% | 91% | 92% | 91% | 78% | 84% | 89% | 59% | 62% | 67% |

**Figure 3- 33: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG A Soils**

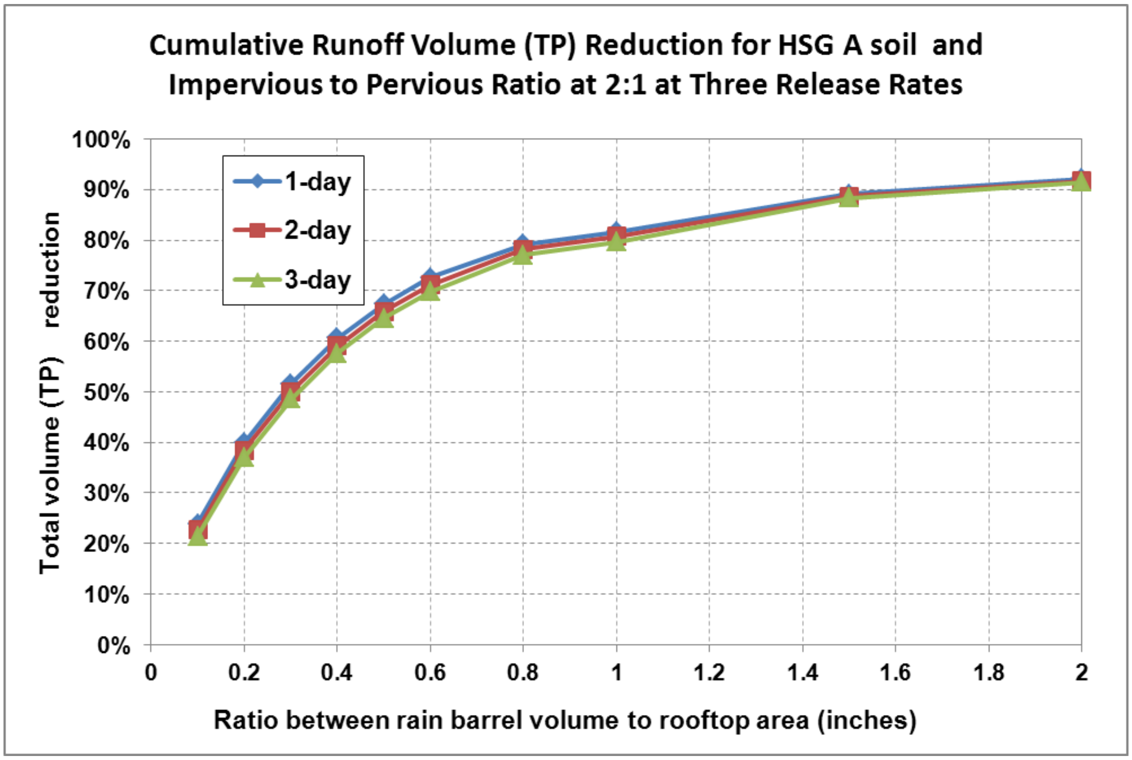



**Figure 3- 34: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG B Soils**

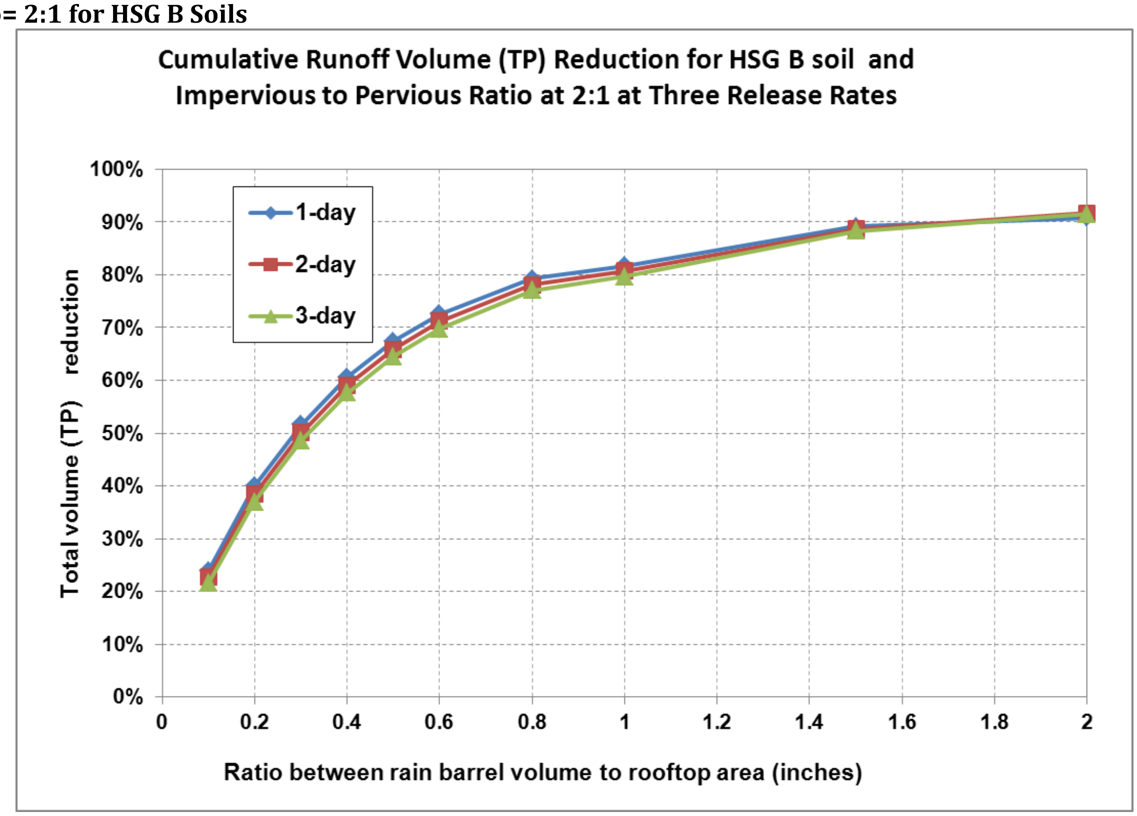


**Figure 3- 35: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG C Soils**

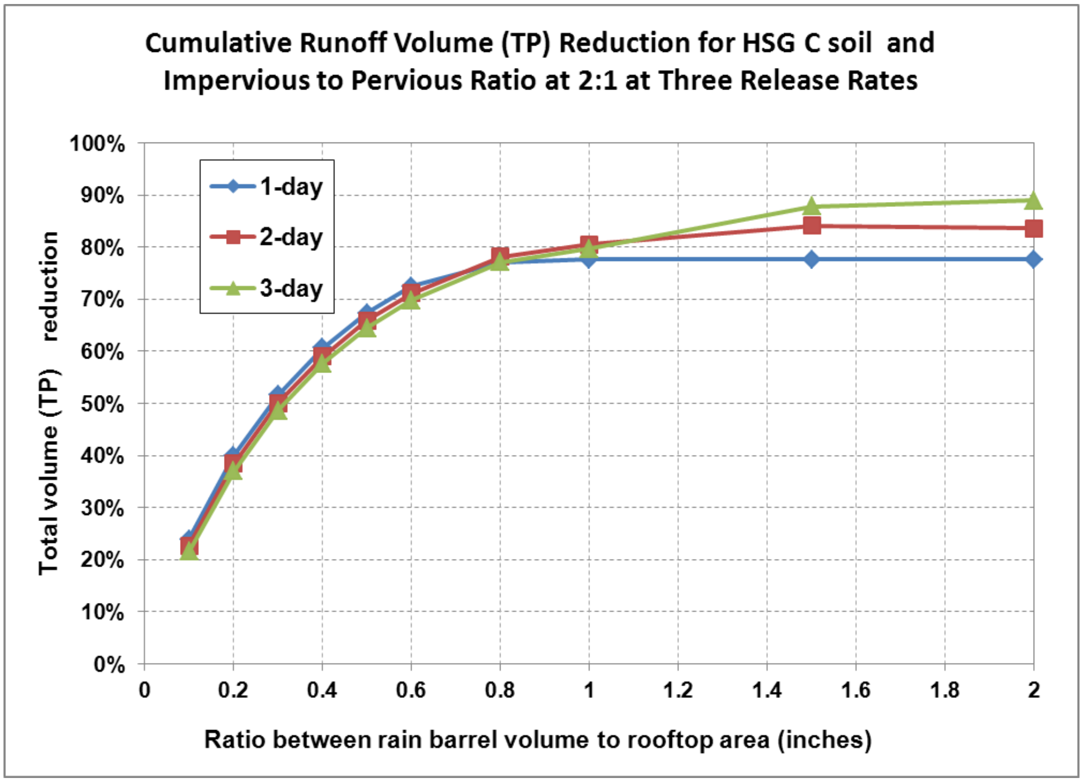



**Figure 3- 36: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG D Soils**

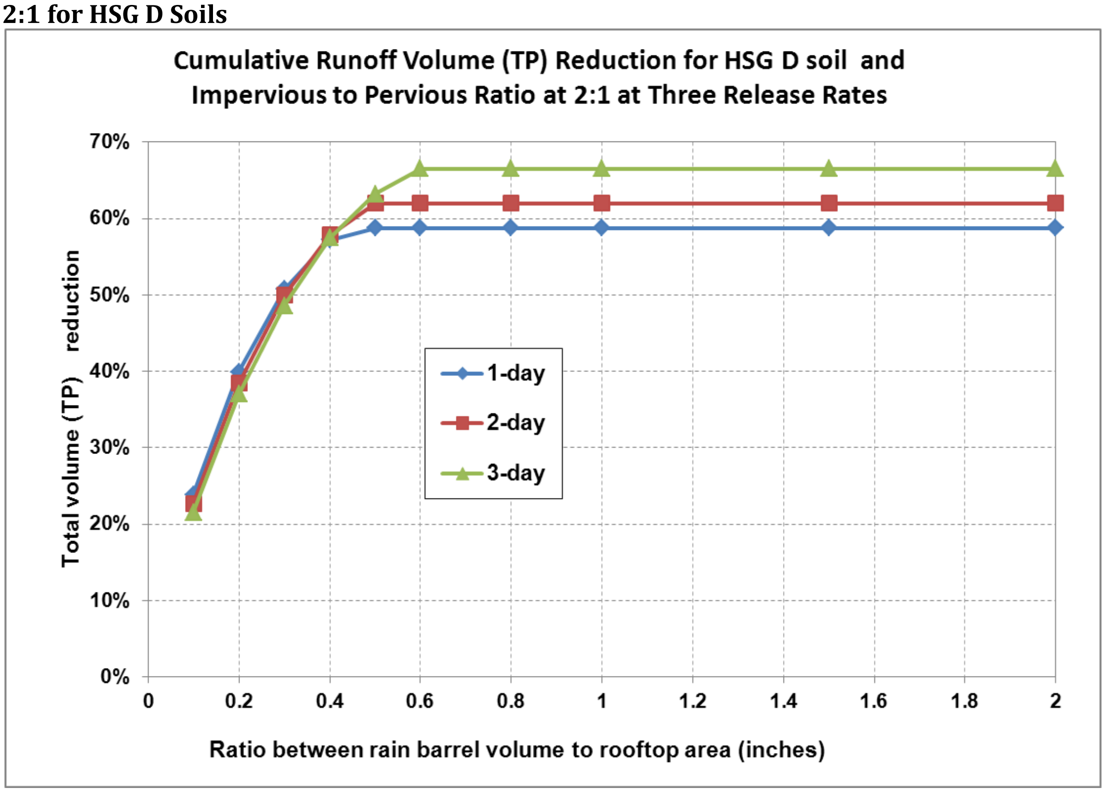


**Table 3- 30: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1**

| Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storage volume to impervious area ratio | Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages | | | | | | | | | | | |
| | HSG A | | | HSG B | | | HSG C | | | HSG D | | |
| | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day | 1-day | 2-day | 3-day |
| 0.1 in | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% | 24% | 23% | 22% |
| 0.2 in | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% | 40% | 38% | 37% |
| 0.3 in | 52% | 50% | 49% | 52% | 50% | 49% | 52% | 50% | 49% | 52% | 50% | 49% |
| 0.4 in | 61% | 59% | 58% | 61% | 59% | 58% | 61% | 59% | 58% | 61% | 59% | 58% |
| 0.5 in | 67% | 66% | 64% | 67% | 66% | 64% | 67% | 66% | 64% | 67% | 66% | 64% |
| 0.6 in | 73% | 71% | 70% | 73% | 71% | 70% | 73% | 71% | 70% | 72% | 71% | 70% |
| 0.8 in | 79% | 78% | 77% | 79% | 78% | 77% | 79% | 78% | 77% | 78% | 78% | 77% |
| 1.0 in | 82% | 81% | 80% | 82% | 81% | 80% | 82% | 81% | 80% | 79% | 80% | 80% |
| 1.5 in | 89% | 89% | 88% | 89% | 89% | 88% | 89% | 89% | 88% | 80% | 82% | 86% |
| 2.0 in | 92% | 92% | 91% | 92% | 92% | 91% | 91% | 92% | 91% | 80% | 82% | 86% |

**Figure 3- 37: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG A Soils**

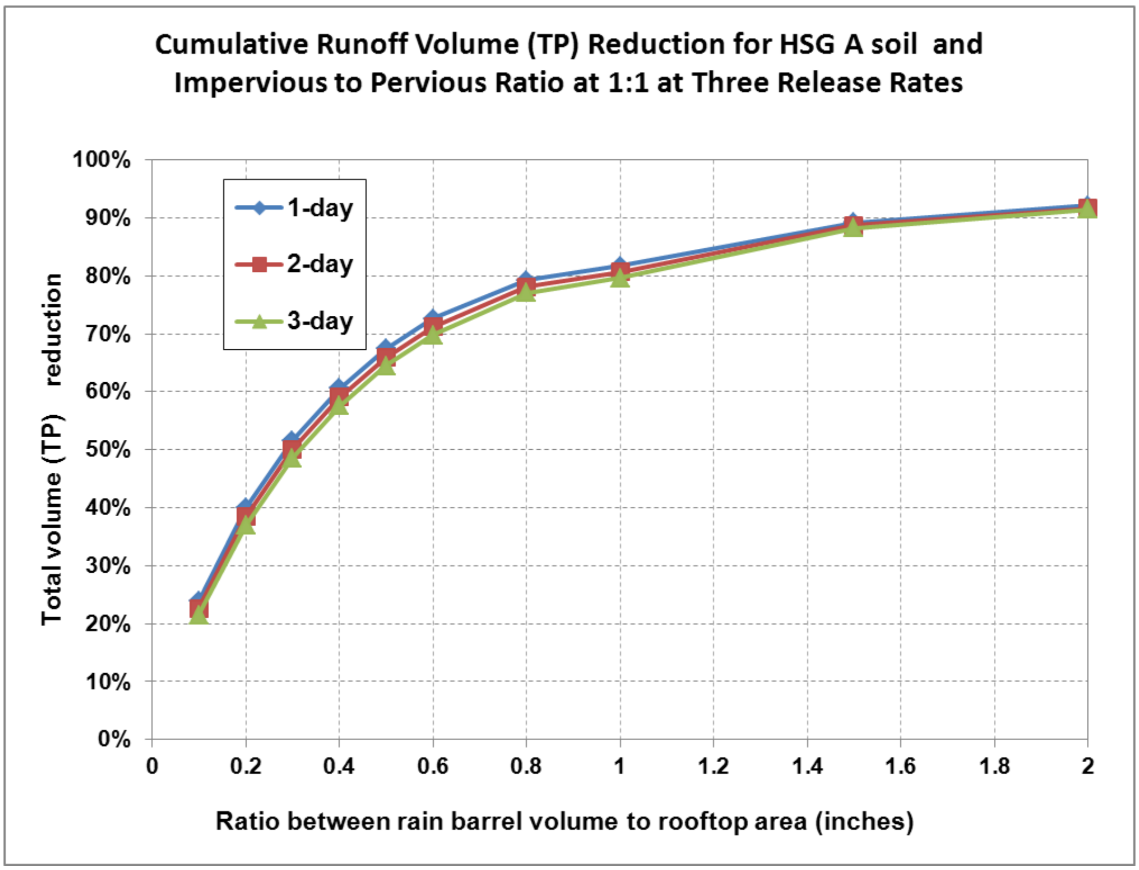


**Figure 3- 38: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG B Soils**

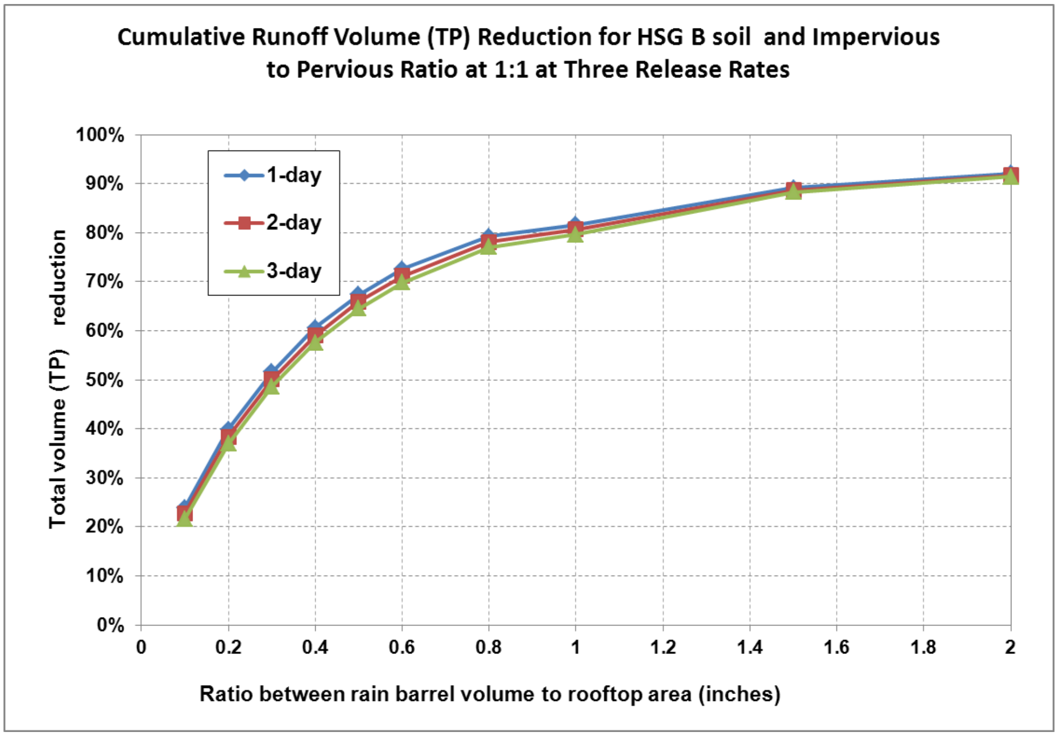



**Figure 3- 39: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG C Soils**

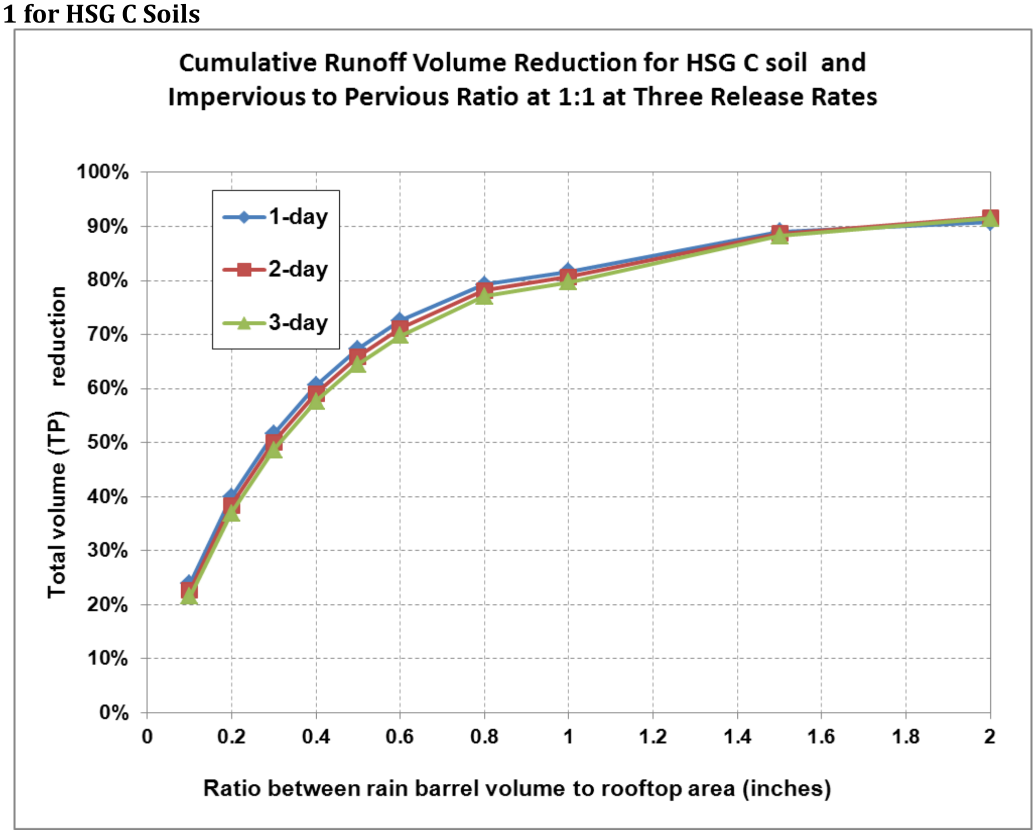


**Figure 3- 40: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG D Soils**

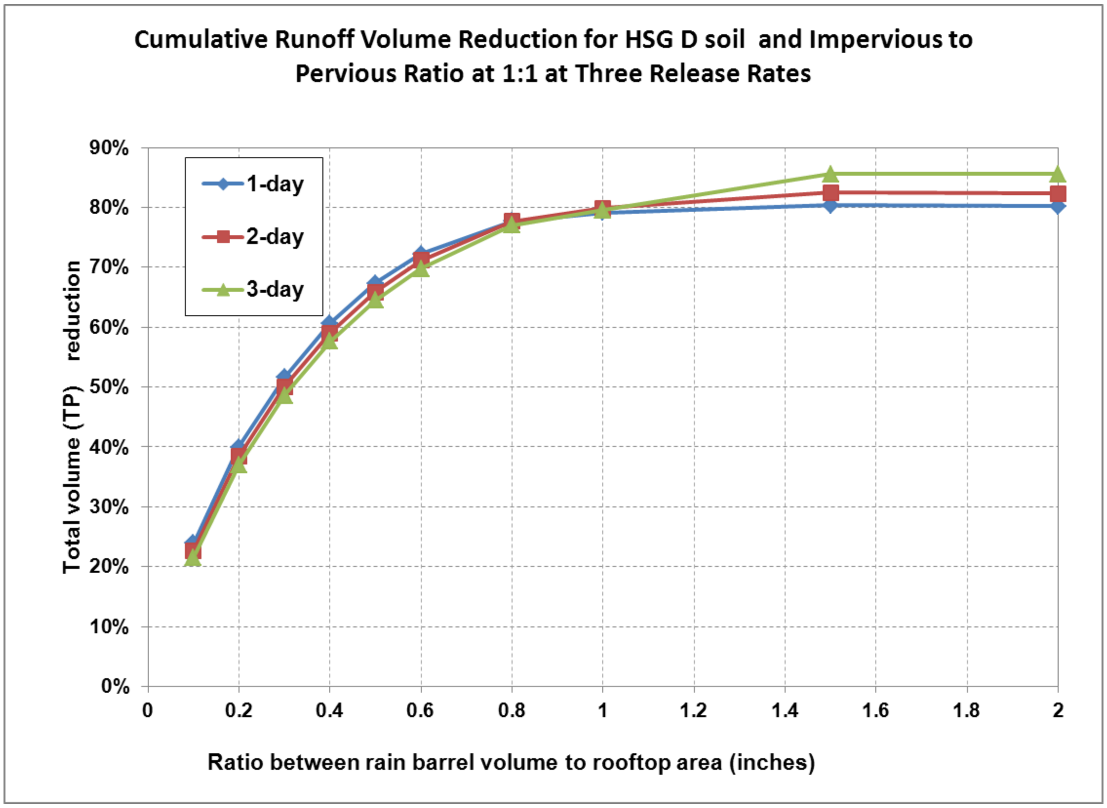



**Table 3- 31: Impervious Area Disconnection Performance Table**

| Impervious area to pervious area ratio | Soil type of Receiving Pervious Area | | | |
|---|---|---|---|---|
| | HSG A | HSG B | HSG C | HSG D |
| 8:1 | 30% | 14% | 7% | 3% |
| 6:1 | 37% | 18% | 11% | 5% |
| 4:1 | 48% | 27% | 17% | 9% |
| 2:1 | 64% | 45% | 33% | 21% |
| 1:1 | 74% | 59% | 49% | 36% |
| 1:2 | 82% | 67% | 60% | 49% |
| 1:4 | 85% | 72% | 67% | 57% |

**Figure 3- 41: Impervious Area Disconnection Performance Curves**

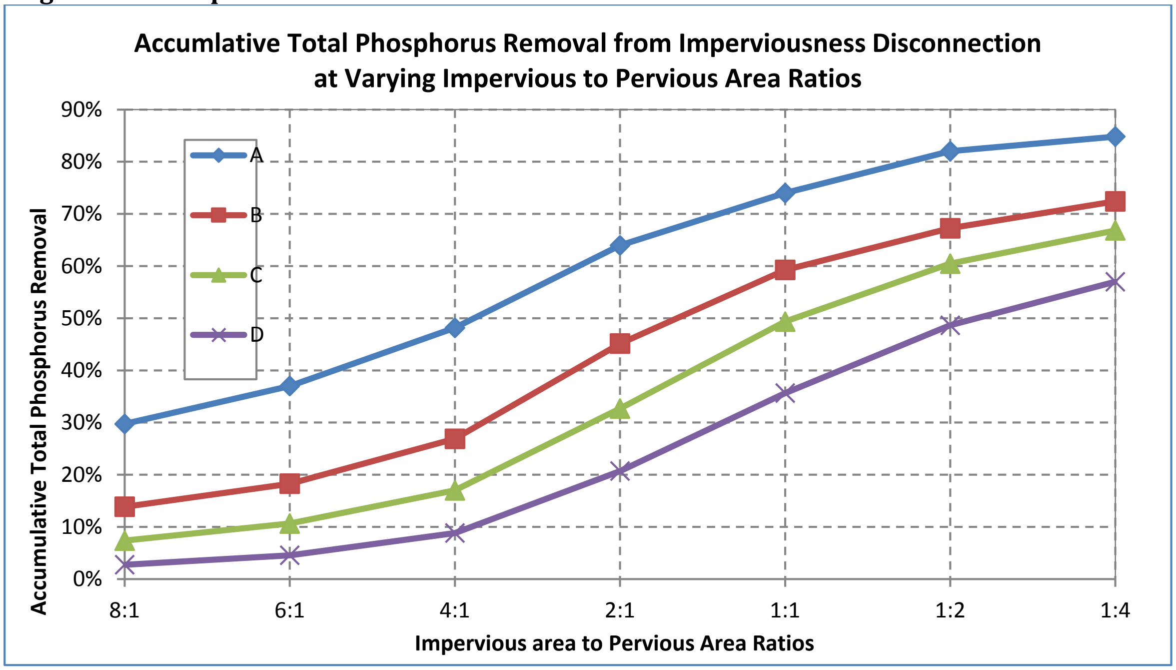



**Table 3- 32: Performance Table for Conversion of Impervious Areas to Pervious Area based on Hydrological Soil Groups**

| Land-Use Group | Cumulative Reduction in Annual Stormwater Phosphorus Load | | | | |
|---|---|---|---|---|---|
| | Conversion of impervious area to pervious area-HSG A | Conversion of impervious area to pervious area-HSG B | Conversion of impervious area to pervious area-HSG C | Conversion of impervious area to pervious area-HSG C/D | Conversion of impervious area to pervious area-HSG D |
| Commercial (Com) and Industrial (Ind) | 98.5% | 93.5% | 88.0% | 83.5% | 79.5% |
| Multi-Family (MFR) and High-Density Residential (HDR) | 98.8% | 95.0% | 90.8% | 87.3% | 84.2% |
| Medium -Density Residential (MDR) | 98.6% | 94.1% | 89.1% | 85.0% | 81.4% |
| Low Density Residential (LDR) - "Rural" | 98.2% | 92.4% | 85.9% | 80.6% | 75.9% |
| Highway (HWY) | 98.0% | 91.3% | 84.0% | 78.0% | 72.7% |
| Forest (For) | 98.2% | 92.4% | 85.9% | 80.6% | 75.9% |
| Open Land (Open) | 98.2% | 92.4% | 85.9% | 80.6% | 75.9% |
| Agriculture (Ag) | 70.6% | 70.6% | 70.6% | 70.6% | 70.6% |

**Table 3- 33: Performance Table for Conversion of Low Permeable Pervious Area to High Permeable Pervious Area based on Hydrological Soil Group**

| Land Cover | Cumulative Reduction in Annual SW Phosphorus Load from Pervious Area | | | | |
|---|---|---|---|---|---|
| | Conversion of pervious area HSG D to pervious area-HSG A | Conversion of pervious area HSG D to pervious area-HSG B | Conversion of pervious area HSG D to pervious area-HSG C | Conversion of pervious area HSG C to pervious area-HSG A | Conversion of pervious area HSG C to pervious area-HSG B |
| Developed Pervious Land | 92.7% | 68.3% | 41.5% | 83.5% | 79.5% |