LIMITING IMPERVIOUS SURFACE COVER AND PROTECTING WATER RESOURCES THROUGH BETTER SITE DESIGN AND PLANNING

A Final Report to

The New Hampshire Estuaries Project

Submitted by

Rockingham Planning Commission
156 Water Street
Exeter, NH 03833

January 7, 2005

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Limiting Impervious Surface Cover and Protecting Water Resources through Better Site Design

Final Report
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Executive Summary

The Rockingham Planning Commission (RPC) provided two forms of technical assistance to coastal communities to raise awareness and understanding of how to limit impervious surface cover, mitigate impacts of development, and protect water resources.

The first phase of this project involved the organization of a workshop entitled “Improving Site Planning and Site Design for Sustainable Development”, held October 4, 2004 in Durham, New Hampshire. The workshop was offered to local decision makers and municipal employees in the forty two coastal communities and featured speakers from state agencies, local government, and the private sector.

For the second phase of this project, the RPC worked with Planning Boards in three coastal communities in New Hampshire - North Hampton, Greenland, and East Kingston, to review existing land use regulations and development review procedures. RPC staff used information from the Center for Watershed Protection to complete these reviews. Reports were prepared for the three communities which include recommendations for changes to local land use regulations to limit impervious surface and protect water resources.

Introduction

With funding from the New Hampshire Estuaries Project, the Rockingham Planning Commission (RPC) implemented a two part project designed to increase awareness and understanding among local decision makers on how to limit impervious surface cover, mitigate impacts of development, and protect water resources. The first part of the project involved a workshop for local decision makers in all of the 42 coastal watershed communities, and the second part of the project involved specific technical assistance for three of these communities.

Project Objectives

The objectives of this project were to:

- increase the understanding of the relationship between impervious surface and water quality among Planning Boards and other local decision makers;
- review municipal land use regulations and policies that impact water quality in selected communities;
- recommend changes to local land use regulations based on the principles of Better Site Design created by the Center for Watershed Protection.

Project Activities

The first part of the project involved organizing and implementing a workshop entitled "Improving Site Planning and Site Design for Sustainable Development", which was held October 4, 2004 in Durham, New Hampshire. The RPC worked with the Strafford Regional Planning Commission to send workshop notices to members of Planning Boards, Conservation Commissions, and Zoning Boards of Adjustment in the 42 coastal watershed communities, as well as Road Agents, Town Planners, Town Engineers, Building Inspectors, Code Enforcement Officers, watershed and river organizations, and land developers. Fifty five people attended the workshop which featured presentations by UNH Complex Systems Research Center on forty years of land use change in the region, a discussion on the values and benefits of conservation subdivisions by a land developer, and a review of regulatory and site design techniques by staff from the NH Department of Environmental Services and the Great Bay National Estuarine Research Reserve. At the end of the workshop, the NH Estuaries Project (NHEP) distributed comprehensive impervious surface reports to Planning Boards and Conservation Commissions in attendance.

In addition to materials distributed by NHEP and workshop speakers, the RPC provided participants with model land use regulations for establishing a conservation zone, a village plan alternative subdivision, creating a mixed use zone, and enabling infill development.

The second part of the project involved providing technical assistance to the Planning Boards in the communities of East Kingston, Greenland, and North Hampton to increase their understanding of how impervious surface impacts water resources and how local land use regulations can mitigate this impact. RPC staff reviewed existing land use regulations and development review procedures in these communities and prepared reports recommending changes which should be made to land use regulations to reduce the impacts of impervious surface on water resources.

Project Results
Results from the first part of the project, the workshop offered to all the coastal communities, were very good, with several towns in the RPC region contacting the RPC after the workshop to request information on how they can use the information in the NHEP Impervious Surface Reports to educate residents and developers. Towns also requested more information on storm water management regulations.

Results from the second part of the project were very good as well, with Planning Boards expressing interest in implementing recommendations made as a result of the review of local land use regulations.

Conclusions
Despite the persistent rate of land development in New Hampshire's coastal watershed, the term impervious surface is new to many local decision makers. Understanding the relationship between impervious surface and water quality and water quantity, and the role local planners play in this relationship, will take time and on-going out reach and education. This project was an important early step towards incorporating the concepts of Better Site Design into local land use decisions in the New Hampshire's coastal watershed.

Recommendations
To further the success of this project, the RPC recommends the following:

- the development of a workshop for Town Planners, Planning Boards, Conservation Commissions, Zoning Boards of Adjustment, and Building Inspectors/Code Enforcement Officers on the subject of how to adopt and enforce local stormwater management regulations. Speakers for the workshop should include engineers familiar with the local land use development process. Stormwater management needs to be addressed in local zoning ordinances, subdivision regulations, and site plan regulations, and may require an expertise not commonly held by many members of local land use boards and commissions;
- provide community specific technical assistance to Planning Boards and Conservation Commissions to increase the effectiveness of local land use regulations to protect water resources.

Appendix A

Handouts from the October 4, 2004 Workshop
"Improving Site Planning and Site Design for Sustainable Development"

* This electronic version of the report does not include all materials in the original report. Contact Rockingham Planning Commission or the NHEP for a complete report.

Improving Site Planning and Site Design for Sustainable Development

A Workshop for Local Decision Makers in New Hampshire's Coastal Watershed

MONDAY, OCTOBER 4, 2004
7PM – 9:30 PM
ALUMNI CENTER – 1925 ROOM
UNIVERSITY OF NEW HAMPSHIRE
9 EDGEWOOD ROAD
DURHAM, NH
(map on reverse side)

I. *Welcome* – Gerry Mylroie, AICP, Senior Land Use Planner, Strafford Regional Planning Commission

II. *Introduction* - Jennifer Hunter, Director, New Hampshire Estuaries Project

III. *Forty Years of Land Use Change in Rockingham and Strafford Counties* – Fay Rubin, GIS Manager, UNH Complex Systems Research Center and Bill Salas, President, Applied GeoSolutions

IV. *Dover's Success with Cluster Development* – Ron Cole, Chair, Dover Planning Board

V. *The Value and Benefits of Conservation Subdivisions* – Eric Chinburg, President, Chinburg Builders

VI. *Review of Regulatory and Site Design Techniques to Reduce Impervious Surface* – Carolyn Russell, Watershed Management Bureau, NHDES; Steve Miller, CTP Coordinator, Great Bay National Estuarine Research Reserve

VII. *Explanation and Distribution of Impervious Surface Reports for Coastal Watershed Communities* - Phil Trowbridge, Coastal Scientist, NHEP

VIII. *Closing Remarks* – Cliff Sinnott, Executive Director, Rockingham Planning Commission

PLEASE RSVP to the Rockingham Planning Commission
603-778-0885
email@rpc-nh.org

Hosted by the Strafford Regional Planning Commission and Rockingham Planning Commission with funding provided by the NH Estuaries Project

Appendix B:

* This electronic version of the report does not include all materials in the original report. Contact Rockingham Planning Commission or the NHEP for a complete report.

LIMITING IMPERVIOUS SURFACE COVER AND PROTECTING WATER RESOURCES THROUGH BETTER SITE DESIGN & PLANNING

A COMMUNITY REPORT FOR THE TOWN OF GREENLAND

DECEMBER 2004

Prepared by the
Rockingham Planning Commission
156 Water St.
Exeter, NH 03833

This report was prepared with funding from the New Hampshire Estuaries Program

understanding of how to limit impervious surface cover, mitigate impacts of development, and protect water resources.

The project was funded by a grant from The New Hampshire Estuaries Project (NHEP), a program involving federal, state, and local government, non-governmental organizations, businesses, university researchers and the public to protect, enhance, and monitor the environmental quality of the State's estuaries.

The RPC's Impervious Surface project involved three tasks:

- Task 1: Technical assistance to three communities in the coastal watershed with regard to limiting impervious surface cover, mitigating impacts of development and protecting water resources. This task included an assessment of existing land use regulations and development review procedures; identification of options for improvement / areas of focus for the community to consider, and; recommendations and/or suggested language to revise existing regulations. The towns of East Kingston, Greenland and North Hampton for selected for technical assistance.

- Task 2: Coordination with the Strafford RPC, NHEP, NH DES and other agencies to develop and conduct a workshop entitled "Limiting Impervious Surface in Your Community" (held October, 2004)

- Task 3: Development of a Final Project Report with specific recommendations for communities to improve regulations to protect water quality and water resources.

This report was developed under Task 1 above, and details the results of the code and ordinance review for the Town of Greenland.

TECHNICAL ASSISTANCE TO THE TOWN OF GREENLAND

I. Land Use Regulation Review: Methodology

RPC staff reviewed Greenland's existing land use regulations (Zoning Ordinance, Subdivision Regulations and Site Plan Review Regulations) using the code and ordinance review process developed by The Center for Watershed Protection in its publication entitled *Better Site Design: A Handbook for Changing Development Rules in Your Community* (August 1998).[3]

The *Handbook* recommends that a community begin an assessment by reviewing its own development rules and comparing them to the Center's 22 "model development principles." These principles are classified into three broad categories:

- Residential streets & parking lots
- Lot development
- Conservation of natural areas

[3] The Center is a non-profit organization based in Ellicott City, Maryland and provides technical guidance to communities concerned with protection of water resources from pollutants.

BACKGROUND

I. Impervious surface cover and its effects

Impervious surfaces are areas covered by any of a variety of materials or surfaces that impedes the infiltration of water into the soil. Examples include buildings, pavement, concrete, and severely compacted soils.

The increase of impervious surfaces caused by development affects water resources in several ways. First, impervious surfaces combined with drainage systems such as curbs, gutters and storm drain pipes alter the natural hydrology in a watershed by increasing the volume of stormwater runoff being discharged from the site, as well as by reducing the amount of groundwater that's being recharge on the site. Impervious surfaces can also result in loss of aquatic habitat, loss of biological diversity, and an overall decrease in water quality due to the accelerated discharge of pollutants into rivers, lakes, and estuaries.

Recently scientists have reported that levels of impervious surface in excess of ten percent in a watershed can affect water quality. "When the percentage of impermeable surfaces in a watershed is ten percent or less, streams typically retain good water quality and stable channels. When the proportion is ten to twenty-five percent, storm-fed flows cause noticeable erosion[1]". More than twenty-five percent impermeable surface can lead to severe physical and ecological damage to streams in a watershed[1]

Pollutants in runoff include suspected carcinogens known as polycyclic aromatic hydrocarbons, which can leach from asphalt-based and coal tar-based sealants used on paved lots. Other pollutants often found in runoff include pesticides, nitrates, phosphates, and salt for de-icing roads[1].

II. Benefits of reducing impervious surface

Reducing impervious surface helps not only to improve water quality; it may also result in lower municipal costs for road maintenance and clearing and lower development costs. A 100-foot reduction in road length will result in a savings of about $15,000. This figure includes savings from reduced pavement, curb and gutter, and stormwater management structures[2]. Well-planned street layouts will also help to alleviate traffic congestion, protect conservation areas, and create a town street system that optimizes the ability of town fire and rescue officials to respond to emergencies in a timely and efficient fashion.

III. Summary of the "Impervious Surface" project

In 2004 the Rockingham Planning Commission (RPC) completed a technical assistance project called "Limiting Impervious Surface Cover and Protecting Water Resources through Better Site Design and Planning." The purpose of this project was to work with coastal communities to raise awareness and

[1] Science News, 2004
[2] Better Site Design, 1998

Taken together, the 22 principles endeavor to reduce impervious cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintain the quality of life within a community. These 22 principles are addressed individually in Table 1 of this document. This Table address the model principles and their environmental benefits, how the Town of Greenland's regulations compare to the model principles, and suggested changes to Greenland Regulations to bring them more in line with the model principles.

II. Findings

Based on this project's review of Greenland's Zoning Ordinance, Subdivision Regulations and Site Plan Regulations; it is clear that these regulations do provide some protection to water resources and place limits on impervious surface. The Planning Board may wish to consider the recommendations for amendments given in the following table to strengthen these existing protections.

We recommend that the Planning Board discuss amendments with a focus on the following three areas: stream buffers regulations (Shoreland Protection District), wetland buffers, and conservation or open-space subdivision districts. We understand that the Greenland Conservation Commission has approached the Planning Board with model regulations for both wetland protection buffers and open-space subdivisions. We recommend that the Planning Board consider amending the existing ordinance and regulations based on the suggestions in this report and the model ordinance presented by the Conservation Committee. The Rockingham Planning Commission and the Town's engineering consultant can provide guidance and support as well as technical manuals and regulatory language to help the Town of Greenland limit impervious surface and protect its water supply.

Appendices to this report include the following:

1. A model Shoreland Protection District Ordinance

2. A model Open Space Preservation Subdivision Ordinance

3. An information packet from the Center for Stormwater Technology Evaluation & Verification (CSTEV), at the University of New Hampshire. These fact sheets detail some of the standard stormwater management technologies that are used throughout New England. CSTEV is testing these designs to provide information on how well they perform in New Hampshire's cold climate. Additional information and training workshops will be available from CSTEV, see their website for more information: http://www.unh.edu/erg/cstev .

4. "Managing Stormwater as a Valuable Resource: A message for New Hampshire municipalities and water suppliers" NH DEP, 2001

TABLE 1
COMPARISON BETWEEN LOCAL REQUIREMENTS AND 22 MODEL DEVELOPMENT PRINCIPLES

Model Development Principle	Recommended practice	Environmental benefit	Greenland's requirement	Consider Ordinance / Regulation amendment
1. Street pavement width	Reduce to 22' or less, based on traffic volumes	Reduces the largest single component of impervious surface in a subdivision	24' pavement width	Consider reducing street pavement width to 22 feet or less
2. Street length	Minimize length (no recommended minimum)	Same as above	1,000' max on dead-ended streets	No change needed
3. Right-of-way width	<50', base on what's needed to accommodate pavement width, utilities, drainage features	Reduces the need for clearing, makes land available for housing	50', entirely cleared	Subd. Reg. 4.2.2.2, Reduce ROW based on use of road
4. Cul-de-sacs	Minimize radius as possible, provide pervious island	Reduces pavement; can be used to store & treat stormwater	60' to the edge of the curbing, 73' to the edge of the ROW, Paved center of "bubble" turnarounds.	Subd. Reg. 4.4.2 and 4.4.2.1, Allow smaller radii and pervious islands
5. Vegetated open channels	Encourage open channels rather than curb & gutter	Remove pollutants from stormwater, allow infiltration	Allowed (curbs & gutters are not required), design criteria for swales exists	No change needed
6. Parking ratios	Evaluate to ensure ratios are in line with regional averages and local experience	Reduces impervious surface	Office: 3 spaces/ 1000ft^2 Shopping Center: 5 spaces/ 1000ft^2	Zoning Article V, decrease parking requirements to under 3 spaces and under 4.5 spaces respectively.
7. Parking codes	Allow shared parking	Reduces impervious surface	Few set requirements for commercial/industrial allows for flexibility	Zoning Article V, include a model shared parking agreement
8. Parking lot size/design	Minimize stall sizes, allow pervious surfaces where appropriate	Reduces impervious surface	Parking spaces are to be 10' wide and 200 ft^2 (20' deep)	Zoning Article V 5.3.1, allow smaller parking (e.g. 9' x 18')
9. Structured parking	Allow where appropriate	Reduces impervious surface	Not specifically addressed	No change needed
10. Parking lot runoff	Reduce impervious surface,	Reduces impervious	10% of parking required	No change needed

Model Development Principle	Recommended practice	Environmental benefit	Greenland's requirement	Consider Ordinance / Regulation amendment
	integrate stormwater mgmt designs into landscaped islands	surface	to be landscaped	
11. Open space design	Allow open space designs by right; ensure ordinances meet impervious surface reduction and land conservation goals	Reduces impervious surface	Elderly Cluster housing is allowed on parcels that are 15 acres	Allow open-space subdivision for any age and on any size parcel
12. Setbacks and frontages	Relax frontage and side setbacks (assumes lots <2 acres)	Reduces total road length and impervious surface	200' frontage 30' front setback 20' side / rear	Allow Smaller setbacks in open-space subdivisions
13. Sidewalks	Reduce width and provide on 1 side of street only when appropriate	Reduces impervious surface	Sidewalk width is 5' Only required on one side of the street in industrial zoned areas.	Reduce required width to 4' or below
14. Driveways	Allow alternative paving surfaces in all development; encourage the use of shared driveways	Reduces impervious surface	Shared drives allowed, and drives do not need to be paved	No changes needed
15. Open space management	Specify allowed uses; ensure maintenance in natural condition; specify options for long-term maintenance and monitoring of open space	Maintain open space in natural condition; ensure adequate financial resources for long-term maintenance of open space	Open space requirements in all zoning districts	No changes needed
16. Rooftop runoff	Divert runoff to on-site pervious surfaces (i.e. swales, bioretention facilities	Increase on-site water infiltration and recharge	Not specifically addressed	Consider amending Building Code to specify / require rooftop runoff be diverted to on-site pervious surfaces
17. Stream buffer systems	Establish riparian buffers with specified width, targeted vegetation and allowed uses	Protect water quality and habitat; regulate the type and location of development along shores	No local shoreland regulations. Streams are often protected under wetland Ordinance due to wetland plant species	Consider developing a local shoreland protection zoning ordinance to officially protect stream buffers
18. Buffer management	Local riparian buffer ordinance which outlines	Effective preservation and mgmt of a local	Same as above	Same as above

Model Development Principle	Recommended practice	Environmental benefit	Greenland's requirement	Consider Ordinance / Regulation amendment
	legal rights and responsibilities of local govt and landowner re: long-term mgmt	buffer program		
19. Clearing and grading	Regulate erosion & sediment control; adopt tree protection ordinance	Reduce stormwater flows and erosion, encourage infiltration	Require erosion and sediment control plan. Trees over 6" required to be survey located on site plans	Subdivision and Site Plan Review Regs. - Consider developing regulations to require the maintenance of natural vegetation in open space and wetland buffers. Also require survey location of sub'd trees.
20. Tree conservation	Establish regs which promote preservation of trees and native vegetation	Reduce stormwater flows and erosion, encourage infiltration	25% of site plans required as greenspace.	Same as above
21. Conservation incentives	By-right open space develop., density incentive, stormwater credit, buffer averaging, property tax relief, transferable development rights, off-site wetland mitigation	Increase the attractiveness of conserving natural areas by offering flexibility in regulations and incentives	Current use tax incentive and wetland mitigation per State rules	Consider open-space subdivisions.
22. Stormwater outfalls	Stormwater mgmt requirements to control quantity and quality of runoff; stormwater best mgmt practices; floodplain development regulations	Protect the quality of wetlands, surface water and groundwater	Floodplain Development Ord., Erosion & Sedimentation Plan requirements	Subdivision and Site Plan Review Regs. - Adopt detailed drainage and stormwater mgmt regulations, which specify best mgmt practices to address the quality and quantity of runoff

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Many pages of the original report were copied from the
Center for Stormwater Technology Evaluation and Verification at
http://www.unh.edu/erg/cstev/

Contact Rockingham Planning Commission or the NHEP for a complete report.

NHDES-R-WD-01-13

Managing Stormwater as a Valuable Resource

A message for New Hampshire municipalities and water suppliers

September 2001

New Hampshire Department of Environmental Services
G. Dana Bisbee, Assistant Commissioner

Harry T. Stewart, P.E., Director
Water Division

Acknowledgements

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Executive Summary

Groundwater is a critical resource in New Hampshire. Not only do 60% of New Hampshire residents depend on groundwater for their drinking water, but the health of many aquatic systems is dependent on the steady discharge of groundwater. The replenishment, or recharge, of groundwater depends on the infiltration of precipitation and snowmelt into the ground. However, each year more and more of the state is paved, built upon, or otherwise altered in ways that prevent or reduce this natural infiltration. This change in the landscape eventually leads to changes in groundwater and stream systems, with potentially costly implications for water users and aquatic ecosystems. There is already evidence that these impacts are affecting some New Hampshire water sources. New Hampshire can no longer take inexpensive, plentiful water supplies for granted.

Early stormwater management systems were designed to quickly convey stormwater from developed areas to streams. After it became clear that the curb-and-gutter approach resulted in more frequent and more severe downstream flooding in urbanized watersheds, stormwater detention structures were built to slow the release of runoff from large developed sites, utilizing best management practices (BMPs) such as detention ponds.

Planners, engineers, and water quality managers have long recognized that such conventional stormwater BMPs do not address all of the important hydrologic impacts of urbanization, particularly the loss of groundwater recharge. However, these impacts have only recently become a concern in historically water-rich New Hampshire, as increasing water use has collided with sprawling impervious areas. As the state's population increases by 15,000 per year amid an annual loss of 20,000 acres of open space, there is an increasing need to manage stormwater in ways that preserve groundwater recharge, most importantly in heavily impacted areas.

The best ways to preserve groundwater recharge in developing areas are to minimize the amount of impervious area and to maximize the opportunities for naturally treated stormwater to infiltrate into the ground. If large impervious areas are going to be created or expanded, steps must be taken to ensure that stormwater is properly treated and infiltrated. Artificial BMPs such as infiltration ponds and infiltration trenches represent a viable approach *where they are properly sited, designed, constructed, and maintained*.

Until recently, DES discouraged the use of artificial infiltration BMPs, in part because the early generation of such BMPs performed poorly due to improper or inadequate siting, design, construction, and maintenance. Now that these factors are better understood and the need to preserve groundwater recharge is clear, DES's policy is to encourage the use of natural infiltration BMPs and to permit the use of artificial infiltration BMPs *where local programs can ensure that those BMPs will continue to function as intended*.

In addition to outlining the background for this policy, this document discusses the importance of local programs to ensure the ongoing inspection and maintenance of infiltration BMPs permitted by DES and the proper siting, design, and construction of BMPs that do not fall under DES's review. The purposes of this document are to alert towns and water suppliers to the need to manage stormwater as a resource, to encourage the appropriate use of best management practices that infiltrate stormwater into the ground, and to solicit comments and suggestions regarding the need for further guidance from DES. Please contact DES's Drinking Water Source Protection Program at 271-7061 with your comments and suggestions.

I. Introduction

Growth means change for many New Hampshire cities and towns. One of the more troublesome changes that accompany increased development is a reduction in available water resources, even as the demand for those resources increases. This document focuses on ways to better manage stormwater (surface runoff of precipitation) to protect important water supply resources. While not a complete guide to stormwater management, this document can be used in conjunction with the existing guidance used by DES and others (see NHDES 1996 and Rockingham 1992, described in Appendix A).

New Hampshire is the fastest-growing state in the Northeast, having added 316,000 people from 1980 to 2000, and expecting to add another 299,000 by 2020. While the state's population grew 34% during the last 20 years, the number of housing units grew a whopping 57%. These statistics begin to hint at the sprawling nature of growth in New Hampshire. Bigger homes, fewer occupants per home, and second and third homes are aspects of this phenomenon. Spreading new development across the landscape means more land clearing, more land consumed per person, more paving, and increased per capita consumption of resources such as building materials, energy, and water. In ten case-study towns examined by NH Office of State Planning's report, *Managing Growth in NH: Changes and Challenges*, population grew by 71% from 1974 to 1992 while the amount of developed land increased 137%. As a result of rapid and sprawling growth, New Hampshire is losing 20,000 acres per year of forest, farmland, and open space. Much of it is being paved, built upon, or otherwise altered in ways that prevent or reduce the natural infiltration of precipitation and snowmelt, leading to important changes in groundwater and stream systems. These changes have potentially costly implications for water users as well as aquatic ecosystems.

Groundwater levels dropping, in-stream flows increasingly variable

Normally, in undeveloped areas of New Hampshire with sandy soils, as much as 50% of rainfall infiltrates into the ground. The actual number varies from one area to another due to vegetative cover, soil type, and slope, but the infiltration component is important everywhere, since it recharges groundwater. Groundwater is a critical water resource across the state. Not only do 60% of New Hampshire residents depend on groundwater for their drinking water, but the health of many aquatic systems is also dependent on its steady discharge. For example, during periods of dry weather, groundwater sustains base flows in streams and helps to maintain fresh-water wetlands. Development creates impervious surfaces (paved, built, or otherwise altered areas where water can not infiltrate) that prevent natural recharge and reduce groundwater recharge rates. Increasing impervious area (see Figure 1) leads to the following changes in water flow and pollution:

- Increased frequency and magnitude of downstream flooding (see Figure 2) due to rapid runoff of stormwater;
- Enlarged stream channels, increased channel scouring and stream bank slumping, and resulting increased sediment loads due to increased frequency and magnitude of high flows;
- Reduced base flow in streams between rainy periods due to less recharge of groundwater, which normally feeds streams. This can reduce the waste assimilation capacity of rivers, increasing municipal wastewater treatment costs;
- Declining water quality due to wash off of pollutants deposited on roads, parking lots, etc.;
- Reduction in natural treatment by vegetation and soils as a result of the removal of natural vegetation and the creation of impervious surfaces;
- Increased water temperature due to loss of vegetative cover, heat buildup on artificial surfaces, and an increased component of surface runoff compared to groundwater flowing to surface water;
- Reduction in the quality of aquatic habitat due to pollutant and heat loading, reduced base flows, enlarged channels, and smothering with sediment.

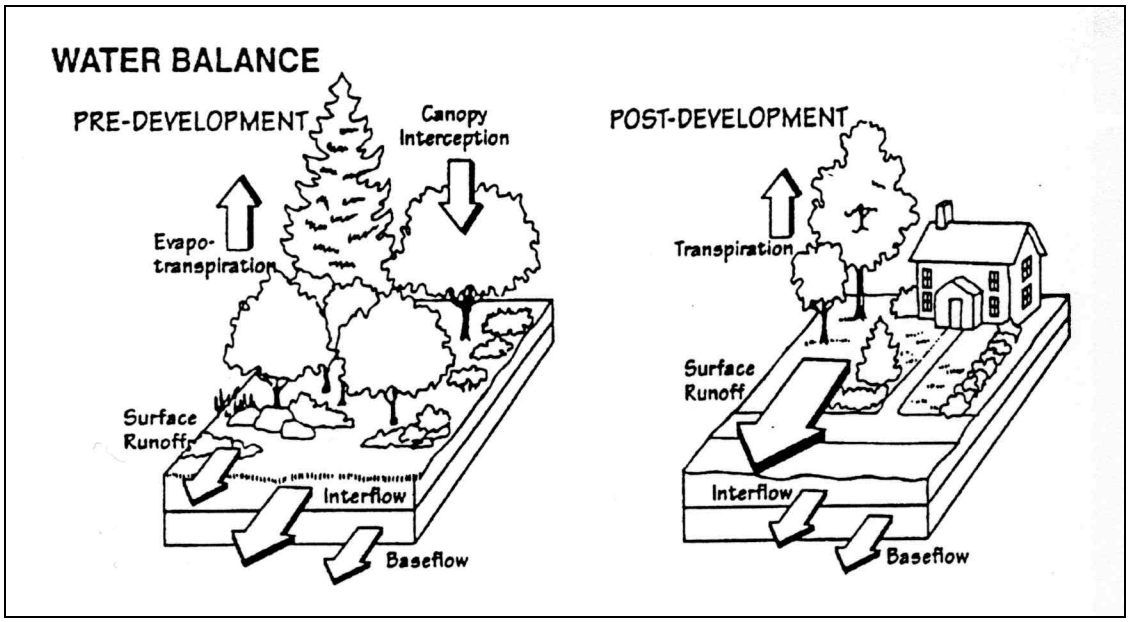

Figure 1: Typical Pre- and Post-Development Water Balance Source: Maryland Department of the Environment Stormwater Manual

These impacts have been well documented in heavily developed areas in other parts of the country, and there is anecdotal evidence that some parts of New Hampshire are already experiencing the same phenomenon. For example, in the Pennichuck Brook

watershed, which supplies water to Nashua and some surrounding areas, summertime flows are noticeably lower or absent in small headwaters streams in developed watersheds. In Merrimack's Naticook Brook aquifer, withdrawals outpace recharge more and more frequently. In the Concord Heights aquifer, groundwater levels have fallen over the years as development has increased.

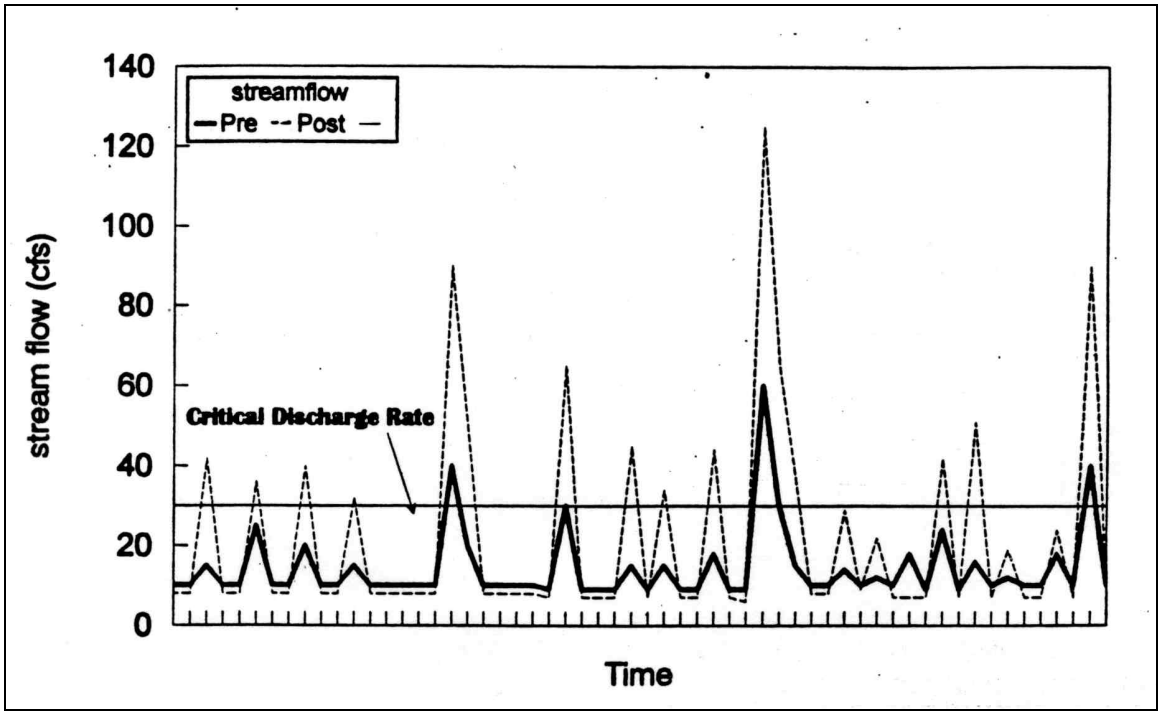

Figure 2. Typical Pre- and Post-Development Streamflow, showing reduced baseflow and increased frequency and magnitude of peak flow (floods).
Source: Maryland Department of the Environment Stormwater Manual

New Hampshire can no longer take inexpensive, plentiful water supplies for granted.

According to RSA 481:1, "The general court declares and determines that the water of New Hampshire whether located above or below ground constitutes a limited and, therefore, precious and invaluable public resource which should be protected, conserved and managed in the interest of present and future generations." More frequent and more severe low flows in water supply rivers such as the Lamprey underscore the need to protect in-stream uses (such as recreation and aquatic life), while providing for water supply and other withdrawals. When the siting of a new municipal well in the seacoast area a few years ago led to local concerns about the withdrawal's impact on streams and wetlands, the Legislature took notice and formally recognized "that groundwater constitutes an integral part of the hydrologic cycle" (RSA 485-C:1). Although these

signs do not indicate that New Hampshire faces a water supply shortage, they do argue strongly for improved stewardship of our water resources.

A Call to Action

The purposes of this document are to alert towns and water suppliers to the need to manage stormwater as a resource, to encourage the appropriate use of best management practices that infiltrate stormwater into the ground, and to solicit comments and suggestions regarding the need for further guidance from DES. Please contact DES's Drinking Water Source Protection Program at 271-7061 with your comments and suggestions.

The best ways to preserve groundwater recharge in developing areas are to minimize the amount of impervious area and to maximize the opportunities for naturally treated stormwater to infiltrate into the ground. If large impervious areas are going to be created or expanded, a number of considerations come into play to ensure that stormwater is properly treated and infiltrated in the right place. The overall goal should be to minimize the impact on existing hydrology and water quality.

II. An Updated Approach to Stormwater Management

The ways in which stormwater is viewed and managed have changed over the years, and continue to change. At first, stormwater was viewed as a nuisance—something to be drained away as quickly as possible in order to prevent on-site flooding. This view led to the curb-and-gutter approach to stormwater management, involving concrete swales, ever-larger culverts, and the replacement of river channels with more concrete. Better understanding of the hydrologic impacts of urbanization prompted a fresh look at this approach.

Flood control: dampen runoff peak.

After it became clear that the curb-and-gutter approach resulted in more frequent and more severe downstream flooding in urbanized watersheds, stormwater detention structures were built to slow the release of runoff from large developed sites. Although the total volume of runoff from a developed site was still greater than the pre-development runoff volume, detention ponds at least reduced the peak discharge rate, which helped avoid the worst of the downstream flooding impacts. With the recognition of nonpoint source pollution as a major cause of water quality impairments, stormwater management structures have taken on the job of stormwater treatment, and are a component of what is collectively called "best management practices" (BMPs). This dual role of stormwater BMPs led to the recognition of a wide variety of structural approaches to stormwater management, from vegetated swales and constructed wetlands to infiltration ponds and trenches.

Infiltration: conserve stormwater as a water resource

Planners, engineers, and water quality managers have long recognized that conventional stormwater BMPs do not address all of the important hydrologic impacts of urbanization, particularly the loss of groundwater recharge and consequent reductions in aquifer yield and base stream flow. However, these impacts have only recently become a concern in historically water-rich New Hampshire, as increasing water use has collided with sprawling impervious areas. As the state's population increases by 15,000 per year amid an annual loss of 20,000 acres of open space, there is an increasing need to manage stormwater in ways that preserve groundwater infiltration, most importantly in heavily impacted areas.

The most common types of BMPs used in New Hampshire include grassed swales, vegetated filter strips, and detention ponds. These BMPs generally allow some infiltration to take place, but they are not designed to retain and infiltrate runoff; they are designed to detain, treat, and release it to surface waters. DES encourages the use of natural infiltration BMPs (grassed swales and vegetated filter strips) where there is enough room to accommodate vegetated areas large enough to provide proper treatment. However, where infiltration is a major design goal, grassed swales and vegetated filter strips are generally not capable of meeting this goal.

In contrast, so-called artificial infiltration BMPs are designed to retain and treat stormwater and allow it to infiltrate into the ground. The most common types of artificial infiltration BMPs used in New Hampshire are infiltration basins (or ponds) and infiltration trenches. Schematics of both types of device are shown in Figures 3 and 4. Infiltration basins are grassed, flat-bottomed basins preceded by sediment forebays or riprap aprons to slow the flow of water and to trap sediment. Infiltration trenches are generally 2 to 10 feet in depth, backfilled with coarse stone. The trench may be covered with grating, stone, gabion, sand, or turf.

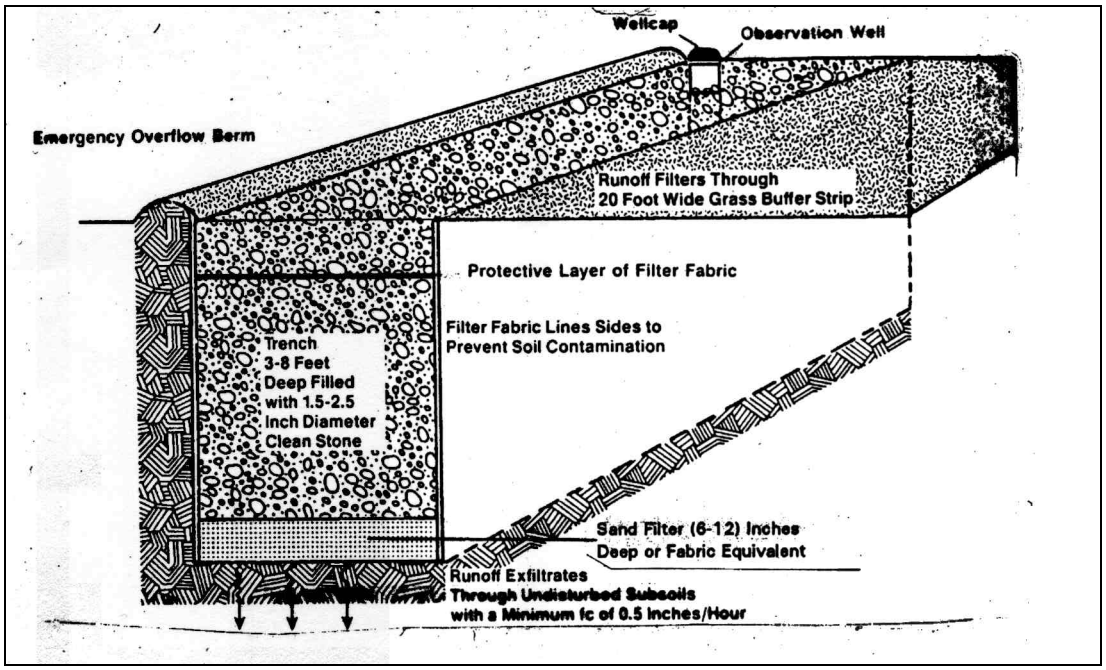

Figure 3. Typical Infiltration Trench
Source: Washington State Department of Ecology (2000)

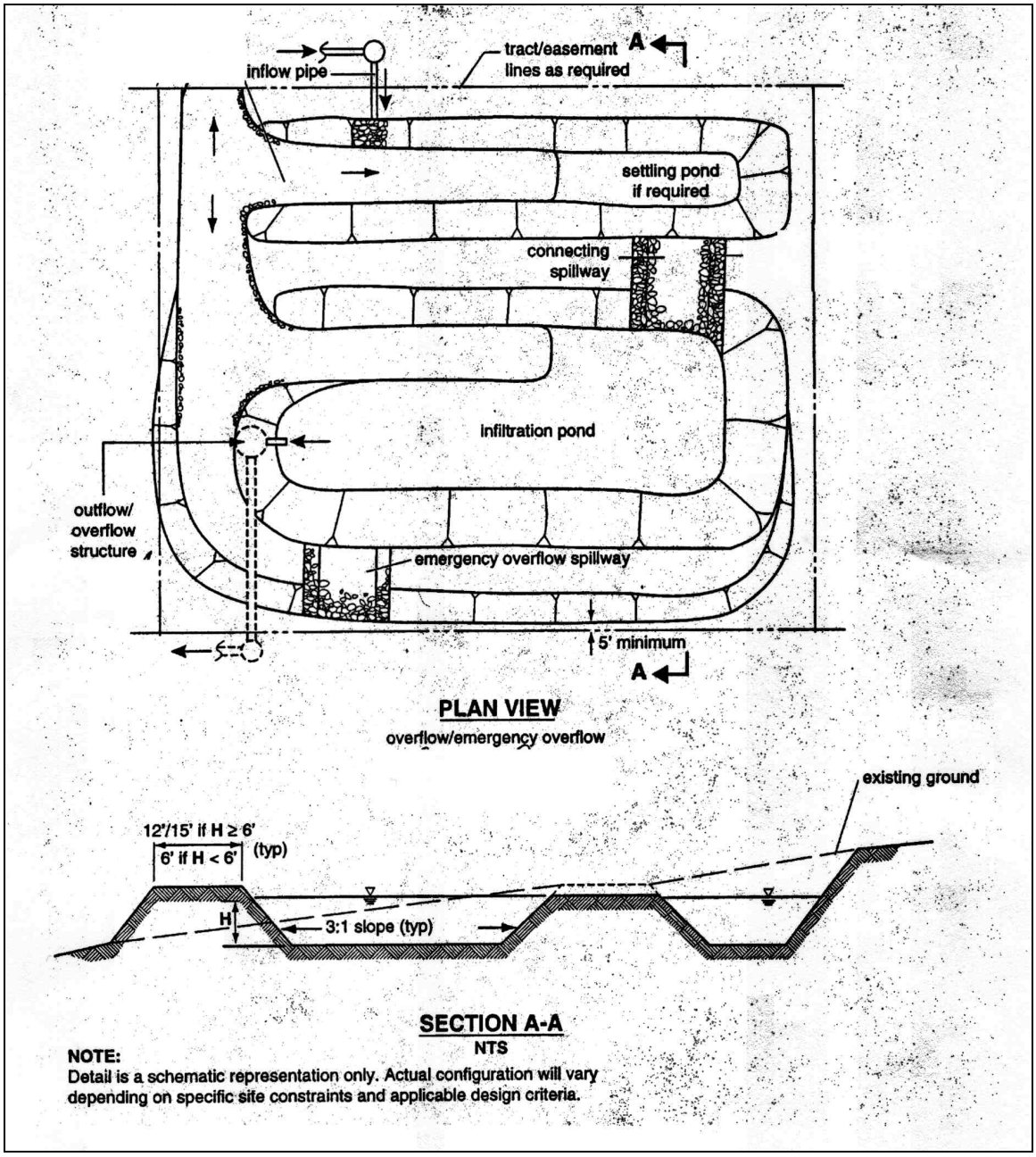

Figure 4. Typical Infiltration Pond
Source: Washington State Department of Ecology (2000)

III. The Need for Local Programs

Until recently, DES has discouraged the use of certain stormwater infiltration BMPs. While DES has encouraged the use of *natural* infiltration, such as in vegetated swales and buffer strips, DES's Site Specific rules, Env-Ws 415.11 (i), state that *artificial* infiltration BMPs (infiltration basins and trenches) may only be used where other methods are not feasible; other specific restrictions are discussed in Section IV of this document. Artificial infiltration was discouraged for two reasons. First, the need to preserve groundwater recharge was not as pressing as it is now. Second, the early generation of artificial infiltration BMPs—retention ponds, infiltration trenches and galleries—tended to clog with silt, largely because they were not properly sited, designed, installed, or maintained. A clogged infiltration structure does not work, and may even worsen surface water quality by allowing re-suspended sediments to be carried into receiving waters.

DES encourages infiltration BMPs where local oversight will ensure maintenance

Today, the state of the art has advanced to the point where proper site selection, design, and installation of infiltration BMPs can be ensured if the right expertise is brought to bear. However, ongoing maintenance is still an issue. Although DES does oversee the design and installation of BMPs permitted under its Site Specific Program, DES does not have the resources to indefinitely ensure maintenance of the large number of BMPs it permits each year. Therefore, **DES's policy is to encourage the use of natural infiltration BMPs and to permit the use of artificial BMPs only where local programs can ensure that those BMPs will continue to function as intended.** What this entails is discussed in Section IV. As a practical matter, a local program also needs to ensure the proper siting, design, and installation of BMPs that do not fall under the Site Specific Program but may be required by local site plan and subdivision approvals.

DES will provide guidance and technical assistance

DES recognizes that municipalities and village districts need guidance designing and establishing programs to manage artificial infiltration BMPs within their boundaries. To help meet that need, DES is providing this guidance and is committed to providing the technical assistance needed to make local programs successful. DES also welcomes comments regarding any additional guidance or technical assistance that may be required.

IV. Elements of a local program

In order for DES's Site Specific Program to permit artificial infiltration BMPs in projects that fall under its review, the municipality in which the facility is located must provide a written description of its stormwater program. Such a description may consist of a letter and/or a copy of relevant zoning, site plan review, and/or stormwater ordinances and regulations. The following discussion is provided as a menu of elements that will help ensure an effective program. DES will *not* require that all six elements be included in every local program. Rather, the most important criterion for acceptance of a local program is that DES will be reasonably assured that infiltration BMPs will be appropriately sited and that they will continue to function as intended.

Site analysis

The first aim of site analysis is to minimize or prevent stormwater runoff and the need for stormwater BMP structures. Since site analysis is usually driven by what local land use regulations allow (as well as the developer's understanding of what the market demands), local ordinances and regulations can play a key role in encouraging better site design. The Low Impact Development (LID) concept, which attempts to replicate the pre-development hydrologic regime by conserving natural features, minimizing impervious surfaces, disconnecting one impervious surface from the next, dispersing runoff, and treating runoff with vegetation, has a great deal to offer. For more information on this approach, please see the summary of LID principles in Appendix B.

Infiltration not suitable for some land uses

A program designed to protect groundwater must recognize that the runoff from some land uses is potentially too contaminated to be infiltrated, even after treatment. There are two types of facilities in particular – industrial facilities and petroleum storage or dispensing sites – where the use of infiltration BMPs is currently subject to special restrictions in DES's Site Specific rules. The restrictions are:

- Infiltration BMPs for industrial facilities and petroleum storage or dispensing sites are prohibited near community or non-transient, non-community public wells. (This applies within 500 feet of a well producing <40 gallons per minute and within 1,000 feet of a well producing 40 gpm or more.) (Env-Ws 415.11 (k)); and

- Where infiltration BMPs are not prohibited, a source control program must be developed and implemented (415.11 (f) (6) and (g) (6)).

Local regulators may also wish to establish siting restrictions – for projects of all sizes – to protect water resources of local importance, such as public water supply wells, sand and gravel aquifers, and sensitive surface waters. An example of these restrictions is provided in Appendix C.

Soils and hydrology

Soil percolation rates and depth to the water table are two more key factors that limit the siting of infiltration BMPs. The DES BMP manual (see excerpt in Appendix D) states that soils should have a percolation rate of at least 0.5 inch/hour and that the depth to the seasonal high water table and bedrock should be at least 4 feet from the bottom of the device. The State of Washington (see item 11 in Appendix A) requires at least one test pit or hole per 5,000 ft^2 of basin infiltrating surface or per 50 feet of trench, but no less than two per device.

Design standards

1. Pretreatment

To prevent clogging of infiltration BMPs, the DES BMP manual states that infiltration devices should be preceded by a pretreatment device such as a vegetated filter strip, treatment swale, or water quality inlet. The DES BMP manual spells out design criteria for each of these pretreatment BMPs.

2. Appropriateness for cold climates

Many of the published design criteria for infiltration BMPs were written for states with climates that are not as cold as New Hampshire's. To address the challenges involved in using stormwater BMPs in cold climates, including northern New England, the Center for Watershed Protection (CWP) conducted a study for US EPA (see #1 in Appendix A). This 1997 study identified design modifications to make infiltration structures and other stormwater BMPs more effective in colder climates. The following modifications (taken from the CWP report with further clarification by DES) are recommended for infiltration BMPs:

- Avoid directing snowmelt runoff from sand- or salt-treated roads or parking lots to artificial infiltration BMPs.
    - Locate snow storage areas and snow dumps so that runoff is directed to other BMPs such as vegetated swales or filter strips.
    - A movable diversion structure (such as a gate) can be used to direct snowmelt runoff around the infiltration BMP. However, care has to be taken to move the diversion structure at the beginning and end of the snowmelt season.
    - If snowmelt runoff from treated areas must be directed to artificial BMPs, recognize that more frequent maintenance may be needed due to heavy sediment loads. However, snowmelt runoff from snow dumps or large snow storage areas should not be directed to artificial infiltration BMPs under any circumstances.

- Increase percolation requirements to 1 inch/hour for trenches and 3 inches/hour for basins, to account for the clogging potential of sand and the reduced infiltration during frozen ground conditions.

- Set artificial infiltration BMPs back at least 20 feet from road subgrades.

- If necessary, upper portions of the soil can be enhanced or replaced with sand to increase permeability.

- Increase the design capacity (perhaps by a factor of 2), or size a downstream BMP to accept some of the treatment volume.

- Incorporate mulch into vegetated treatment areas to maintain soil fertility and compensate for the effects of road salt in runoff.

3. Access for inspection and maintenance

Studies of the high failure rates of the early generation of infiltration BMPs found that there had been a complete lack of proper maintenance. The importance of maintenance of infiltration BMPs cannot be overstated. To ensure that maintenance is done on a timely basis, BMPs need to be inspected. To this end, the DES BMP manual states that an observation well should be installed in every infiltration trench. Adequate access (12 feet wide, able to withstand light equipment) should also be provided to the floor of an infiltration basin to allow for maintenance.

Underground infiltration galleries (especially those located under parking lots), represent a special class of infiltration BMPs. While such underground galleries are an effective way to maximize use of a site and they can be built with access for inspection, reconstruction can be prohibitively expensive since it may involve tearing up and rebuilding the parking lot. In order to avoid failure of infiltration galleries, ensuring the maintenance of pretreatment BMPs becomes even more critical.

4. Capacity

The DES BMP manual states that infiltration devices should be used on smaller watershed areas (up to 25 acres) and that they should be capable of infiltrating runoff from the design storm within 72 hours. Where there is some doubt as to whether infiltration devices will be maintained according to schedule, they should be over-designed to lessen the likelihood of failure. In the interest of preserving pre-development hydrology, multiple small infiltration devices, located up-gradient in the watershed, are far better than a single large device located at the lower end of the watershed area. Additional capacity requirements are included in Appendix D.

Monitoring to ensure performance and maintenance

Monitoring of BMPs should begin during construction, to ensure that the stormwater system is being constructed according to the approved design and that infiltration BMPs are being protected from sediment loads. A final construction inspection should also be conducted before the construction bond is released (see page 13) to ensure that the BMP is free of sediment and able to function as intended.

For infiltration basins and trenches, the DES BMP manual states that the change in the depth of standing water above the basin floor or trench bottom should be checked after each major storm in the first few months after construction to monitor infiltration rates. DES recommends that similar tests be conducted annually to help in scheduling maintenance. Annual inspections should include removal of accumulated sediments, inspection and maintenance of pretreatment devices, maintenance of the grass buffer strip for surface trenches, and a partial or total reconstruction in the event of clogging.

Ideally, annual inspections should be performed during or following wet weather and be done with as-built plans in hand. If infiltration performance deteriorates to unacceptable levels, the sediments should be removed, and any of the drainage layer removed should be replaced.

A legally enforceable and binding maintenance agreement should be included in the site plan and/or property deed, clearly spelling out maintenance tasks and schedules. These should include annual maintenance inspections, maintaining a dense grass buffer strip for surface trenches, removing accumulated sediments in pre-treatment devices, and remedying any clogging.

Massachusetts' *Stormwater Policy Handbook* (see item 5 in Appendix A) offers a useful outline of what an operation and maintenance plan should contain:

- The stormwater management system(s) owner(s);
- The party or parties responsible for operation and maintenance;
- A schedule for inspection and maintenance; and
- The routine and non-routine maintenance tasks to be undertaken.

The owner of the BMP is generally considered to be the landowner of the property on which the BMP is located, unless other legally binding agreements are established with another entity.

Oversight, maintenance, and financial aspects

Overseeing the construction, monitoring, and maintenance of BMPs costs money, but there are several options available for municipalities to meet these costs. Following is a

brief discussion of these options. DES does not require a municipality to implement any of these options; rather, they are presented here for information purposes. At a minimum, the municipality should conduct spot checks to monitor BMP owners' records regarding scheduled inspections and maintenance and to inspect the BMPs themselves.

Site plan review and inspection costs

Few municipal planning boards or departments can expect to have the expertise to evaluate the adequacy of stormwater management designs, or to perform inspections to ensure that facilities are built and maintained properly. To cover the cost of municipal staff or contractors to review plans, monitor construction, and ensure that stormwater BMPs and other structures are built according to plan, local planning boards may adopt regulations to require applicants to pay the cost of such services (RSA 674:44, V) when required for site plan review. Planning boards should make a standard practice of hiring consulting engineers (at the applicant's expense) to evaluate plans for compliance with all provisions of the applicable ordinances and regulations.

Construction bond

Local planning boards may also require "a performance bond, irrevocable letter of credit, or other type or types of security" to ensure that the municipality has the money to complete the construction of streets and utilities (RSA 674:36, III and 674:44, III). The security is typically released when an inspection determines that roads, stormwater systems, and/or other improvements have been constructed according to plan.

Enforcement

Land use ordinances and regulations, including site plan review, subdivision review, and stormwater regulations, are enforceable by municipalities under RSA 676:17 through RSA 676:17-b. These statutes provide for cease and desist orders, citations (similar to traffic tickets), injunctive relief, civil fines of up to $275 per day, and the recovery of legal fees. Under RSA 676:17-a, VIII, the municipality may take corrective action, such as maintenance or repair of a stormwater structure, if the owner fails to do so when ordered, and the municipality's costs will constitute a lien against the property. Such corrective action expenses can ultimately be turned over to the tax collector, in which case they can be recovered in the same way as overdue taxes, including placing a lien against and selling the property. Note that the statutes spell out the necessary procedures to follow before any of these actions can be taken. For more information on enforcement of local ordinances and regulations, please see the NH Bar Association publication listed in Appendix A (item 6).

Fees for ongoing inspection and enforcement costs

Under RSA 41:9-a, boards of selectmen may also establish permit fees to cover certain costs, when so empowered by town meeting. A municipality might require facility owners to obtain a periodic permit (e.g., renewable every five years) to operate a stormwater management facility, and charge a permit fee to pay for the municipality's

inspection and enforcement program. Note that such fees must be "reasonably calculated to cover the town's regulatory, administrative and enforcement costs." (RSA 41:9-a, III.) This approach assumes the owner of a developed site will continue to own and operate, and be responsible for maintenance of, the stormwater facility.

Municipal ownership

An alternative to private ownership with public oversight is for the municipality to take on ownership and maintenance responsibility for all stormwater BMPs, assessing an annual fee to pay for all costs – maintenance, repair, etc. An increasing number of communities across the country have formed "stormwater utilities" to provide a wide range of services—BMP ownership, inspection, maintenance, street-sweeping, and public education. The utility charges a fee, usually based on the impervious area of a site. In some cases, credits or waivers are granted for privately operated BMPs. The number of stormwater utilities is expected to grow from 400 today to as many as 2,500 within ten years, mainly as a result of the federal stormwater Phase II requirements discussed in Section V.

The enabling legislation for village districts (RSA 52:1) allows the formation of districts for the purposes of water supply (including the protection of water supply sources) and the construction and maintenance of drains or common sewers. Such districts have the ability to raise money by taxation and other means and to establish capital and non-capital reserve funds.

V. Other program aspects

Consistency among master plan and land use regulations

Land use ordinances and regulations should be in harmony with one another and with the municipality's master plan. One way to ensure this with respect to stormwater management would be to adopt a stormwater management ordinance, which is then referenced in the municipality's site plan review and subdivision regulations. To support a stormwater management ordinance or regulation, particularly an innovative one that emphasizes the protection of groundwater recharge, the master plan should be revised to address stormwater both in terms of infrastructure needs and water resources protection.

EPA Stormwater Phase II requirements

Owners of municipal separate storm sewer systems in "urbanized areas" in 26 New Hampshire municipalities must apply to US EPA for Phase II stormwater permits by March 2003 (see Appendix E). The owners of these systems may be municipal, county, state, or federal agencies. Operators of these storm sewer systems will be required to develop stormwater management programs that control pollutants from all of the system's discharge points to the maximum extent practicable. Following the guidelines in this document to minimize stormwater runoff and infiltrate it (rather than discharging it to surface water) and to ensure maintenance of *all* stormwater BMPs, will help regulated municipalities meet the new federal requirements. Municipalities on the list of 26 should begin now (if they have not already) to review existing stormwater management programs and make appropriate revisions. Municipalities that are *not* on the list should be aware that the list is likely to expand when the EPA acts on the results of the 2000 Census. Also, EPA may bring six to twelve additional municipalities into the Phase II stormwater program if EPA determines that their stormwater discharges are causing or contributing to water quality standard violations or if they are a "significant source of pollutants to waters of the U.S." Thus, the requirement to come into compliance with federal standards makes a local review of stormwater regulations all the more urgent.

VI. New Hampshire Examples

Nashua

Pennichuck Water Works, which serves Nashua and a number of surrounding communities, relies largely on a chain of ponds whose watershed lies partly in Nashua. Recognizing the role that urbanization plays in reducing the watershed's yield over time, the City of Nashua established an ordinance that requires infiltration of stormwater at most sites in the watershed. Pennichuck Water Works provides the expertise to review BMP designs as well as operation and maintenance plans. The City has since broadened the applicability of the ordinance to the entire city. A copy of the ordinance, which specifies the volume of runoff to be treated, the volume to be infiltrated, the standard for pollutant removal, a list of acceptable BMPs and their design removal rates for pollutants, restrictions on the use of infiltration for certain land uses, requirements for operation and maintenance plans, and enforcement provisions, can be found in Appendix F.

Sunapee

Sunapee was faced with a large-scale condominium/elderly housing development with a high percentage of impervious lot coverage located directly on the shores of Lake Sunapee. The Sunapee Planning Board worked with the developer's engineers and attorneys to establish an enforceable, long-term agreement providing for the operation, maintenance and monitoring of state-of-the-art stormwater BMPs. A copy of the agreement is included in Appendix G.

Dover

Concerned about expanding commercial development within the protection area for its Smith and Cummings wells, the City of Dover (with funding assistance from DES) hired a consultant in 1998 to develop standards for protecting groundwater quality and yield. Following the report's recommendations, the City now requires applicants to show that post-development infiltration volumes will equal pre-development volumes and to design a treatment system for 80 percent removal of total suspended solids before stormwater reaches the infiltration system. However, to allow time for die-off of viruses, Dover prohibits stormwater discharges to groundwater within a 200-day travel distance (1,117 foot radius) of municipal wells.

In one recent project, where DES's policy discouraging infiltration conflicted with the City's pro-infiltration policy, the solution involved a stormwater detention pond followed by an infiltration gallery. The system is designed so that if the infiltration gallery fails (which has not yet happened), the treated water from the pond will overflow to a surface discharge. The infiltration gallery, located under a parking lot, was built with an access that allows light machinery such as a Bobcat to drive in for maintenance.

To address Phase II stormwater requirements, Dover developed a stormwater management plan in 1999. The plan calls for a maintenance program, but has not yet

been implemented in an ordinance. The City's Environmental Projects Manager has expressed interest in developing a stormwater utility to address maintenance.

Appendices

A. Annotated Bibliography of Guidance Manuals

B. Low Impact Development Basics

C. Land Uses Which May Not Use Artificial Infiltration When Located in Critical Areas

D. Excerpt from NH DES Urban BMP Manual

E. Federal Stormwater Phase II Permits – Fact Sheets

F. Nashua Stormwater Ordinance

G. Sunapee BMP O&M Agreement

H. Sample Ordinance and BMP Maintenance Agreements

1. Stormwater Management and Right-of-Way Agreement, Montgomery County, Maryland
2. Stormwater and Sediment and Erosion Control Ordinance: Operation and Maintenance, Grand Traverse County, Michigan
3. Stormwater Management/BMP Facilities Agreement, Albemarle County, Virginia

Appendix A: Annotated Bibliography of Guidance Manuals

1. Center for Watershed Protection, *Stormwater BMP Design Supplement for Cold Climates* (December 1997)

Based on surveys of stormwater management experts in cold climates, and prepared for US EPA by a leading organization in the watershed management and stormwater management field. Defines what is meant by cold climate and why this presents challenges for BMP design. Includes recommended modifications for infiltration and other stormwater BMPs in cold climates. Can be ordered from http://www.cwp.org/.

2. Center for Urban Policy and the Environment, Indiana University-Purdue University Indianapolis, An Internet Guide to Financing Stormwater Management (2001) http://stormwaterfinance.urbancenter.iupui.edu/

This Web site is designed to help communities find ways to pay for stormwater management projects. The site includes:

- an annotated bibliography of existing stormwater finance materials
- an archive that contains selected previously published materials concerning stormwater finance
- a manual that discusses the financing options available to communities for stormwater management programs
- a set of case studies that describe successful finance mechanisms that have been used in seven communities around the country
- a group of links to other useful web sites about stormwater management

3. Center for Watershed Protection. The Stormwater Manager's Resource Center (2001) http://www.stormwatercenter.net.

This Web site is designed to provide technical information to stormwater professionals and communities searching for information about stormwater management. The site includes a library of over 600 references and several slide shows that explain stormwater management issues. One page helps communities design their own stormwater manuals. The site also includes examples of local ordinances, simple ways to assess a community's stormwater needs, pollution prevention and resource protection techniques.

4. Center for Watershed Protection, Environmental Quality Resources, and Loiederman Associates, *Maryland Stormwater Design Manual*, 2 volumes (December 1997)

Discusses the impacts of stormwater runoff on watersheds; includes extensive design criteria for the full range of stormwater BMPs.

5. Massachusetts Department of Environmental Protection and Massachusetts Office of Coastal Zone Management, *Stormwater Management, Volume One: Stormwater Policy Handbook* and *Volume Two: Stormwater Technical Handbook* (March 1997)

Volume One is a guide for local conservation commissions regarding applying the state's 9-point stormwater management policy. The policy includes standards for groundwater recharge, pollutant removal, land uses with high potential pollutant loads, and operation and maintenance plans. Volume Two deals with selection and design of BMPs. Both volumes can be downloaded from www.state.ma.us/dep/brp/ww/wwpubs.htm#storm.

6. New Hampshire Bar Association, *Guide to District Court Enforcement of Local Ordinances and Codes* (Prepared in 1995, Updated March 2001)

Provides guidance regarding the enforcement of zoning and building codes, health officer regulations, housing standards, and the like, in District Court. 44 pages, including forms for Cease and Desist Orders and Land Use Citations. Can be downloaded from the "Publications" area on www.nhbar.org.

7. New Hampshire Department of Environmental Services, *Best Management Practices for Urban Stormwater Runoff* (1996).

Discusses the impacts of urban runoff; covers effectiveness, siting considerations, and DES's design criteria for seven BMP types, including infiltration practices. This guide complements Rockingham 1992. Available from the DES Public Information Center at 271-2975.

8. Ocean County (NJ) Planning and Engineering Departments, *Ocean County Demonstration Study, Stormwater Facilities Maintenance Manual* (NJ Department of Environmental Protection, June 1989)

Discusses who is responsible for maintenance and who will be responsible if maintenance is neglected. Contains *design and planning* guidelines regarding bottoms, dams and slopes, inlets, outlets, vegetative cover, access, and perimeters to ensure practicality of maintenance. Has *construction inspection* guidelines, such as what to be concerned about before, during, and after construction. Discusses *maintenance equipment and procedures* such as maintaining grass and other vegetation, removing sediment, and it has forms and checklists for inspections, and maintenance and repair work. It raises a number of issues related to the *town assuming responsibility for maintenance* – issues that need to be addressed by the town counsel: liability, ownership, insurance. Contains a sample language dealing with maintenance provisions in an ordinance. Emphasizes that a stable funding source is needed for maintenance.

9. Pioneer Valley Planning Commission, How to Create a Stormwater Utility (2000)

This packet includes briefing papers on key aspects of stormwater utilities (legal foundation, community outreach and public involvement, management, assessment, and rate setting), a model stormwater utility ordinance, public information materials, and a description of Chicopee, Massachusetts' model stormwater management program. The packet is available for $18 from the Pioneer Valley Planning Commission at (413) 781-6045.

10. Rockingham County Conservation District, *Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire* (1992)

Commonly known as the "green book," this guide deals with construction-site erosion control as well as permanent stormwater management. It includes specifications for estimation of runoff and plans required under DES's Site Specific program. This guide should be used in conjunction with NHDES 1996. Copies available from DES's Public Information Center at 271-2975.

11. Washington State Department of Ecology, *Stormwater Management Manual for Western Washington, Volume III, Hydrologic Analysis and Flow Control Design - Final Draft* (2000)

This volume (the third of a five-volume set) contains 32 pages (pages 138-169) on the purposes, applicability, site suitability, design, and maintenance of infiltration BMPs. There is extensive information on determining infiltration rates. The entire five-volume set can be downloaded from http://www.ecy.wa.gov/biblio/9913.html.

12. Watershed Management Institute, *Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation* (1997)

The Watershed Management Institute prepared this manual for the EPA to provide recommendations to individuals who are responsible for developing and managing urban runoff control programs. The Institute surveyed thirty-two local, regional, and state government programs and based their recommendations on the experiences of those who were surveyed. This manual provides valuable contact information in the individual program summaries in Appendix B. This information would be very useful to communities that wanted to examine several different types of stormwater management programs and financing methods before determining what type of system would be best for their area of concern. Viewable at http://stormwaterfinance.urbancenter.iupui.edu/PDFs/Institutional.pdf

Appendix B: Low Impact Development Basics

This appendix introduces the concept of low-impact development (LID), a different approach for managing stormwater. LID principles and practices were developed by Prince George's County in Maryland to integrate stormwater controls throughout the developed landscape to better mimic natural processes. Prince George's County implemented this approach on a 200-acre residential development. More information on low-impact development practices is available from Prince George's County, Department of Environmental Resources' publication: ***Low-Impact Development Design Strategies: An Integrated Design Approach***, January 2000 (EPA 841-B-00-003). The LID guidance document provides detailed information on site planning, hydrologic analysis, integrated management practices, erosion and sediment control, and public outreach for LID. This appendix only briefly touches on some of these topics.

Conventional stormwater control measures are limited in their ability to protect aquatic habitat and cannot reproduce pre-development hydrologic functions. Low-impact development methods enable a developer to maintain the predevelopment hydrologic functions of a site by incorporating small, cost-effective landscape features that store, infiltrate, evaporate, and detain runoff throughout the developed landscape. In doing so, the LID approach better protects habitat structure and hydrology within receiving streams (e.g., cover, substrate, base flow, peak flow), protecting important aquatic communities.

LID focuses on (1) site design techniques that reduce runoff and maintain existing hydrologic features and (2) site-level or "at-source" stormwater controls. The fundamental LID site planning concepts include:

- Using hydrology in designing new development;
- Thinking "micromanagement" for stormwater control;
- Controlling stormwater at the source;
- Using simplistic, nonstructural stormwater control methods when feasible; and
- Creating a multi-functional landscape and infrastructure.

Hydrology is integrated into the site planning process by first identifying and protecting areas important to the natural hydrology of the site: streams and their buffers, floodplains, wetlands, steep slopes, high-permeability soils, and woodland conservation zones. Future development is then located in remaining areas that are less sensitive to disturbance or have lower value in terms of hydrologic function. Development is designed to minimize clearing and grading, minimize and disconnect impervious surface, and provide for on-site/on-lot management of runoff. Existing topography and drainage are maintained to encourage dispersed flow paths.

LID design works to minimize the amount of impervious surface created by a development. The transportation network (roadways, sidewalks, driveways, and parking areas) represents the greatest source of impervious surface. Thus, an LID development design might include narrower roads in a layout that minimizes the amount of pavement

required, sidewalks and on-street parking on only one side of the road, and reduced driveway widths (e.g., 9 ft) and lengths. Other LID design elements to minimize impervious surface and site runoff include minimizing the footprint of homes (less rooftop impervious surface), using permeable materials, such as pervious pavers or gravel, for driveways and parking areas, using shared driveways, and maintaining existing trees.

LID concepts can also be applied to better manage flows from impervious surfaces and increase treatment provided by flow and conveyance systems within the developed site. Whenever possible, LID designs use open, vegetated drainage systems in lieu of conventional storm drains, and lots are graded to minimize the quantity and velocity of surface runoff to the open drainage system. LID flow and conveyance systems are designed to maximize overland sheet flow, involve wider, rougher, and longer flow paths, and include pockets of vegetation (trees and shrubs) in the flow path. To reduce the impact of impervious surfaces, flows from impervious surface are directed to stabilized, vegetated areas, using sheet flow when feasible. In addition, flows from large paved surfaces are directed in multiple directions.

In addition to the above design considerations, LID involves micromanagement of stormwater using small-scale integrated management practices (IMPs) distributed throughout the site. Example IMPs include on-lot bioretention facilities, dry wells, filter/buffer strips, grassed swales, bioretention swales, wet swales, rain barrels, cisterns, and infiltration trenches (see text box for brief descriptions). These techniques are used to control runoff **at its source**. This approach provides increased reliability, since one or more of the smaller, microcontrol systems can fail without undermining the overall site control strategy. Integrated management techniques also pose fewer safety concerns because of their smaller scale, shallow depths and gentler slopes compared to large stormwater ponds. Space requirements, soil and subsoil conditions, location of the water table, and proximity to building foundations are factors in locating IMPs. Although critical to traditional stormwater controls, slopes are rarely a limiting factor in using IMPs.

IMPs do require monitoring and periodic upkeep, including trash removal and maintenance of vegetation. With education on the purpose and proper care for IMPs, private property owners can assume responsibility for maintaining IMPs located on their property. Education on appropriate pollution prevention techniques, such as appropriate fertilizer use, parking lot sweeping, and mowing practices, can help further reduce water pollution from developed land uses.

By following LID practices, developers can often reduce the cost of development. Reducing the amount of pavement and sidewalks, reducing the extent of clearing and grading, eliminating the need for curbs and gutters, decreasing the use of storm drain piping and inlet structures, and eliminating or reducing the size of stormwater ponds can all reduce the infrastructure costs associated with new development. Also, because of the smaller scale of IMPs compared to conventional stormwater management systems, state and local governments can expect lower costs for upkeep and repairs. Despite the

potential cost savings to developers and government, communities that wish to benefit from the LID approach may need to adopt environmentally sensitive and flexible zoning options in their subdivision and site plan ordinances (e.g., an overlay district, performance zoning, impervious overlay zoning) to facilitate (or require) the use of LID techniques by developers.

Example Integrated Management Practices (IMPs)
As described in *Low-Impact Development Design Strategies: An Integrated Design Approach*

Bioretention Area - A practice to manage and treat stormwater runoff by using a conditioned planting soil bed and planting material to filter runoff stored within a shallow depression. The system can include the following components: a pretreatment filter strip of grass in inlet channel, a shallow surface water ponding area, a bioretention planting area, a soil zone, an underdrain system, and an overflow outlet structure. Detailed design guidance is available from Prince George's County *Bioretention Manual*.

Dry Well – A small excavated pit backfilled with aggregate, usually pea gravel or stone. Used to infiltrate runoff from building rooftops and in modified catch basins, where the inflow is direct surface runoff.

Filter Strip – Bands of close-growing vegetation, usually grass, planted between pollutant source areas and downstream receiving waterbody. Also used as outlet or pretreatment devices for other stormwater control practices. For LID, a filter strip is viewed as one component of a management practice.

Vegetated Buffer – Strips of vegetation around sensitive areas.

Level Spreader – An outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope to prevent erosion. One type of level spreader is a shallow trench filled with crushed stone.

Grassed Swale – Engineered grassed channel to transport stormwater. Dry swales facilitate quality and quantity control by allowing for infiltration. Wet swales use residence time and natural growth of water-tolerant vegetation to regulate flow and quality of stormwater before discharge.

Rain Barrel – Retention barrel attached to gutters and downspouts to collect roof runoff in residential and commercial/industrial settings. Barrels include overflow outlet, mosquito screening, and hose spigot. Water can be used on lawn and gardens.

Cisterns – Retention device to collect roof runoff in underground storage tanks. Water can be reused. Applicable in residential and commercial/industrial settings. Premanufactured residential cisterns available from 100 to 1,400 gallons in size.

Infiltration Trench – An excavated trench that is backfilled with stone to form a subsurface basin. Water is slowly infiltrated into the soil, usually over several days. Most effective when combined with some form of pretreatment, such as a filter strip, to reduce the amount of sediment reaching the trench.

Resources:

Center for Watershed Protection. ***Site Planning for Urban Stream Protection.*** Ellicott City, Maryland. December 1995.

Center for Watershed Protection. ***Better Site Design: A Handbook for Changing Development Rules in Your Community.*** Ellicott City, Maryland. August 1998.

Prince George's County, Department of Environmental Resources, Programs and Planning Division. ***Low-Impact Development Design Strategies: An Integrated Design Approach.*** EPA 841-B-00-003. January 2000.

Prince George's County, Department of Environmental Resources, Programs and Planning Division. ***Low-Impact Development Hydrologic Analysis.*** EPA 841-B-00-002. January 2000.

Prince George's County, Department of Environmental Resources, Programs and Planning Division. ***Low-Impact Development Design Manual.*** 1997.

United States Environmental Protection Agency. ***Low-Impact Development (LID): A Literature Review.*** Office of Water. EPA 841-B-00-005. October 2000.

Appendix C: Land Uses Which May Not Use Artificial Infiltration When Located in Critical Areas

Massachusetts' *Stormwater Policy Handbook* identifies the following as "land uses with higher potential pollutant loads." When located in critical areas, infiltration trenches, infiltration basins, or dry wells *may not be used* for these land uses. When located outside critical areas, these land uses must have source reduction measures (e.g., pollution prevention, snow management) and pretreatment of stormwater. Certain other infiltration BMPs (sand or organic filters, detention basins, wet ponds, or constructed wetlands) may be used only if sealed or lined.

- Stormwater discharges associated with Standard Industrial Classifications [NPDES stormwater permit program requirements apply]
- Auto salvage yards (auto recycler facilities)
- Auto fueling facilities (gas stations)
- Fleet storage areas (cars, buses, trucks, public works)
- Vehicle service, maintenance and equipment cleaning areas
- Commercial parking lots with high intensity use. Such areas typically include fast-food restaurants, convenience stores, high-turnover [chain] restaurants, shopping centers and supermarkets.
- Road salt storage and loading areas (if exposed to rainfall)
- Commercial nurseries
- Flat metal (galvanized metal or copper) rooftops of industrial facilities
- Outdoor storage and loading/unloading areas of hazardous substances
- SARA 312 generators (if materials or containers are exposed to rainfall)
- Marinas (service, repainting, and hull maintenance areas)

Appendix D: Excerpt from DES Urban BMP Manual: Infiltration Practices

(Chapter 8 from DES's *Best Management Practices for Urban Stormwater Runoff*, January 1996)

Appendix E: Stormwater Phase II Permits (fact sheet)

F. Nashua Water Supply Protection District Ordinance

G. Sunapee BMP O&M Agreement

Appendix H: Sample ordinance language from other states

The documents in this appendix can be downloaded from http://www.epa.gov/owow/nps/ordinance/stormwater.htm.

1. Stormwater Management and Right of Way Agreement – Montgomery County, Maryland

2. Operation and Maintenance Provisions – Grand Traverse County, Michigan

3. **BMP Maintenance Agreement – Albemarle County, Virginia**

Appendix C: "Limiting Surface Conver and Protecting Water Resources through Better Site Design and Planning - A Report for the Town of North Hampton.

IMPERVIOUS SURFACE REPORT FOR THE TOWN OF NORTH HAMPTON, NEW HAMPSHIRE

PREPARED BY
DR. JILL ROBINSON, LAND USE PLANNER
ROCKINGHAM PLANNING COMMISSION
2004

note that this electronic version of the report for North Hampton does not contain all of the information sent to the town, most notably the "Tree Regulations for the Town of North Hampton, New Hampshire". To obtain a complete report contact Rockingham Planning Commission or the NHEP.

FUNDED THROUGH A GRANT FROM THE NEW HAMPSHIRE ESTUARIES PROJECT

Impervious Surface Report
for the Town of North Hampton, New Hampshire

Introduction

Impervious surfaces are paved areas such as parking lots and areas covered by material that impedes the infiltration of water into the soil. Examples of impervious surfaces are buildings, concrete, pavement, and severely compacted soils (New Hampshire Estuaries Project, 2004). Such surfaces are also sometimes referred to as impermeable.

The increase of impervious surfaces through development affects water resources in several ways. Impervious surfaces combined with urban drainage systems such as curbs and gutters and storm drain pipes can alter the natural hydrology in a watershed by increasing the volume of stormwater and reducing groundwater recharge. Impervious surfaces can also result in loss of aquatic habitat, loss of biological diversity, and an overall decrease in water quality due to the accelerated delivery of pollutants into rivers, lakes, and estuaries (New Hampshire Estuaries Project, 2004).

Recently scientists have reported that levels of impervious surface in excess of ten percent in a watershed can affect water quality. "When the percentage of impermeable surfaces in a watershed is ten percent or less, streams typically retain good water quality and stable channels. When the proportion is between ten to twenty-five percent, storm-fed flows cause noticeable erosion" (Science News, 2004). More than twenty-five percent impermeable surface can lead to severe physical and ecological damage to streams in a watershed (Science News, 2004).

Pollutants in runoff include suspected carcinogens known as polycyclic aromatic hydrocarbons, which can leach from asphalt-based and coal tar-based sealants used on paved lots. Other pollutants often found in runoff include pesticides, nitrates, phosphates, and salt for de-icing roads (Science News, 2004).

Reducing impervious surface helps not only to improve water quality; it may also result in lower municipal costs for road maintenance and clearing and lower development costs. A 100-foot reduction in road length will result in a savings of about $15,000. This figure includes savings from reduced pavement, curb and gutter, and stormwater management structures (Better Site Design, 1998). Well-planned street layouts will also help to alleviate traffic congestion, protect conservation areas, and create a town street system that optimizes the ability of town fire and rescue officials to respond to emergencies in a timely and efficient fashion.

The Rockingham Planning Commission (RPC) recently completed a technical assistance project called "Limiting Impervious Surface Cover and Protecting Water Resources through Better Site Design and Planning." The purpose of this project was to work with coastal communities to raise awareness and understanding of how to limit impervious surface cover, mitigate impacts of development, and protect water resources.

The project was funded by a grant from The New Hampshire Estuaries Project, (NHEP), which is a program involving federal, state, and local government, non-governmental organizations, businesses, university researchers and the public to protect, enhance, and monitor the environmental quality of the State's estuaries.

The three coastal communities of East Kingston, Greenland, and North Hampton were selected for the project. Planners from the RPC reviewed existing land use regulations from these three towns using the code and ordinance review process developed by The Center for Watershed Protection, a non-profit organization which provides technical guidance to communities concerned with protection of water resources from pollutants. This report details the results of the code and ordinance review.

In addition to this review, RPC staff in conjunction with NHEP and the New Hampshire Department of Environmental Services held a community workshop entitled "Limiting Impervious Surface in Your Community." The workshop was offered in October at the University of New Hampshire to Planning Boards, Conservation Commissions, Zoning Boards of Adjustment, Building Inspectors, Code Enforcement Officers, watershed and river organizations, and developers in the 42 communities in the NHEP region.

After our review, we consulted engineers from Altus engineering and planners from the New Hampshire Department of Environmental Services. We especially thank Jeff Clifford of Altus Engineering for his helpful comments and Carolyn Russell of NHDES for helpful suggestions regarding regulatory language. As an appendix to this report, we provide a model tree conservation regulations.

Review of Existing Land Use Regulations

RPC staff reviewed existing land use ordinances and regulations for the Town of North Hampton using the method for review developed by the Center for Watershed Protection in its publication entitled Better Site Design: A Handbook for Changing Development Rules in Your Community (August 1998).

The handbook recommends that a community begin an assessment by reviewing its own development rules and comparing them to the Center's model development principles. These principles are classified into three broad categories: residential streets and parking lots, lot development, and conservation of natural areas.

Taken together, these principles endeavor to reduce impervious surface cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintaining the quality of life within a community. Specifically, this review focuses on the following 22 separate principles:

- Street width
- Street length

- Right-of-way width
- Cul-de-sacs
- Vegetated open channels
- Parking ratios
- Parking codes
- Parking lots
- Structured parking
- Open space design
- Setbacks and frontages
- Sidewalks
- Driveways
- Open space management
- Rooftop runoff
- Buffer systems
- Buffer maintenance
- Clearing and grading
- Tree conservation
- Land Conservation Incentives
- Stormwater outfalls

The table that follows summarizes the review of North Hampton's land use ordinances and regulations. The table is divided into five columns: the model development principle, the recommended practice, the environmental benefit of the practice, North Hampton's requirement, and a suggested amendment (if needed).

TABLE 1
COMPARISON BETWEEN LOCAL REQUIREMENTS AND 22 MODEL DEVELOPMENT PRINCIPLES

Model Development Principle	Recommended practice	Environmental/other benefit	North Hampton's Requirement	Consider Ordinance / Regulation amendment
1. Street pavement width	Reduce to 22' or less, based on traffic volumes	Reduces the largest single component of impervious surface in a subdivision	twenty-four (24) feet paved (travel) surface	Consider amending §X.B.1., subdivision regs (SR) to require 22' or less, based on traffic volume of road.
2. Street length	Minimize length and use efficient street layout	Same as above	Arrangement of streets shall provide for the continuation of principal streets in adjoining subdivisions No street that begins in N. Hampton shall extend into another town w/o connecting w/ existing street in that town"	Amend §X.A.1, SR, as follows: No street shall be longer than 1000 feet, and no driveway shall be longer than 200 feet.
3. Right-of-way width	<50', base on what's needed to accommodate pavement width, utilities, drainage features	Reduces the need for clearing, makes land available for housing, preserves rural character and aesthetics	50 feet in width	Consider amending §X.A.2, to allow a ROW of 35 to 45 feet in residential areas.

Model Development Principle	Recommended practice	Environmental benefit	North Hampton's requirement	Consider Ordinance/Regulation Amendment
4. Cul-de-sacs	Minimize radius as possible, provide pervious island	Reduces pavement; can be used to store & treat stormwater. Prohibiting cul-de-sacs enhances connectivity and may result in lower municipal costs	No dead-end or cul-de-sac streets allowed; If street has a turn around and it contains a lot of legal size, turn around will not be considered a cul-de-sac.	Amend §X.A.3 to encourage alternatives to cul-de-sacs such as loop roads. Require interior of cul-de-sac to be vegetated and used for stormwater management and prohibit building impervious structures.
5. Vegetated open channels	Encourage open channels rather than curb & gutter	Remove pollutants from stormwater, allow infiltration	Open channels are not discussed, design parameters are for storm drainage pipes and catch basins.	Amend §X.C, SR, and §X.C, site plan regs, (SPR) to encourage dry swales, biofilters, and grass swales, and design for both peak and non-peak storm events. Work with town engineering consultants to develop standards for vegetated channels.
6. Parking ratios	Evaluate to ensure ratios are in line with regional averages and local experience	Reduces impervious surface	Parking ratios are are consistent with recommended practices.	Add language to §XII, SPR, for <u>maximum</u> as well as minimum allowed parking to reduce impervious surface.
7. Parking codes	Allow shared parking	Reduces impervious surface	No language regarding shared parking.	Add language to §XII, SPR to allow, encourage shared parking.

8. Parking lot size/design	Minimize stall sizes, allow pervious surfaces where appropriate	Reduces impervious surface	9-foot width and 18-foot length	Add language requiring a certain percentage (30% recommended) of spaces in large lots to be for compact car spaces, width of <9 feet.
9. Structured parking, i.e., w/in garages	Allow where appropriate	Reduces impervious surface	No requirements for structured parking	Allow where appropriate if need arises.
10. Parking lot runoff	Reduce impervious surface, integrate stormwater mgmt designs into landscaped islands	Reduces impervious surface	Requires interior landscaping of parking lots.	Add language to give parking spaces bonus for the use of cold-climate pervious pavement (currently used at UNH Durham).
11. Open space/conservation design	Allow open space/conservation designs by right; ensure ordinances meet impervious surface reduction and land conservation goals	Reduces impervious surface	All districts require new lots to be 2 acres.	Create new district allowing half-acre and 1-acre lots and requiring 80 percent open space. Overall density must be same as conventional development would yield. Provide expedited review as incentive to developers.
12. Setbacks and frontages	Relax frontage and side setbacks (assumes lots <2 acres)	Reduces total road length and impervious surface	Lot setbacks are based on 2-acre lots.	No amendment needed; consider allowing smaller lots in new district.
13. Sidewalks	Reduce width and provide on 1 side of street only when appropriate	Reduces impervious surface	Separated from shoulders by curbing and width of four feet.	No amendment needed.

Model Development Principle	Recommended practice	Environmental/other benefit	North Hampton's requirement	Consider Ordinance/ Regulation Amendment
14. Driveways	Allow alternative paving surfaces in all development; encourage the use of shared driveways	Reduces impervious surface	No language for alternative surfaces, shared driveways.	Allow alternative surfaces such as pervious asphalt. Allow shared driveways through recorded easements for maintenance and snow removal.
15. Open space management	Specify allowed uses; ensure maintenance in natural condition; specify options for long-term maintenance and monitoring of open space	Maintain open space in natural condition; ensure adequate financial resources for long-term maintenance of open space	No language for open space management.	Revise subdivision regs to require open space management plan to be included with application to Planning Board.
16. Rooftop runoff	Divert runoff to on-site pervious surfaces (i.e. swales, bioretention facilities	Increase on-site water infiltration and recharge	No language about rooftop runoff. Ordinance states "all runoff from impervious surfaces shall be recharged on the site"	Require developers to address rooftop runoff and recommend diversion to on-site pervious surfaces. §X.G (SPR).
17. Stream buffer systems	Establish riparian buffers with specified width, targeted vegetation and allowed uses	Protect water quality and habitat; regulate the type and location of development along shores	Definition of inland wetlands includes rivers and streams. §413 of ordinance provides authority to protect critical and unique areas. Buffers are required in §409.9.	No amendment needed except to require that vegetated areas of buffer remain vegetated. Require DO NOT MOW markers or blazes at edge of buffer.
18. Buffer management	Local riparian buffer ordinance which outlines legal rights and responsibilities of local govt and landowner re: long-term mgmt	Effective preservation and mgmt of a local buffer program	§409.6-8 provides description of permitted and prohibited uses.	Require long-term management plan with site plan or subdivision application.

Model Development Principle	Recommended practice	Environmental/other benefit	North Hampton's requirement	Consider Ordinance/ regulation amendment
19. Clearing and grading	Regulate erosion & sediment control; adopt tree protection ordinance	Reduce stormwater flows and erosion, encourage infiltration	• SR and SPR regulate erosion and sediment control. • §409.6 allows cutting of live trees with a diameter of six inches or greater in tidal wetlands. Partial cutting is limited to 30 percent of total pre-harvest basal area. Developer must consult w/ forester. • Excavation regs require excavation plan and reclamation plan to be submitted to "The Regulator" defined as the Planning Board.	• Amend ordinance to restrict tree cutting in inland wetlands also (§409.7). • Amend site plan and subdivision regs to require developer to consult with forester for cutting in buffer areas. • Amend §409 of Ordinance to restrict clearing and grading in all wetland buffer areas. • Amend §409 to require retention of existing vegetation in buffer areas. Restrict mowing in buffer areas.
20. Tree conservation	Establish regs which promote preservation of trees and native vegetation	Reduce stormwater flows and erosion, encourage infiltration	Wetland buffer ordinance has some provisions (see above).	Amend subdivision and site plan regs w/ tree conservation provisions. Require review of developer's plan by certified arborist or forester, at applicant's expense.
21. Conservation incentives	By-right open space develop. density incentive, stormwater credit, buffer averaging, property tax relief, transferable development rights, off-site wetland mitigation	Increase the attractiveness of conserving natural areas by offering flexibility in regulations and incentives	No incentives currently offered in regs.	Consider possible appropriate incentives for conservation of natural areas as determined through discussions by town Boards and citizens.

22. Stormwater outfalls	Stormwater management requirements to control quantity and quality of runoff; stormwater best mgmt practices; floodplain development regulations. Allowance for non-structural, natural systems such as open channels as well as for structural systems.	Protect the quality of wetlands, surface water and groundwater. Utilize existing hydrology to receive and filter stormwater flows. Use simple systems.	Floodplain development regs are in place. Stormwater regs require BMPs.	No amendment needed to floodplain regs. Board's consultants can provide technical guidance for low-impact development and cold-climate BMPs and language for regs to add provisions re non-structural BMPs. • Infiltration areas, such as bioretention areas and raingardens, shall be designed to fully infiltrate the 2-yr, 24-hr storm within 24 hours. Addresses concerns about mosquito breeding). • Total volume of runoff post development for both the 2 and the 10-yr storm must be no greater than the total volume of pre-development runoff. • Require maintenance schedule/agreement. • Consider incentives for quality site design, such as increase in impervious surface if specified performance criteria are met.

Conclusions

Based on the above analysis, it is clear that North Hampton has taken several steps to protect groundwater and to limit impervious surface. The Planning Board may wish to consider the recommendations for amendments given in the preceding table.

We recommend that the Planning Board discuss amendments with a focus on the following three areas: stormwater management practices, wetland buffers/tree regulations, and conservation subdivision districts. We recommend that the Planning Board consider amending the existing ordinance and regulations based on the suggestions in this report. The Rockingham Planning Commission and the Town's engineering consultant can provide guidance and support as well as technical manuals and regulatory language to help the Town of North Hampton limit impervious surface and protect its water supply. We include in the appendix to this report a model tree preservation regulation.

Resources

Center for Watershed Protection. 1998. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, MD: Center for Watershed Protection.

New Hampshire Estuaries Project (NHEP). 2004. The Impacts of Impervious Surfaces on Water Resources. Portsmouth, NH: NHEP.

Perkins, Sid. 2004. Paved Paradise? Impervious surfaces affect a region's hydrology, ecosystems, even its climate. Science News 166: 152- 153.

Appendix D - note not all materials were included in this electronic copy. Contact Rockingham Planning Commission or the NHEP for a complete report.

LIMITING IMPERVIOUS SURFACE COVER AND PROTECTING WATER RESOURCES THROUGH BETTER SITE DESIGN & PLANNING

A COMMUNITY REPORT FOR THE TOWN OF EAST KINGSTON

DECEMBER 2004

Prepared for the New Hampshire Estuaries Project
by the
Rockingham Planning Commission
156 Water St.
Exeter, NH 03833

This report was funded by a grant from the New Hampshire Estuaries Project, as authorized by the U.S. Environmental Protection Agency.

BACKGROUND

I. Impervious surface cover and its effects

Impervious surfaces are areas covered by any of a variety of materials or surfaces that impedes the infiltration of water into the soil. Examples include buildings, pavement, concrete, and severely compacted soils.

The increase of impervious surfaces caused by development affects water resources in several ways. First, impervious surfaces combined with drainage systems such as curbs, gutters and storm drain pipes alter the natural hydrology in a watershed by increasing the volume of stormwater runoff being discharged from the site, as well as by reducing the amount of groundwater that is recharged on the site. Impervious surfaces can also result in loss of aquatic habitat, loss of biological diversity, and an overall decrease in water quality due to the accelerated discharge of pollutants into rivers, lakes, and estuaries.

Recently scientists have reported that levels of impervious surface in excess of 10% in a watershed can affect water quality. "When the percentage of impermeable surfaces in a watershed is ten percent or less, streams typically retain good water quality and stable channels. When the proportion is between ten to twenty-five percent, storm-fed flows cause noticeable erosion" (Science News, 2004). More than 25% percent impermeable surface can lead to severe physical and ecological damage to streams in a watershed (Science News, 2004).

Reducing impervious surface helps not only to improve water quality, it may also result in lower municipal road maintenance costs and lower development costs. A 100-foot reduction in road length will result in a savings of about $15,000. This figure includes savings from reduced pavement, curb and gutter, and stormwater management structures (Better Site Design, 1998). Well-planned street layouts will also help to alleviate traffic congestion, protect conservation areas, and create a town street system that optimizes the ability of town fire and rescue officials to respond to emergencies in a timely and efficient fashion.

II. Summary of the "Impervious Surface" project

In 2004 the Rockingham Planning Commission (RPC) completed a technical assistance project called "Limiting Impervious Surface Cover and Protecting Water Resources through Better Site Design and Planning." The purpose of this project was to work with coastal communities to raise awareness and understanding of how to limit impervious surface cover, mitigate impacts of development, and protect water resources.

The project was funded by a grant from The New Hampshire Estuaries Project (NHEP), a program involving federal, state, and local government, non-governmental organizations, businesses, university researchers and the public to protect, enhance, and monitor the environmental quality of the State's estuaries.

The RPC's Impervious Surface project involved three tasks:

- Task 1: Technical assistance to three communities in the coastal watershed with regard to limiting impervious surface cover, mitigating impacts of development and protecting water resources. This task included an assessment of existing land use regulations and development review procedures; identification of options for improvement / areas of focus for the community to consider, and; recommendations and/or suggested language to revise existing regulations. The

towns of East Kingston, Greenland and North Hampton for selected for technical assistance.

- Task 2: Coordination with the Strafford RPC, NHEP, NH DES and other agencies to develop and conduct a workshop entitled "Limiting Impervious Surface in Your Community" (held October, 2004)

- Task 3: Development of a Final Project Report with specific recommendations for communities to improve regulations to protect water quality and water resources.

This report was developed under Task 1 above, and details the results of the code and ordinance review for the Town of East Kingston. Numerous recommendations are included for the Town of East Kingston Planning Board to consider; however, three are recommended as high priority items.

The RPC would like to thank Jeff Clifford of Altus Engineering and Jay Stephens from Civil Consultants for their helpful comments and Carolyn Russell of the NH Department of Environmental Services for suggestions regarding regulatory language.

TECHNICAL ASSISTANCE TO THE TOWN OF EAST KINGSTON

I. Land Use Regulation Review: Methodology

RPC staff reviewed East Kingston's existing land use regulations (Zoning Ordinance, Subdivision Regulations and Site Plan Review Regulations) using the code and ordinance review process developed by The Center for Watershed Protection in its publication entitled *Better Site Design: A Handbook for Changing Development Rules in Your Community* (August 1998).[1]

The *Handbook* recommends that a community begin an assessment by reviewing its own development rules and comparing them to the Center's 22 "model development principles." These principles are classified into three broad categories: residential streets & parking lots; lot development, and; conservation of natural areas. Specifically, the 22 model principles deal with:

1. Street pavement width
2. Street length
3. Right-of-way width
4. Cul-de-sacs
5. Vegetated open channels
6. Parking ratios
7. Parking codes
8. Parking lot size/design
9. Structured parking
10. Parking lot runoff
11. Open space design
12. Setbacks and frontages
13. Sidewalks
14. Driveways
15. Open space management
16. Rooftop runoff
17. Stream buffer systems
18. Buffer management
19. Clearing and grading
20. Tree conservation
21. Conservation incentives
22. Stormwater outfalls

Taken together, the principles endeavor to reduce impervious cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintain the quality of life within a community.

II. Findings

Overall, the Town of East Kingston's regulations fared reasonably well when compared to the *Better Site Design* model development principles. In particular, the Town's flexible development regulations do not require curbs, gutters and closed drainage systems, as well as allow great flexibility with regard to parking lots surfaces and parking requirements.

However, many other areas of the Town's land use regulations are not in alignment with the *Better Site Design* model development principles. Roadway and cul-de-sac standards, open space and natural resource protection, and stormwater management guidelines are all areas that should be reviewed by the Planning Board for improvement as appropriate.

The table that follows summarizes the review of East Kingston's land use ordinances and regulations against the 22 model development principles. The table is divided into 5 columns: model principle; recommended practice; environmental benefit, and suggested amendment (if needed).

[1] The Center is a non-profit organization based in Ellicott City, Maryland and provides technical guidance to communities concerned with protection of water resources from pollutants.

COMPARISON BETWEEN EAST KINGSTON'S LAND USE ORDINANCES & REGULATIONS AND THE 22 MODEL DEVELOPMENT PRINCIPLES

Model Development Principle	Recommended practice	Environmental benefit	E. Kingston's requirement	Consider Ordinance / Regulation amendment
1. Street pavement width	Reduce to 22' or less, based on traffic volumes	Reduces the largest single component of impervious surface in a subdivision	24' pavement width	Subd. Reg. Section XVI, F.1
2. Street length	Minimize length (no recommended minimum)	Same as above	1,000' max., no more than 20 SF homes from a single access	No change needed
3. Right-of-way width	<50', base on what's needed to accommodate pavement width, utilities, drainage features, limit clearing beyond what's necessary to accommodate improvements	Reduces the need for clearing, makes land available for housing	50', entirely cleared but selected shade trees can be preserved when indicated by Town Engineer	Subd. Reg. Sec. VII.C, Sec. XVI.A A and Appendices C and D
4. Cul-de-sacs	Minimize radius as possible, provide pervious island in center of cul-de-sac	Reduces pavement; can be used to store & treat stormwater	75' radius to edge of ROW, fully paved	Subd. Reg. Appendix D
5. Vegetated open channels	Encourage open channels rather than curb & gutter	Remove pollutants from stormwater, allow infiltration	Allowed (curbs & gutters are not required)	No change needed
6. Parking ratios	Evaluate to ensure ratios are in line with regional averages and local experience	Reduces impervious surface	Few set requirements; allows for flexibility.	No change needed
7. Parking codes	Allow shared parking	Reduces impervious surface	Few set requirements for commercial/industrial allows for flexibility	No change needed
8. Parking lot size/design	Minimize stall sizes, allow pervious surfaces where appropriate	Reduces impervious surface	Require landscaping in lots with > 30 spaces; no other requirements	No change needed
9. Structured parking	Allow where appropriate	Reduces impervious surface	Not specifically addressed	No change needed

Model Development Principle	Recommended practice	Environmental benefit	E. Kingston's requirement	Consider Ordinance / Regulation amendment
10. Parking lot runoff	Reduce impervious surface, integrate stormwater mgmt designs into landscaped islands	Reduces impervious surface	Minimize dust, erosion and run-off; no specific design guidelines	Site Plan Reg. Sec. VI.D and E
11. Open space design	Allow open space designs by right; ensure ordinances meet impervious surface reduction and land conservation goals	Reduces impervious surface	Single Family Residential Development Ord. and Elderly Housing Ord. are both open space designs; SF Cluster requires 20 acre parcel, EH requires 10 acres	Review Zoning Ord. Articles XI and XII to ensure that Town's land conservation goals are met; consider reducing parcel size requirement
12. Setbacks and frontages	Relax frontage and side setbacks (assumes lots <2 acres)	Reduces total road length and impervious surface	200' frontage 30' front setback 25' side / rear	No change needed
13. Sidewalks	Reduce width and provide on 1 side of street only when appropriate	Reduces impervious surface	Required in Elderly Housing developments but no other residential development; required between building entrance & parking lot in non-residential development	No change needed
14. Driveways	Allow alternative paving surfaces in all development; encourage the use of shared driveways	Reduces impervious surface	SF Cluster Residential Ord. requires that driveways and parking must be paved; no paving requirements for other driveways; shared driveways not allowed (except by waiver of Subd. Reg.)	Zoning Ord. Art. XI, L (SF Cluster Residential Development); Subd. Reg. Sec. VII.F (each lot to have its own driveway)

Model Development Principle	Recommended practice	Environmental benefit	E. Kingston's requirement	Consider Ordinance / Regulation amendment
15. Open space management	Specify allowed uses; ensure maintenance in natural condition; specify options for long-term maintenance and monitoring of open space	Maintain open space in natural condition; ensure adequate financial resources for long-term maintenance of open space	Allowed uses are specified; requires that covenants address protection of open space; no requirement to maintain min. % of open space in natural condition	Zoning Ord. Art. XI.Q and Art. XII.C.4 - Explore alternative arrangements for long-term protection of open space (i.e. easements held by third party or town)
16. Rooftop runoff	Divert runoff to on-site pervious surfaces (i.e. swales, bioretention facilities	Increase on-site water infiltration and recharge	Not specifically addressed	Consider amending Building Code to specify / require rooftop runoff be diverted to on-site pervious surfaces
17. Stream buffer systems	Establish riparian buffers with specified width, setbacks, targeted vegetation and allowed uses	Protect water quality and habitat; regulate the type and location of development along shores	No local shoreland regulations; Powwow Pond falls under State Shoreland Protection Act	Consider developing a local shoreland protection zoning ordinance to cover water bodies other than Powwow Pond
18. Buffer management	Local riparian buffer ordinance which outlines legal rights and responsibilities of local govt and landowner re: long-term mgmt	Effective preservation and mgmt of a local buffer program	Same as above	Same as above
19. Clearing and grading	Regulate erosion & sediment control; adopt tree protection ordinance	Reduce stormwater flows and erosion, encourage infiltration	Require erosion and sediment control plan; require preservation of natural vegetation only in required buffers or open space	Subdivision and Site Plan Review Regs. - Consider developing tree protection regulations with on-site pre-construction meetings to ensure clearing limits are followed

Model Development Principle	Recommended practice	Environmental benefit	E. Kingston's requirement	Consider Ordinance / Regulation amendment
20. Tree conservation	Establish regs which promote preservation of trees and native vegetation	Reduce stormwater flows and erosion, encourage infiltration	Not addressed	Same as above
21. Conservation incentives	By-right open space develop., density incentive, stormwater credit, buffer averaging, property tax relief, transferable development rights, off-site wetland mitigation	Increase the attractiveness of conserving natural areas by offering flexibility in regulations and incentives	Current use tax incentive and wetland mitigation per State rules	Zoning Ord. Art. XI
22. Stormwater outfalls	Stormwater mgmt requirements to control quantity and quality of runoff; stormwater best mgmt practices; floodplain development regulations	Protect the quality of wetlands, surface water and groundwater	Floodplain Development Ord., Erosion & Sedimentation Plan requirements	Subdivision and Site Plan Review Regs. – Consider detailed drainage and stormwater mgmt regulations, requirement for reducing suspendible solids, and specific best mgmt practices to address the quality and quantity of runoff

III. Conclusions

Based on the above review, it is clear that East Kingston has taken numerous steps to limit impervious surface coverage and protect groundwater. As listed in the above table, there are numerous additional strategies for forwarding this goal. We recommend that the Planning Board discuss amendments with a focus on the following model development principles:

Principles # 1 & 3: Street pavement width and associated right-of-way

Subdivision Reg. Section XVI, F.1 requires a minimum of 24' pavement on all roadways. Subdivision Reg. Sec. VII.C, Sec. XVI.A and Appendices C and D require a 50' right of way, entirely cleared with the exception of selected shade trees that can be preserved when indicated by Town Engineer. The Board should consider amending the Regs. to allow a minimum of 22' roadway pavement width based on expected traffic volumes and type.

Principle #4: Cul-de-sacs

The Town currently requires that the cul-de-sac bulb be paved, and designed with a radius of 75' to the edge of the right-of-way (Subdivision Reg. Appendix D). The Board should consider amending the Subdivision Regs. to require a vegetated island, and examine the feasibility of reducing the radius requirement.

Principles #10, 16 & 22: Stormwater outfalls, parking lot and rooftop runoff

While the Town's regulations allow for
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\leaves the site. Such requirements should be considered as a means of protecting water resources (quality and quantity).

Clearly, discussions on all of the above amendments should involve significant input from the Town's consulting engineer, Road Agent, Fire Department and Conservation Commission. The Rockingham Planning Commission can help provide guidance and support, technical manuals and regulatory language to help the Town of East Kingston limit impervious surface and protect its water supply. Included with this report are samples of stormwater management ordinances, which could be used as a starting point for discussion in East Kingston.

IV. Resources

Center for Watershed Protection. 1998. Better Site Design: A Handbook for Changing Development Rules in Your Community. Ellicott City, MD: Center for Watershed Protection.

Center for Watershed Protection. 1997. Stormwater BMP Design Supplement for Cold Climates. Ellicott City, MD: Center for Watershed Protection. http://www.cwp.org/cold-climates.htm

New Hampshire Estuaries Project (NHEP). 2004. The Impacts of Impervious Surfaces on Water Resources. Portsmouth, NH: NHEP.

Perkins, Sid. 2004. Paved Paradise? Impervious surfaces affect a region's hydrology, ecosystems, even its climate. Science News 166: 152-153.

The Impacts of Impervious Surfaces on Water Resources

NewHampshire EstuariesProject

What Are Impervious Surfaces?

Impervious surfaces are areas covered by material that impedes the infiltration of water into the soil. Examples of impervious surfaces are buildings, pavement, concrete, and severely compacted soils.

How Do Impervious Surfaces Affect Water Resources?

Altering the Natural Flow of Water: The addition of impervious surfaces, especially coupled with urban drainage systems (i.e. curbs, gutters, and storm drain pipes), alters the natural hydrology in a watershed by increasing the volume of stormwater runoff and reducing groundwater recharge. The result is more frequent flooding, higher flood peaks, lower dry weather flow in streams, and lower water table levels.

Aquatic Habitat Loss: Impervious surfaces and urban drainage systems add to the volume of stormwater during rain events and can reduce stream flow in dry weather. These hydrologic extremes can damage plant, fish, and invertebrate habitat. The increase in water volume during storm events causes erosion of stream banks and changes the stream channel's shape. The released sediment can smother habitat and stress aquatic organisms. During dry periods, low flows reduce deep water and swift-flowing habitats. In addition, stream edge habitat and stream channel protection is lost when the natural, vegetated stream buffer is replaced by impervious surfaces.

Decreased Water Quality: Impervious surfaces and urban drainage systems accelerate the delivery of pollutants from the watershed to rivers, lakes, and estuaries. For estuaries and their freshwater tributaries, the pollutants of greatest concern are fecal coliform bacteria and nutrients. Shellfish beds are commonly closed to harvesting after rainstorms due to elevated amounts of fecal coliform bacteria washed into the estuary by stormwater. Excessive nutrients from backyard and farm fertilizers, septic systems, and animal wastes, can cause algae blooms, which block sunlight, deplete dissolved oxygen, inhibit the growth of other aquatic plants, and can adversely affect recreational activities. Other pollutants of concern are toxic contaminants, such as metals and oil, from vehicles and business or homeowner activities that are washed off impervious surfaces into waterbodies by stormwater.

Loss of Biological Diversity: The Center for Watershed Protection reports that hydrologic alteration, habitat loss, and decreased water quality "stresses aquatic species and collectively diminishes the quality and quantity of habitat." Therefore, increasing impervious surface coverage generally results in reduced biological diversity, changes in the biological community, and a shift toward pollution-tolerant species.

How Much Is Too Much?

Various studies from around the country show that stream ecosystems and water quality become degraded as impervious surfaces increase. Impairment to streams often occurs when more than 10% of the land within a watershed is covered with impervious surfaces. However, sensitive species can be affected in watersheds with less than 10% imperviousness, especially when impervious surfaces are located adjacent to water bodies. When the percentage of impervious cover exceeds 25%, most watersheds experience severe habitat and water quality impairment.

What Can Towns Do To Reduce the Impacts of Impervious Surfaces?

A community should consider their existing natural resources, development, regulations, and priorities before planning to address the impacts of impervious surfaces. For assistance, the New Hampshire Estuaries Project recommends that towns work with the Regional Planning Commissions on strategies to minimize the effects of development on natural resources.

There is no single solution; however, some steps a community may take include:

- **Conducting a Natural Resource Inventory (NRI):** An NRI in your watershed will help communities identify protection priorities and the best areas for development.
- **Targeting Conservation Efforts:** A recent study by the NH Coastal Program and the US Geological Survey found that impervious surfaces near water bodies have a greater impact on water resources than impervious surfaces that are farther away.
- **Considering Conservation Design Alternatives:** Conservation designs for development minimize the amount of land disturbed, maintain significant ecological areas in a natural state, and reduce the amount of impervious surface created.
- **Managing Existing Impervious Surfaces and Stormwater Drainage Systems:** From planting vegetative buffers, to keeping parking areas clean of debris, to capturing stormwater for treatment or groundwater recharge, there are approaches communities can pursue to reduce the impacts of impervious surfaces.
- **Providing Community Outreach:** Educating your community about the impacts of impervious surfaces and what they can do will not only get residents on board for new local regulations, but will also reduce impacts from existing developed areas (see box below). Municipalities in the New Hampshire coastal watershed that are under the new federal **Phase II Stormwater Management Program** can use this information to assist them with meeting the new federal requirements.

How Homeowners Can Reduce the Impact of Impervious Surfaces

- Minimize lawn areas by planting shrubs, ground covers, flowers and trees at the border of the property. Studies have indicated that lawn areas recharge groundwater less efficiently than planted landscaped areas.
- Limit the amount of impervious surface, e.g., sidewalks, roofs, driveways, and patios, on your property.
- Direct rainwater runoff from gutter drains to areas that are landscaped. This provides the plants with the moisture that is needed for survival and increases groundwater recharge.
- Sweep driveways and walkways instead of hosing them down.
- Encourage your local government to adopt ordinances that protect water quality and enhance the quality of life in your community.

For More Information

The New Hampshire Estuaries Project (NHEP) is a program involving federal, state, and local government, non-governmental organizations, businesses, university researchers, and the public to protect, enhance and monitor the environmental quality of the State's estuaries. The NHEP works with various planning and conservation organizations to provide assistance and resources to towns in New Hampshire's coastal watershed. To learn more about the NHEP, go to www.nh.gov/nhep.

For more information about impervious surfaces and what towns can do to minimize their impacts on water resources, contact Theresa Walker at the Rockingham Planning Commission at 778-0885 or Gerry Mylroie at the Strafford Regional Planning Commission at 742-2523 ext. 108. For information on the Natural Resources Outreach Coalition (NROC), a coalition of organizations that assists communities in identifying and protecting natural resources, contact Amanda Stone, NROC coordinator, at the University of New Hampshire Cooperative Extension at 364-5324. Most of the information on impervious surfaces and their impacts is from *Impacts of Impervious Cover on Aquatic Systems*, Watershed Protection Monograph No. 1. Center for Watershed Protection, Ellicott City, MD. March 2003. Available at www.cwp.org. The Stormwater Manager's Resource Center, available at www.stormwatercenter.net, provides detailed information for stormwater practitioners, local government officials and others that need technical assistance on stormwater management issues. Information on the recent study of water quality impacts from impervious surfaces in New Hampshire is available from Sally Soule at the NH Coastal Program at (603) 559-0032 or ssoule@des.state.nh.us.

This summary sheet was produced by the New Hampshire Estuaries Project, 50 International Drive, Suite 200, Pease International Tradeport, Portsmouth, NH. Septemnber 2004