TOWN OF CHAPEL HILL
Impervious Surfaces / Best Management Practices Report

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Statement of Purpose

The Chapel Hill Comprehensive Plan reports that approximately 10 percent (1,732 acres) of the Urban Services Area remains[1] and that by 2025 that Area will be developed with an increase of over 7,000 new homes and 20,000 new residents. Urban watershed health is directly related to development and unmitigated increases in impervious surface cover. Impervious surfaces can be defined as any material that prevents the infiltration of water into the soil.[2] Rooftops of industrial, commercial, and residential buildings and transport systems such as roads, highways, and parking lots are the most common type of impervious surface but patios, quarries, tennis courts, golf courses, and dirt roads also act as impervious surfaces. Calculation of site level imperviousness should include all land cover that is impervious, as well as land cover that is partially pervious. For example, manicured lawns only absorb 30% or less of stormwater. However, calculations for impervious surfaces in developed areas typically include only those surfaces that are 100% impervious, when in reality impervious surface estimates should be inclusive of partially pervious land cover.

The purpose of this report is to present a range of alternatives in impervious surface standards for the Town of Chapel Hill to consider in order to improve overall watershed health. Specifically, alternatives for impervious cover standards as well as best management practices are presented for not only new development, but also to effectively mitigate redevelopment of existing urban land uses. The report presents case studies of other jurisdictions facing similar problems and the range of solutions being implemented to address the impacts of imperviousness. Recommended policy options are presented for the Town of Chapel Hill to consider in effectively reducing the quantity and improving the quality of runoff from developed lands. Further, beneficial benchmarks and feasible monitoring of indicators are discussed.

Emerging Trends in Chapel Hill

The current impervious surface cover in 18 subwatersheds of Chapel Hill ranges from 0.32% to 31.02%, and anticipated increases at build out conditions range from 18.35% to 48.47% (see Map 1).[3] Studies throughout the mid-Atlantic have shown that increases in the amount of impervious surfaces are a problem because watershed health begins to decline at or around 10% imperviousness (see Figure 1).[4] Therefore, at future build-out conditions, Chapel Hill will continue to experience problems with managing stormwater and maintaining watershed health if measures are not taken to prevent increases in stormwater run-off or to reduce the effects of existing run-off.

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[1] The 10 % includes undeveloped land and land developed at very low density (one unit per three or more acres); this figure excludes vacant land committed to developments and land owned by UNC.

[2] Arnold, Chester L. and C. James Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62,2:243-58.

[3] O'Prey, Catherine. 2000. Masters Project Report: Evaluation of Chapel Hill Watersheds: Impervious Surface Cover as Stream Health Indicators. Available: Department of City and Regional Planning, University of North Carolina at Chapel Hill.

[4] Schueler, T.R. (1994) "The Importance of Imperviousness." Watershed Protection Techniques, 1,3: 100-11.

For Chapel Hill, the effects of imperviousness are evident in increased sedimentation, increased flooding potential, and decreased water quality. In addition, increases in impervious surfaces exacerbate groundwater infiltration problems in the town due to the highly impermeable clay soils that dominate Chapel Hill's ground cover. Clay soils are naturally more impermeable to infiltration of stormwater than other soil types. Regardless, there are many indicators that Chapel Hill's streams and lakes are becoming degraded as a direct result of development within town and measures must be taken to enhance and restore these valuable natural features. There are several additional reasons for managing impervious surfaces in the Town of Chapel Hill.

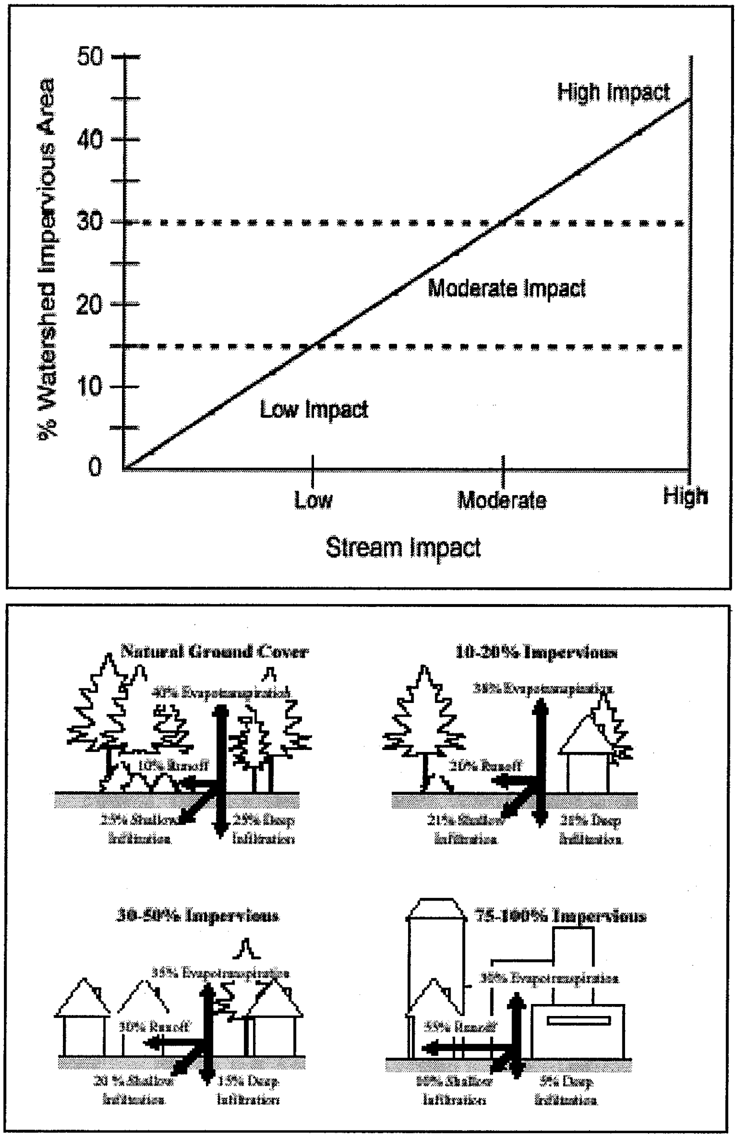

Figure 1: Relationship Between Impervious Cover and Stream Quality *(Source: Schueler, T.R. (1994) "The Importance of Imperviousness." Watershed Protection Techniques, 1,3: 100-11.)*

First, areas within the town are experiencing problems associated with sediment loading of streams and lakes from construction and development, eroded stream banks and stream straightening due to increased stormwater flows, and loss of riparian and in-stream habitat due to siltation. Second, impervious surfaces contribute to the amount and velocity of stormwater runoff into Chapel Hill's streams, thereby increasing the potential for scour and flooding. Further development in the upstream reaches of the watershed will continue to impair the ability of downstream watercourses to convey the necessary water volumes. Finally, paved surfaces, including transportation networks and parking lots as well as increased human activities, increase non-point source pollutant and nutrient loading of urban streams.[5] Therefore, implementing more

[5] Stream sampling has identified stream sites within Chapel Hill with water quality measures lower than the permitted State standards. Between 1994 and 1999, these included Meeting of the Waters Creek at Laurel Hill Road, Morgan Creek at NC 54, and Little Creek at Chapel Hill Country Club. Of the water pollutants measured by the Town of Chapel Hill, fecal coliform is the most common pollutant; however, other measured local impacts included excessive phosphorous, nitrates, lead and zinc loading. Increased pollutants and nutrient loading degrade localized stream health, but also impact downstream drinking water supplies in Jordan Lake. (Cape Fear Basinwide Water Quality Plan, August 2000)

restrictive impervious cover standards in the Town of Chapel Hill is necessary to improve the water quality and reduce the volume and velocity of stormwater runoff into the Town's streams both from new development and redevelopment.

Implementation of impervious cover standards contributes to a holistic approach to stormwater management, linking local, State and Federal goals. First, Chapel Hill's Stormwater Utility Advisory Committee has identified various strategies for improvement that may be considered by the Town.[6] Of those, impervious cover standards and BMPs received significant support as mitigation alternatives to improving overall watershed health. Second, impervious cover standards will assist the Town in meeting the requirements of Phase II of the National Pollutant Discharge Elimination System (NPDES) by decreasing construction and post-construction run-off. This should have a noted effect on impaired streams. Further, technical assistance and public education in reducing the impacts of impervious cover and integrating BMPs will contribute to the Town's participation in the NPDES program. Finally, whereas the Town currently may meet the minimum requirements of the anticipated Cape Fear Rules and regulations, future revisions to these rules may require the Town to further develop its stormwater management practices.

Benefits of Managing Impervious Surfaces

There are three main reasons for managing impervious surfaces in Chapel Hill as the town continues to develop. First, managing imperviousness is critical to protecting the water quality in Chapel Hill's urban lakes and streams. Impervious surfaces are the primary source of non-point source pollutants and these surfaces facilitate the transfer of pollutants from urban surfaces to urban waterways. It has been found that polluted stormwater runoff is the leading cause of water quality impairment in approximately 40% of all the surveyed water bodies in the United States that do not meet water quality standards.[7]

Second, managing imperviousness is crucial to curtailing the recent series of flooding events in Chapel Hill. In August of 2000, a number of successive storm events in Chapel Hill resulted in flooding of homes and businesses, including Eastgate shopping center and the surrounding neighborhoods. As the amount of impervious surface on a site increase, the quantity and velocity of stormwater runoff increase as well, with less stormwater infiltrating the ground. When a large storm event occurs, intermittent and perennial stream flows exceed the capacity of the stream to handle these flows, and the result is frequent flooding.

Finally, research from various geographic locations in the mid-Atlantic has shown that the amount of impervious land cover in a watershed can serve as a good indicator of the health of the streams and rivers within a watershed (see Figure 1).[8] This research found significant

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[6] Stormwater Utility Advisory Committee Minutes, Memo from Fred Royal, Stormwater Management Engineer, December 19, 2000.
[7] National Water Quality Inventory. 1996. Available: http://www.epa.gov/305b/
[8] Schueler, 1994.

correlation between the amount of impervious surfaces within a watershed and water quality, stream bank and streambed stability, species diversity, and habitat quality.

Therefore, the Town of Chapel Hill will benefit from the following if imperviousness is more effectively managed:

1. Reduced flooding of streams and lakes;
2. Reduced stormwater runoff;
3. Improved and protected water quality;
4. Improved and protected stream ecosystems and wildlife habitats.

Reducing Flooding Potential of Streams and Lakes

Reducing or more effectively managing the effects of impervious surfaces can result in a reduced quantity of stormwater delivered to streams during a storm event. Impervious surfaces increase the volume of stormwater runoff delivered to streams and decrease the time needed for runoff to reach the stream. These two factors, combined with increasing velocities of stormwater run-off, increase the chances for peak flooding events. Figure 2 illustrates the effects of development on floodplain elevations. Managing imperviousness as a mechanism of preventing flooding involves maximizing the amount of stormwater that infiltrates the ground by allocating more open space to a site, buffering intermittent and perennial streams, and implementing structural and non-structural BMPs.

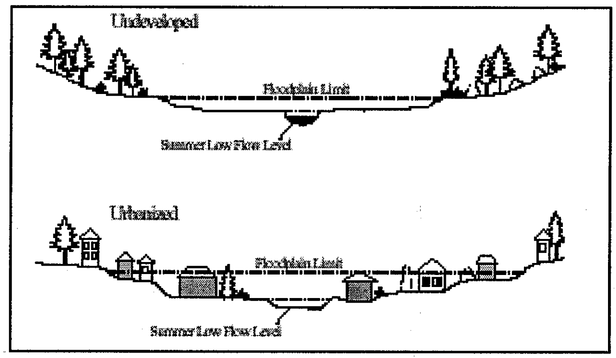

Figure 2: Effect of Urbanization on Stream Slope and Flooding *(Source: Preliminary Data Summary of Urban Stormwater Best Management Practices, EPA. 1999)*

Controlling Stormwater Runoff

Managing imperviousness will reduce both the quantity of runoff and the velocity of runoff from a site. The benefits of such reductions include maintaining or restoring the natural hydrology of streams and lakes; preventing stream bank erosion and the widening and straightening of stream channels; maintaining stream bank stability; and preventing the loss of riparian and in-stream habitat.[9] In Chapel Hill, stormwater runoff is currently regulated for both pre- and post- development activities with respect the quantity of runoff but not the quality of runoff. Therefore, Chapel Hill will benefit from impervious surface standards that addresses both the quantity and quality of runoff:

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[9] Booth, Derek B. and Lorin E. Reinelt. 1993. Consequences of Urbanization on Aquatic Systems - Measured Effects, Degradation Thresholds, and Corrective Strategies. pp. 545-550 in Proceedings Watershed '93 A National Conference on Watershed Management. March 21-24, 1993. Alexandria, Virginia.

Water Quality Protection and Enhancement

Impervious surface standards will protect and enhance water quality by encouraging the natural infiltration of stormwater into the soil, decreasing non-point source pollutant loads, and meeting total maximum day load (TMDL) limits for impaired streams. Impervious surfaces collect and accumulate pollutants that are transported to aquatic systems during rainfall. This adversely affects the water quality of Chapel Hill's streams, lakes, and reservoirs. These pollutants are characterized as non-point source pollutants and they include pathogens that pose human health hazards, nutrients (nitrogen and phosphorus), toxics which threat aquatic species and human health, debris, and sediment. Up to 90% of the pollutants deposited on impervious surfaces are delivered to the receiving waters.[10] Studies have shown that urban pollutant loads are directly related to the amount of impervious surfaces in a watershed.[11]

Ecosystem and Stream Habitat Protection

Impervious standards will protect stream habitat by maintaining stream biodiversity, maintaining and restoring stream ecosystem functions, preventing dramatic temperature fluctuations in streams, and preventing declines in fish and reptiles populations. The cumulative impacts of impervious surfaces with respect to water quality, stormwater runoff, and flooding result in impaired or degraded stream habitats. Changes in stream habitat are largely dictated by fluctuations in stream temperatures. Impervious surfaces absorb and reflect heat and during the summer months and they tend to be 10-12 degrees warmer than natural surfaces.[12] Studies report that stream temperatures in urban watersheds increase during the summer months and decrease during the winter months and that seasonal fluctuations in stream temperature is related to the amount of impervious surface in the watershed.[13] Three trends in stream habitat are evident with increasing urbanization of the stream, including a decrease in taxa richness, a decrease in population, and a shift in community composition.[14] It has been documented that as levels of impervious surface coverage within a watershed increase losses of fish, reptiles, and amphibians occur around 25% imperviousness.[15]

Policy Options

There are three main mechanisms to achieving the improvements in stormwater management through impervious surface standards. First, as Chapel Hill continues to grow, the

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[10] Schueler, Thomas R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs, Metropolitan Washington Council of Governments.
[11] Griffin, D.M et al. 1980. Analysis of non-point pollution export from small catchments. Journal of the Water Pollution Control Federation, 52,4:780-790.
[12] Schueler, 1994.
[13] Galli, J. 1991. Thermal impacts associated with urbanization and stormwater management best management practices. Metropolitan Washington Council of Governments. Maryland Department of the Environment. Washington, DC 188 pp.
[14] Garie, Henry L and McIntosh, Alan. 1986. Distribution of Benthic Macroinvertebrates in a Stream Exposed to Urban Runoff. Water Resources Bulletin. 22:447-458.
[15] Schueler, T. and John Galli. 1992. Environmental Impacts of Stormwater Ponds. In Watershed Restoration SourceBook. Anacostia Restoration Team. Metropolitan Washington Council of Governments. Washington, DC, 242 pp.

Town can take measures to reduce the amount of impervious cover associated with new and existing development as redevelopment and expansion take place. These measures include increasing impervious surface limits in critical environmental areas and adopting site design standards for new development. Second, the Town can introduce measures to reduce the effects of runoff from development. This is done at both the construction stage and post construction stage through sediment and erosion controls and the introduction of best management practices (BMPs). Finally, improved stormwater management can be accomplished through public education and outreach to local residents, property owners, and developers. Regardless of the specific policy or combination of policies the Town of Chapel Hill should adopt, implementation must include monitoring and enforcement mechanisms. The remainder of the report presents a range of options illustrated through definitions, case studies, and examples of policies and available to the town to better manage impervious surfaces.

Impervious Cover Standards

Impervious surfaces standards are being used for watershed planning at the state, regional, and municipal level to minimize the effects of non-point source pollutants on water quality, to protect terrestrial and aquatic habitats, and to reduce the potential for flooding. Efforts to mitigate the cumulative impacts of imperviousness on watershed hydrology, water quality, and stream habitats must be a combination of restoration and protection measures backed by specific land use policies. Land use policies that address imperviousness do so directly, through impervious surface limits or limits on the built upon area of a site, or indirectly through site design and open space preservation. In Chapel Hill, policies for managing impervious surfaces currently apply within three overlay districts (Resource Conservation District, Water Quality District, and Watershed Protection District). The town does not mandate impervious surface standards in the planning area outside the overlay zones. Recommendations follow for better management of impervious surfaces both within the overlay districts and for the remainder of the Chapel Hill planning areas.

Overlay District Impervious Surface Limits

A practical mechanism for controlling the amount and impact of impervious surfaces in a watershed is by placing site level limits on imperviousness in critical areas with the use of overlay zones. Site level limits place restrictions on the quantity of impervious surface or built upon area allowed on a site. Currently, Chapel Hill limits the amount of impervious surfaces in the Resource Conservation District, the Watershed Protection District, and the Water Quality District. The Resource Conservation District limits impervious surface cover on any zoning lot to 20% impervious surface in sewered areas, 12% impervious surface cover in unsewered areas, and 6% impervious surface in the Town-Designated Water Critical Area.[16] In addition, impervious surfaces are limited within the Watershed Protection District and the Water Quality District according to two development options. The first is a Low Density Option in which development activities shall not exceed 2 DU/acre or 24% impervious surface area. The second is a High Density Option in which development activities exceeding the Low Density Option

[16] Chapel Hill, North Carolina Development Ordinance, July 2000 Edition (Adopted May 11, 1981. Revised with Town Council Amendments through July 5, 2000.), Article 5 – Resource Conservation District 5.5.2.2

requirements must control the runoff from the first inch of rainfall and the built-upon area may not exceed 50% gross land area.[17]

The current limits in the Chapel Hill Watershed Protection and Water Quality Districts conform to the state of North Carolina Water Supply Watershed Protection Rules adopted in 1992. The rules require that all local governments possessing land use jurisdiction within water supply watersheds adopt and implement water supply watershed protection ordinances, maps, and a management plan. The purpose of the program is to maintain the water quality in those watersheds supporting public drinking water supplies. A key component of the watershed protection ordinances are impervious surface limits established within critical and protected areas of the water supply watershed. Box 1 presents the key components of the water supply protection rules with regard to critical and protected areas.

There are three main alternatives to better management of impervious surfaces in the Resource Conservation, Watershed Protection, and Water Quality Districts including:

- Enlarge the Watershed Protection and Water Quality Districts beyond that mandated by the state;
- Require wider buffers for intermittent perennial streams in the RCD and watershed protection districts;
- Implement more stringent impervious surface limits than proscribed by the Water Supply Watershed Protection rules; and
- Require watershed development plans for all development within the water supply watershed.
- Eliminate the RCD overlay district in lieu of buffer rules similar to the Neuse River or Tar/Pamlico Buffer Rules.

Box 1: North Carolina Water Supply Watershed Protection Program Definitions and Limits

Critical Areas: Land immediately adjacent to a water supply intake where the risk associated with pollution is greatest within the watershed, including land within ½ mile upstream and draining to a river intake, or within ½ mile and draining to the normal pool elevation of water supply reservoirs

Protected Areas: Land within 5 miles and draining to the normal pool elevation of water supplies, or within 10 miles upstream and draining to a river intake

Watershed Classification and Development Density

Watershed Classification	Allowable Built-Upon Area: Low Density	Allowable Built-Upon Area: High Density
WS-I Watershed	none	none
WS-II Critical	1 du/2 acres 6%	6-24%
WS-II	1 du/acre 12%	12-30%
WS-III Critical	1 du/acre 12%	12-30%
WS-III	2 du/acre 24%	24-50%
WS-IV Critical	2 du/acre 24%	24-50%

[17] CHDO, Article 10 – Watershed Protection District, Section 10.5.2

For example, the town of ***Greensboro, NC***, requires that a watershed development plan be submitted for approval for any new development or redevelopment project in a water supply watershed. The plan must show the following:

- Built upon areas do not exceed the maximum impervious surface allowed;
- For high density development sites, the plan must show how BMP's will be implemented to improve the quality of runoff;
- Low density development must indicate how the site design will minimize impacts on the environment;
- The plan must show buffers along to the streams to be protected.

Managing Impervious Surfaces Outside the Overlay Districts

Managing impervious surfaces in areas outside the three overlay zones is equally important as those standards set for the overlay zones. Due to the current levels of development, management of impervious surfaces in the developed and developing areas of the Town requires a different approach than mandating site level impervious surfaces limits. Several options for the Town include enforcing more stringent stormwater run-off requirements and implementing an urban forestry program that requires reforestation or forest set-asides for all development sites. These strategies are currently being used by the ***Chesapeake Bay Critical Area Commission*** to protect the Bay and its tributaries. The Critical Area Act, adopted in 1984, established a set of criteria to guide new development within the "Critical Area" of the Chesapeake Bay. The Critical Area is defined as "all land within 1,000 feet of the mean high water line of tidal waters, or the landward edge of tidal wetlands and all waters of and lands under the Chesapeake Bay and its

Box 2: Chesapeake Bay Critical Area Act Key Policies and Standards for Mitigating Impacts of Imperviousness

Intensely Developed Areas (IDA): Areas with greater than 20 adjacent acres of residential, commercial, and industrial land uses.

- BMPs must be used to reduce runoff from the site to at least 10% below the load generated from the same site prior to development

Limited Development Areas (LDAs): Areas of low to moderate intensity of development, with housing densities ranging from 1 du/5 acres to 4 du/acre.

- Cleared forests must be replaced at ratios ranging from 1:1 to 3:1
- In-lieu fees are collected when there is an unavoidable forest loss
- Tree planting is required on 15% of a site in which no forest cover currently exists
- Impervious surface limits range from 15-25%

Resource Conservation Areas (RCAs): Land uses characterized by "resource-utilization activities" such as agriculture, aquaculture, commercial forestry and fisheries.

- Residential development is limited to 1 du/acre
- New commercial and industrial development is prohibited
- BMPs are required to prevent agricultural soil erosion.

Source: Chesapeake Bay Critical Area Commission, Maryland Department of Natural Resources tributaries."[18] Box 2 outlines the land classification system and requirement for development all lands located within the Critical Area.

Currently, the Town of Chapel Hill does not require forest set-asides, replacement of cleared forests, or tree planting on a cleared site as part of the development process. Construction sites are regulated with regard to ground cover to prevent soil erosion and sedimentation.[19] However, the forestry requirements identified by the Critical Area Act are intended to minimize the impacts of imperviousness into the future. An urban forestry program in Chapel Hill would protect existing forested areas in the Town and promote reforestation of cleared sites. Requirements on site level forest cover provide developers with incentives to maintain vegetative cover and plant more trees on site. Finally, urban forestry provides an opportunity for community outreach and education that involve citizens in tree-planting activities. In-lieu of fees could be collected from all sites with unavoidable forest loss, which could serve as a funding source for continued forestry and stormwater programs, as well as restoration and reforestation of impaired streams such as Booker Creek, Little Creek, Morgan Creek, and Bolin Creek.

Site Design Techniques: Low Impact Development

The emerging trend in communities concerned with managing stormwater and minimizing the effects of impervious surfaces on local streams, creeks and lakes is implementing Low Impact Development (LID) principles and standards. LID practices equate to minimal disturbance of natural areas, less impervious surfaces, infiltration of stormwater on-site, and enhanced erosion and sedimentation control standards and enforcement procedures. An example of Chapel Hill's commitment to guiding development that conforms to LID principles can be found in the Article 5.6 of the Resource Conservation District stating, "wherever practicable no stormwater discharge shall be allowed directly off an impervious surface into the channel of a watercourse."[20]

Further, Article 9.6.2 of the Water Quality District states that it is

Box 3: Low Impact Development Principles, Prince George's County, MD

Reducing Total Site Imperviousness:

- Design alternative road layouts;
- Narrow road sections;
- Install sidewalks on one side of primary roads;
- Reduce on-street parking;
- Favor vertical construction to reduce rooftop cover;
- Minimizing driveway widths, use shared driveways, and use alternative driveway material to reduce runoff.
- Reduce building setbacks,

Minimizing Directly Connected Impervious Areas:

- Disconnect roof drains and direct flows to vegetated areas;
- Direct flows from paved areas such as driveways to stabilized vegetated areas;
- Break up flow directions from large paved surfaces;
- Encourage sheet flow through vegetated areas;
- Locate impervious areas so that they drain to natural systems, vegetated buffers, natural resource areas, or infiltratable zones/soils.

Source: Prince George's County, Maryland, Department of Environmental Resources

[18] Chesapeake Bay Critical Area Commission, Available: http://www.dnr.state.md.us/criticalarea/
[19] CHDO, Article 14 – Design Standards
[20] CHDO, Article 5 – Resource Conservation District, Section 5.6

Box 4: Low Impact Site Design Standards in Fort Bragg, NC

A 1993 initiative by the U.S. Army in Fort Bragg to build a new vehicle maintenance facility on a 26 acre site adopted site designs that enabled the Army to reduce the development from a total of 25 acres of building and pavement to 14.3 acres.

Original Plan (Cost of 8 million):

- 420 vehicle spaces with no traffic islands or planting tress
- Runoff (up to 48 inches) conveyed through culverts to single discharge outlet into an existing creek
- Removal of all on-site pine trees

Alternative Design (Cost of 6.4 million):

- 520 parking spaces including grassed islands and planted areas
- Eliminated storm drain system with four on-site stormwater management basins discharging into small storm drain systems
- Preservation of on-site trees

Source: Natural Resources Defense Council, Stormwater Strategies in the Southeast

Burnt Hickory Registry in Cobb County, Georgia

"Town Park Planning" strategies for minimizing the impact of imperviousness:

- Moving away from traditional uniform lot sizes that ignore the natural topography of the land;
- Reducing the width of streets to reduce impervious surfaces by 10-20%
- Cul-de-sacs developed with vegetated cover in the middle;
- Providing an 8-foot setback for all sidewalks with trees buffering the sidewalks and the roads;
- Lessening the impact of runoff from the construction site with the use of felled trees to slow runoff from the site, temporary small detention ponds, and filtering sediments through. check dams

Source: Natural Resources Defense Council, Stormwater Strategies in the Southeast

desirable to encourage as much infiltration as possible of runoff from hard surfaces onto land areas that can absorb and filter runoff. This is to prevent damage to the water quality of the reservoirs. However, these principles of managing stormwater are not explicitly stated for areas of the Town located outside the Resource Conservation District and the Water Quality Districts. In addition, development ordinances that apply to the remainder of the Chapel Hill planning area do not manage or limit impervious surface coverage. According to the Chapel Hill Comprehensive Plan, Chapel Hill is committed to encouraging conservation principles in residential development. Comprehensive Plan Strategies 8A-3 and 9B-2 identify goals to decrease the built land area of a site and encourage conservation of open space in residential site design. Given this stated goal, the Town of Chapel Hill should actively promote and encourage LID principles for future development. A number of examples are provided to illustrate how communities are applying these principles to mitigate the effects of impervious surface cover.

Prince George's County, MD, pioneered LID techniques to address problems associated with runoff on new residential, commercial, and industrial development. LID seeks to control stormwater by mimicking the pre-development natural hydrology of a site using techniques that store, infiltrate, evaporate, and detain runoff.[21] ***Box 3*** identifies specific LID

[21] Low Impact Design Strategies: An Integrated Design Approach. Prepared by the Prince George's County Department of Environmental Resources, Programs and Planning Division. July 1999. Available: http://www.epa.gov/owow/nps/lidnatl.pdf

design principles that will reduce the effects of imperviousness on a site by achieving a total reduction in the volume of runoff from impervious surfaces.

LID principles are being used for site development in North Carolina communities as well. Box 4 compares a traditional parking lot design in **Fort Bragg** to one that adopts alternative design principles.[22] This alternative design standard takes advantage of a number of mechanisms to reduce the impact of development on the surrounding environment, including on-site rather than off-site drainage systems, on-site grass islands to protect trees and habitat for an endangered woodpecker, and increased shading of the site from existing and newly planted trees. This illustrates the environmental and economic advantages of implementing alternative site design standards that reduce overall impervious surface cover on a site.

Another good example of LID in practice is found in **Cobb County, Georgia** where an Atlanta developer made use of "town park planning" in residential development to maximize the amount of open space in the residential development and reduce impervious surface cover.[23] Box 4 describes the differences between traditional oriented approaches to sites design to approaches that adopt LID strategies for reducing impervious surface cover.

Some local municipalities are establishing explicit goals to reduce impervious surface cover associated with additional development. **Olympia, Washington** has set a goal for a 20% reduction in future impervious surfaces by the year 2012. This study makes recommendations to reduce impervious surfaces with respect to vehicle-oriented impervious surfaces, construction practices and landscaped areas, design and placement of buildings, and community involvement and education. [24] These recommendations are summarized in Box5.

Implementation and Monitoring

Implementation of impervious surface standards must be done through a variety of mechanism. For example, site level impervious surface limits must be controlled with the use of site design plans indicating the amount of impervious cover on a site. Site design standards would require adopting new street design standards that are in compliance with safety standards for fire and emergency health services. In addition, Low Impact Development standards would require a revision of commercial and residential development standards for the town.

The key element with respect to monitoring impervious surfaces within the Town of Chapel Hill is to make a regular assessment of impervious cover in Chapel Hill's watershed on a regular basis. Such an assessment should be done every 1-5 years in order to assess the overall watershed health.

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[22] Lehner, Peter, Aponte Clark, George, Cameron, Diane, and Frank, Andrew. Stormwater Strategies: Community Responses to Runoff Pollution. National Resources Defence Council, May 1999.
[23] Lehner et al
[24] City of Olympia, Washington. 1995. Impervious Surface Reduction Study: Final Report. City of Olympia Public Works Department.

> **Box 5: Olympia, Washington Impervious Surface Reduction Study, 1995**
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> *Vehicle-Oriented Pavement:*
> - Provide public transportation that reduces the need for streets and parking
> - Implement standards for narrower residential streets with reduced parking
> - Use pavers and other pervious surfaces for overflow parking and emergency access roads
> - Narrow alley widths using alternative surfaces and/or design alleys to drain into vegetated strips or central drains
> - Encourage cooperative, shared, and coordinated parking
> - Encourage underground and multi-storied parking structures
> - Develop parking regulations that limit the amount of impervious surface
> - Gently slope sidewalks away from the streets and toward vegetated strips
>
> *Constructions Practices:*
> - Limit soil compaction on newly developed residential and commercial sites
> - Reduce soil compaction and restore infiltration on already cleared sites
> - Limit land clearing on newly developed residential and commercial sites
> - Encourage homeowner association covenants, plat map conditions, and/or conservation easement that protect existing vegetation and undisturbed areas
>
> *Design and Placement of Buildings:*
> - Encourage cluster development that minimizes impervious surfaces
> - Encourage the building and use of taller structures to reduce the size of building footprints
>
> *Source: City of Olympia, Impervious Surface Reduction Study Final Report*

Another mechanism for implementing and monitoring impervious surface standards is through a stormwater utility. A stormwater utility provides funding from a utility fee to manage programs to reduce or eliminate the problems associated with stormwater management. Stormwater utilities are a good opportunity to combine capital improvements with impervious surface standards and they educate the public on issues of stormwater management and run-off control as well as providing incentives for developers to reduce site level imperviousness. Local municipalities, including Charlotte, Greensboro, and Durham, in North Carolina are using stormwater utilities to fund local agencies to oversee stormwater management, such as the Stormwater Services Division in Greensboro. The Stormwater Services Division is responsible for monitoring water quality in streams, stormwater master planning, environmental education of the public, and implementing capital improvement projects.

Best Management Practices (BMPs)

Even with impervious limits, the effects of runoff from new development and existing impervious surfaces will continue to increase. These effects include the erosion of stream banks, silt and sedimentation buildup, pollutant loading, and increased potential for flooding as higher volumes of water enter the stream channel. Reducing the effects of runoff from impervious surfaces must address essentially two development stages: construction stage and post-construction stage. First, during construction, measures must be taken to prevent sedimentation and erosion created by the movement of earth and by the lack of permanent controls to mitigate runoff. Second, development must provide controls that both reduce the amount and timing of runoff from sites and improve the quality of runoff to- at a minimum- natural, pre-construction conditions. The first is done primarily through sediment and erosion controls and the latter through the introduction of best management practices (BMPs).

Definitions

Currently, the Chapel Hill Ordinance targets stormwater controls in the watershed overlay districts as a means to protect water quality. In the Watershed Protection District, BMPs are combined with a land use intensity option in its through a combination of "density limits and engineered stormwater controls to minimize the risk of water pollution".[25] In the Resource Conservation District (RCD), BMPs are encouraged in stream buffers where "water dependent structures, and public projects such as road crossings and greenways may be allowed where no practicable alternative exists".[26] However, the same end goals of pollutant and sediment reduction can be achieved while reducing the rates and amounts of water entering Chapel Hill streams through the implementation of BMPs.

Box 6: Ten Elements of an Effective Erosion and Sediment Control (ESC) Plan

- Minimize Needless Clearing & Grading
- Protect Waterways & Stabilize Drainage Ways
- Phase Construction to Limit Soil Exposure & Compaction
- Stabilize Exposed Soils Immediately
- Protect Steep Slopes & Cuts
- Install Perimeter Controls to Filter Sediments
- Employ Advanced Sediment Settling Controls
- Certify Contractors on ESC Plan Implementation
- Adjust ESC Plan at Construction Site
- Assess ESC Practices After Storms

Source: Eight Tools of Watershed Protection in Developing Areas. Center for Watershed Protection, Environmental Protection Agency, Office of Water Quality.

The Chapel Hill Development Ordinance defines BMPs as a "structural or nonstructural management-based practice used singularly or in combination to reduce non-point source pollution inputs to receiving waters in order to achieve water quality protection goals"[27]. Whereas this definition reflects the traditional target of BMPs to reduce pollutants, it does not address flood mitigation. A more thorough definition is provided by the and in the ***State of Maryland*** as "a structural device or nonstructural practice designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities"[28]. This is a derivative of the definition provided in the U.S. Environmental Protection Agency technical documents [29]

BMPs can be implemented independently of impervious surface standards, or in combination with impervious surface standards. Combinations of approaches are generally more

[25] CHDO, Article 10 – Watershed Protection District, Section 10.5.2.
[26] CHDO, Article 10 – Watershed Protection District, Section 10.6.
[27] Chapel Hill, North Carolina Development Ordinance, July 2000 Edition (Adopted May 11, 1981. Revised with Town Council Amendments through July 5, 2000.), Article 2 – Definitions, Section 2.9.3.
[28] Title 26, Maryland Department of the Environment, Subtitle 17 Water Management.
[29] Schueler, Thomas, R., Kumble, Peter A., and Heraty, Maureen A. A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-Point Source Pollution in the Coastal Zone. Anacostia Restoration Team. Metropolitan Washington Council of Governments. Washington, DC, March, 1992.

BOX 7: Construction Phase Enforcement
Charlotte, NC & Chattanooga, TN

Charlotte, NC combines enforcement tools through preconstruction plan approval, permit fees, frequent inspections (weekly or bi-weekly), and fines of $250 - $500 for violations. This is backed by citizen Adopt-A-Stream groups that regularly identify violations otherwise not caught by staff.

Source: City of Charlotte, NC

Chattanooga, TN, enforcement officers have implemented an Erosion Control School with the Chattanooga Home Builders' Association. Although currently voluntary, the program has certified over 185 developers in 3 years, and the City intends to make the education program mandatory for all developers. Violations are fined $500 to $5000 per day.

Source: Tennessee Department of Public Works

effective than single-measure approaches. For example, the ***State of Maryland*** generally requires all municipalities to develop watershed management plans, reducing the amount of stormwater runoff through decreased impervious surfaces, installation of BMPs, or both in new development and redevelopment.[30]

Construction Phase Sediment and Erosion Controls

Construction phase erosion and sediment control (ESC) plans are required for all land clearing activities in Chapel Hill.[31] Generally, BMPs used in construction phases include silt fencing, riprap, and temporary sediment basins; however, the most effective form of control is limiting the amount of cleared land altogether. The key policy options available for the Town of Chapel Hill, therefore, are either to increase the ESC regulations, increase enforcement of existing regulations, or both.

Erosion and sediment control regulations may be strengthened through additional on-site and off-site requirements during construction and stabilizing a site after construction. For example, the ***City of Durham, NC*** requires an erosion control plan for all development greater than one 1 acre in size. Unlike Chapel Hill, Durham also requires the installation of perimeter buffers and revegetation after all land clearing activities have been completed.[32] BOX 6 identifies elements of ESC plans advocated by the Center for Watershed Protection. Second to less land disturbance, the most effective stormwater management tool during construction is increased enforcement. Policy options include:

- improved monitoring programs;
- frequent inspections;
- incentives for less land clearance; and
- strict penalties (e.g., fines) for violations.

BOX 7 identifies effective ESC enforcement programs in ***Charlotte, NC***, and ***Chatanooga, TN***. Integral in both is regular inspections and adequate staffing to enforce the programs.

Implementing Urban BMPs in New Development

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[30] Title 26, Maryland Department of the Environment, Subtitle 17 Water Management.
[31] CHDO, Article 14 – Design Standards, Section 14.8.
[32] City of Durham Zoning Ordinance, Section 8.1.29 Land Disturbance.

Case studies have shown that implementation of BMPs has been effective to improving overall urban watershed conditions.[33] BMPs can be either structural, such as detention ponds, or non-structural, such as land use regulations or public education.

Performance standards for implementing BMPs range from retaining or detaining water volumes in storm events to reducing pollutant loading from urban uses. Four general opportunities related to BMPs in new development are available for Chapel Hill to improve water quality and quantity objectives and to work toward a sustainable, holistic watershed management approach. These include:

1. introduction of alternative BMPs;
2. implementing BMPs to reduce off-site water quantity and flooding impacts;
3. implementing BMPs to improve water quality and pollutant loading; and
4. increasing district coverage for BMP requirements.

First, Chapel Hill can provide guidance for alternative BMPs to meet stormwater management objectives. The most common BMP in Chapel Hill is the detention pond; specifically, the Watershed Protection District requires stormwater controls be "designed to control the first one inch of stormwater using wet detention ponds".[34] However, other BMPs have been shown to provide pollutant control and prevention at greater levels than detention ponds, and the use of more than one method has been shown to be more effective than single BMPs.[35] Appendix B provides a description of different types of BMPs available to the Town of Chapel Hill, developers and residents. In addition, charts that compare the benefits and suitability of different types of BMPs are included.

No specific guidelines exist for the most appropriate combination of BMPs for any given site; however, considerations by developers and land use managers in selecting site-specific BMPs include:

- type of land use (e.g., residential or commercial);
- water quality goals (e.g., pollutant prevention, flood control or both);
- physical characteristics (e.g., drainage area, slope, soils);
- costs of improvements; and
- long-term maintenance.

[33] Lehner, Peter, Aponte Clark, George, Cameron, Diane, and Frank, Andrew. Stormwater Strategies: Community Responses to Runoff Pollution. National Resources Defence Council, May 1999.
[34] CHDO, Article 10 – Watershed Protection District, Section 10.7.3.
[35] Schueler, March, 1992

As discussed under the impervious cover standards, a recent trend in site development is Low Impact Development, a site development concept of maintaining the hydrologic functions of a site through site design.[36] Many of the examples listed in the ***Prince George's County*** example act as structural and non-structural BMPs.

> **Box 8: Durham, NC & Greensboro, NC Peak Runoff and the "10% Rule"**
>
> Durham, NC ordinances requires stormwater controls to maintain the first one inch of runoff onsite (Section 5.5.7 Water Protection Overly District, Stormwater Control Requirements). In addition, the City also requires a stormwater impact analysis for development that increases peak runoff from the 2- or 10-year storm by more than 10% offsite (Section 8.1.26 Stormwater Controls for Offsite Impacts).
>
> *Source: Durham, NC Zoning Ordinance*
>
> In Greensboro, NC, where a development shows an increase above the "10% Rule", stormwater controls are to be installed to "limit the 2- and 10-year post-development peak discharge rates to pre-development peak discharge rates, to minimize increased flooding, drainage, and erosion problems". The ordinance further encourages a combination of both nonstructural controls (e.g., "natural swales, depressions in the land and other natural approaches") and structural controls (e.g., "detention structures (wet and dry basins), extended detention facilities and alternative best management practices with provisions for stormwater quantity control").
>
> *Source: City of Greensboro , NC Development Ordinance, Article VII*

Second, Chapel Hill may consider specifying limits on the discharge of water off-site. This is often measured in peak discharge or as a percent increase over a measurable storm event, such as a 2- or 10-year storm. Several local governments in North Carolina, including ***Durham*** and ***Greensboro***, apply a "10% Rule"; that is, peak runoff from a site cannot increase off-site peak runoff by more than 10% (See Box 8). Stormwater controls and BMPs become an integral site component to maintaining post-development runoff limits.

Third, more specific standards need to be established for water quality, particularly since BMPs are defined as a measure to control water pollution. Currently, Chapel Hill only requires detention ponds to detain the first inch of peak stormwater in the Water Protection District.[37] However, where ponds effectively detain water conveyance, they do not provide the most effective form of pollutant removal, and may not be effective in smaller watersheds (e.g., less than 10 acres)[38]. Therefore, the introduction of water quality performance standards should be incorporated into an overall watershed management plan. The ***Neuse River Basin Rules*** utilize a coordinated approach to pollutant reduction through peak flow limitations, impervious cover standards, site development recommendations and BMPs. Box 9 discusses Neuse's 30% nitrogen reduction rule, and the assignment of "credits" for site development to meet the new standards. Chapel Hill may consider similar rules, particularly as the Cape Fear River Basin considers amendments to its rules in the next few years.

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[36] Low Impact Development (LID): A Literature Review, United States Office of Water (4203) EPA-841-B-00-005 Environmental Protection Agency Washington, DC, October 2000.
[37] CHDO, Article 10 – Watershed Protection District, Section 10.7.3.
[38] Schueler, March, 1992.

Finally, district coverage can be expanded to include BMP requirements and specific runoff requirements for areas <u>outside</u> of the watershed overlay districts. The Chapel Hill Ordinance currently requires submittal of a drainage plan with general provisions for stormwater management for any land clearance of greater than 20,000 square feet.[39] Under the ***City of Charlotte, NC***, Zoning Ordinance, developments are approved where "the peak level of storm water runoff from the site, unless the drainage plan identifies measures to control and limit runoff to peak levels no greater than would occur from the site if left in its natural, undeveloped condition"[40].

Redevelopment & Retrofitting Activities

Given that the Town of Chapel Hill Urban Services District is 90% built out, redevelopment activities should be targeted to either reduce runoff, or at a minimum, maintain the amount of runoff currently exiting a site. "Retrofitting" means the construction of structural BMPs in previously developed areas, the modification of existing structural BMPs, or the implementation of nonstructural practices to improve water quality over current conditions[41]. Alternatively, retrofitting has been defined as "a process that involves the modification of existing surface water runoff control structures or surface water runoff conveyance systems which were designed to control flooding, so they

Box 9: Neuse River Basin Rules
Basinwide Land Use & BMP
Approach to Pollutant Reduction

The Neuse River Basin has some of the most stringent water quality guidelines in North Carolina. Specifically, the Rules target a basin-wide nitrogen reduction goal of 30%, and individual communities are required to adopt regulations to meet the basin standard that there be no net increase in peak flow leaving the site from the predevelopment conditions for the 1-year, 24-hour storm. This is determined first by the 10% Rule that the increase in peak flow between pre- and post-development conditions cannot exceed ten percent. Second, the proposed new development has to have overall impervious surfaces of less than fifteen percent, and the remaining pervious portions of the site are utilized to the maximum extent practical to convey and control the stormwater runoff. In order to streamline the process, the Neuse River Basin assigns specific nitrogen reduction credits to certain BMPs that have been found to effectively reduce nutrient loading.

BMP Type	Nitrogen Removal Rate
Wet detention ponds (1)	25%
Constructed wetlands (1)	40%
Open channel practices (1)	30%
Riparian buffers (2)	30%
Vegetated buffer strips & level spreader (1)	20%
Bioretention (1)	25%
Sand filters (1)	35%

(1) NC and MD Design Manuals
(2) Orange Co. Buffer Standards

Further, the Neuse River Basin Plan identifies specific site development techniques to be incorporated wherever possible in new development. These include minimizing road widths, reduced parking requirements, less use of curb and gutter, increased cluster or open space developments, maximized use of traditional neighborhoods and mixed use developments.

Source: Neuse River Basin Water Quality Plan, Section 11 Land Use Planning Provisions

[39] CHDO, Article 14 – Design Standards, Section 14.7 Drainage and Storm Water Management requires: "Natural drainage systems and storm water management installations shall be designed, constructed, and maintained so as to 1) provide for natural infiltration of storm water; 2) control velocity of run-off flows; 3) extend the time of concentration of storm water run-off; and 4) to collect and transmit excess storm water flows into either the Town drainage system or into a natural drainage system."
[40] Charlotte, North Carolina Zoning Ordinance, Section 12.
[41] Title 26, Maryland Department of the Environment, Subtitle 17 Water Management.

will also serve a water quality improvement function". [42]

Currently, the Town Water Quality District permits redeveloped areas up to a 10% increase over the permitted imperviousness of the watershed protection area. This permits, therefore, up to 34% imperviousness in a low-density development and up to a 60% imperviousness in high-density area with BMPs. An alternative is described in Box 10 for a more stringent redevelopment regulation applied in ***Alexandria, VA***, designed to not only maintain pollutant runoff, but to decrease impacts of redevelopment.

Retrofit activities can be implemented by private property owners, by public agencies or both. Again, ***Alexandria, VA,*** provides a rigorous program to reduce pollutants through public and private retrofits and required retrofitting in redevelopment proposals. Locally, ***Orange County*** is instituting a retrofit program under the Neuse River Basin watershed management plan where a minimum of three retrofit sites are required to be identified each year. [43] Targeting and prioritizing retrofit opportunities is particularly important for communities that may have financial or political constraints, or where limited land is available to integrate conventional BMPs such as detention ponds.[44] Chapel Hill has some prime areas for retrofit; examples may include Eastgate Shopping Center, Lake Ellen dam or Eastwood Lake.

Monitoring, Enforcement and Performance Benchmarks

Studies of BMPs and stormwater management programs have identified that strong monitoring programs, clearly articulated performance standards and regular enforcement are key to improving overall watershed health. Enforcement should include both strong incentives and strong disincentives that produce a high level of accountability.[45]

Erosion and sediment control monitoring and enforcement were briefly discussed in the preceding section and in the case studies. Integral to the effectiveness of these programs is enforcement through consistent inspections.

Unfortunately, data on BMP effectiveness do not provide uniform performance standards. First, some BMPs, particularly non-structural BMPs and those that do not have discrete inflow or outflow points, are difficult to monitor. Therefore, non-structural BMPs effectiveness will be reliant on program-related benchmarks. Second, benefits of BMPs are largely site-specific and are dependent on a variety of factors, including intensity and frequency of storms, characteristics of receiving waters (e.g., perennial, fast flowing vs. intermittent, first-flush streams), and physical characteristics of the land (e.g., soils, slope, land use).[46] However, this should not preclude establishing performance standards for pollutant reduction, decreased water volumes

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[42] Developing Successful Runoff Control Programs For Urbanized Areas. Northern Virginia Soil and Water Conservation District: Fairfax, Virginia, 1994.
[43] Neuse River Basin Water Quality Plan.
[44] Northern Virginia Soil and Water Conservation District, July 1, 1994.
[45] Lehner, Peter, Aponte Clark, George, Cameron, Diane, and Frank, Andrew. Stormwater Strategies: Community Responses to Runoff Pollution. National Resources Defence Council, May 1999.
[46] Preliminary Data Summary of Urban Stormwater Best Management Practices, Environmental Protection Agency, EPA-821-R-99-012, August, 1999.

and conveyance times, maintenance standards and inspections. Several measures were discussed in the preceding sections and in the case studies. For example, water quality measures should be conducted consistently and ongoing in accordance with standard protocols, such as those established by the American Society of Civil Engineers (ASCE) for the National Stormwater BMP Database.

Appendix B includes examples of performance measures that the Town of Chapel Hill may consider. In addition, tables are provided that illustrate pollutant removal rates of various tested BMPs; these may serve as performance benchmarks as well.

Conclusions

If the Town of Chapel Hill is to proactively prevent future flooding of homes and residents, decrease levels of sedimentation and stream bank erosion, and improve the health of urban steams, lakes, and creeks, it must adopt a more forward-thinking approach to managing impervious surfaces. The scientific literature provides evidence that increasing levels of imperviousness in a watershed lead to degraded waterways and stream habitats, increased flooding, and poor water quality. Whereas Chapel Hill is currently meeting state mandates for stormwater, other communities are improving their stormwater management programs to meet even more stringent standards. Further, state and federal programs such as the NPDES Phase II requirements and the possible adoption of new Cape Fear River Basin rules will necessitate more rigorous stormwater management techniques in the Town of Chapel Hill.

Management of impervious surfaces provides the town with an opportunity to adopt a more holistic approach to stormwater management that focuses on watershed health. Adopting improved standards and guidelines for impervious surfaces and BMPs presents opportunities for the Town of Chapel Hill to improve the quality of life for its residents and to be a "good neighbor" to nearby municipalities who are affected by Chapel Hill's stormwater practices and policies. The importance of managing impervious surfaces is not completely unrecognized by the town. However, recent events, such as the flooding of Eastgate and the continual degradation of Bolin and Booker Creeks, have left residents of the community concerned about the adequacy of the existing policies with regard to imperviousness.

This paper presented a range of options to improve and enhance the town's current policies. Ultimately, an approach that incorporates impervious surface standards such as low impact design and better soil erosion and control measures such as BMPs will sustain Chapel Hill's unique natural character, as well as protect water quality for future residents. It is for these reasons that the Town of Chapel Hill should consider the follow "next steps" to better management of impervious surfaces.

Next Steps

The next steps for the Town of Chapel Hill to take toward a sustainable watershed management program include consideration of guidelines and regulations to enhance the existing requirements. Specific to impervious surface standards and BMPs, the following steps are recommended for consideration:

- *The Town of Chapel Hill should re-evaluate how impervious surfaces are being managed in the RCD and the Water Supply and Watershed Protection Districts.* The Division of Water Quality Water Supply Watershed Protection rules set the minimum standards for development within water supply watersheds. Improving upon these minimum requirements includes expanding the jurisdictions of the Water Supply and Watershed Protection Districts to more effectively protect the Jordan Lake and University Lake reservoirs and setting more stringent imperviousness surface limits for new development and redevelopment.

- *The Town of Chapel Hill should re-evaluate the intermittent and perennial stream buffer requirements in the RCD and the Watershed Protection Districts.* Currently, buffers are required for both low- and high-density development within in the Watershed Protection District at 30-feet and 100-feet, respectively. The town should consider expanding these buffer requirements and require buffers for all intermittent and perennial streams.

- *The Town of Chapel Hill should consider Low Impact Development standards for new development in order to reduce the overall impervious surface cover on a site.* Alternative design standards such as LID are becoming more widely used and are easily transferable to site designs in Chapel Hill. LID should be considered as a feasible alternative for managing impervious surfaces associated with new development, as well as retrofitting options for existing development (Appendix A includes a detailed overview of LID standards).

- *The Town of Chapel Hill should implement an Urban Forestry Program in order to preserve open space and prevent the unnecessary clearing of development sites.* An urban forestry program could include forest set-aside requirements, in-lieu of fees for unavoidable removal of forest cover, and a forest replacement requirement for all development sites. Such a program would enhance Chapel Hill's existing forest resource and provide on-site economic benefits such as energy savings due to increased shading. Finally, such a program is an opportunity for to increase public involvement in community enhancement activities.

- *The Town of Chapel Hill should implement a stormwater utility to generate revenues for capital improvements to the existing stormwater infrastructure.* A stormwater utility that charges fees based on total impervious surface area of a site will provide an incentive to developers to adopt site design standards that reduce overall impervious surface cover on a site. Finally, a stormwater utility will be a dedicated source of funding to resolve the current problems associated with stormwater management and implement new policies that comply with the NPDES Phase II requirements.

- *The Town of Chapel Hill should revise its scope and definition of BMPs.* The traditional definition of BMPs has expanded from a water quality protection measure to an all-inclusive watershed health control, targeting both water quality and water quantity goals.

- *The Town of Chapel Hill must increase its enforcement of erosion and sedimentation from construction practices.* Second to reducing the amount of land disturbed during construction, the most effective stormwater management tool is increased enforcement of sediment and erosion control.

- *The Town of Chapel Hill should, at a minimum, provide construction guidelines on the installation of alternative BMPs.* BMPs should be site-specific, taking into consideration the land uses, soils, topography and other site-specific considerations. Implementation of multiple or secondary BMPs onsite is more effective than single measures used to control runoff.

- *The Town of Chapel Hill should consider adopting more stringent performance standards for off-site impacts from runoff.* BMPs have been effectively integrated into site development requirements in order to meet regulations to reduce off-site impacts of increased flooding and pollutant loading of streams.

- *The Town of Chapel Hill should incorporate a retrofitting program into its capital improvements program,* identifying public-private retrofit opportunities and prioritizing funding and resource allocation to BMP retrofit sites.

- *The Town of Chapel Hill must integrate a rigorous monitoring and enforcement program for the implementation of BMPs.* Studies of BMPs and stormwater management programs have identified that strong monitoring programs, clearly articulated performance standards and regular enforcement are key to improving overall watershed health. Stringent regulations attached to the performance of each of these measures must be clearly articulated to developers and property owners.

Appendix A:
Impervious Surface Standards & Low Impact Development Guidelines

Construction Materials and Surfaces
that Generate Most Frequently Asked Questions Regarding Perviousness

Type of Structure	Impervious	Pervious	Notes
Deck, special Construction	X		Spaces between boards, 6" gravel under deck, plantings
Driveway, asphalt	X		
Driveway, bank run gravel	X		Use causes gravel to become compacted over time
Driveway, blue chip stone	X		Use causes stone to become compacted over time
Driveway, concrete	X		
Driveway, oyster shell	X		Use causes shells to become compacted over time
Driveway, pavers			Site-specific evaluation determines imperviousness
Parking lots, gravel	X		Use causes gravel to become compacted over time
Parking lots, gravel overflow	X		Use causes gravel to become compacted over time
Parking lots, gravel overflow	X		Use causes gravel to become compacted over time
Parking lots, "turf block"	X		Use causes turf to become compacted over time
Patios, brick on sand	X		
Sidewalks, concrete	X		
Sidewalks, brick and mortar	X		
Sidewalks, brick on sand	X		
Sidewalk, wood (boardwalk)		X	Spaces between boards, 6" gravel under deck, plantings
Swimming Pools, in-ground	X		
Swimming Pools, above ground	X		
Tennis Courts, asphalt or polymer	X		
Tennis Courts, clay	X		
Tennis Courts, grass	X		
Walkways, gravel			Site specific determines perviousness
Walkways, wood chip		X	

Source: Chesapeake Bay Critical Area Commission. Impervious Surfaces. Prepared by Mary Owens.

Impacts of Impervious Surfaces

	Resulting Impacts				
Increased Imperviousness Leads to:	**Flooding**	**Habitat Loss**	**Soil Erosion**	**Channel Widening**	**Streambed Alteration**
Increased Volume	X	X	X	X	X
Increased Peak Flow	X	X	X	X	X
Increased Peak Flow Duration	X	X	X	X	X
Increased Stream Temperature		X			
Decreased Base Flow		X			
Changes in Sediment Loadings	X	X	X	X	X

Source: Urbanization of Streams: Studies of Hydrologic Impacts, EPA 841-R-97-009, 1997

An Overview of Low Impact Development (LID)
Source: Adopted from the Low Impact Development (LID) Literature Review, EPA-841-B-00-005, October 2000.

Low Impact Development is based on microscale controls that are distributed throughout the site. There are two types of Low Impact Development measures including those that reduce Effective Impervious Area (EIA), or the amount of imperviousness directly connected to the storm drain system, and measures to reduce the Total Impervious Area (TIA) of a site, including the total amount of impervious surfaces on a site. An overview is provided below of the benefits of imperviousness, the challenges associated with implementation of LID measures, and common types of LID practices. LID seeks to preserve and protect of environmentally sensitive site features such as riparian buffers, wetlands, steep slopes, valuable (mature trees), flood plains, woodlands and highly permeable soils.

Benefits of LID:

- Easily integrated into infrastructure
- More cost effective and aesthetically pleasing than traditional stormwater conveyance systems
- Less disturbance of the development area
- Conservation of natural features
- Less intensive than traditional stormwater control mechanisms
- Cost saving for construction activities and long-term maintenance

Challenges of LID include:

- May need to be implemented in conjunction with structural BMPs in order to achieve watershed objectives
- The appropriateness of LID is dependent of site conditions
- Soil permeability, slope and water table depth must be evaluated in order to effectively use LID practices
- Existing development ordinances may restrict innovative practices associated with LID such as subdivision codes, zoning regulations, parking and street standards, and local ordinances
- The community may be resistant to LID in terms of lot sizes and street design

Low Impact Development Practices:

1) Bioretention Areas: Bioretention systems are designed based on soil types, site conditions, and land uses. They are effective in reducing runoff volume and treating the first flush (first ½ inch) of stormwater. There are six components of a bioretention system: grass buffer strips, sand beds, ponding areas, organic layers, planting soil, and vegetation.

   Cost: $5,000-$10,000 per acre drained (Prince George's County, MD)

$3-$15 per square foot of bioretention area

2) Grass Swales: Grass swales are open channel systems most appropriate for smaller drainage areas with mildly sloping topography. They are effective at reducing runoff velocity and maximizing filtration and infiltration.

   Cost: $40-$50 per running foot

3) Vegetated Roof Cover/Green Roofs: Green roofs consist of a vegetative layer, media, a geotextile layer, and a synthetic drain layer. They reduce the amount of impervious surfaces in urban areas and they are particularly effective in aging urban areas with sewer overflow problems. Green roofs reduce the total runoff volume from a building and can be building can be easily retrofitted with green roofs without structural design changes to the building.

4) Permeable Pavements: Porous pavements are best suited for low traffic areas, such as parking lots, sidewalks, and driveways. Permeable pavements allow stormwater to infiltrate into the underlying soils as opposed to impervious pavements which generate large volumes of runoff.

Appendix B:
Structural & Non-Structural BMPs

Types of Stormwater Best Management Practices
Source: Adapted from the Preliminary Data Summary of
Urban Stormwater Best Management Practices,
EPA-821-R-99-012, August 1999

Structural BMP's

Dry Detention Basins - temporary detention of stormwater runoff where it is slowly released to reduce flooding and to remove a limited amount of pollutants by allowing them to settle out of the water as it drains; referred to as "dry detention" or "dry ponds" because they dry between rain events. Overall pollutant removal in dry detention devices is low to moderate.

Wet Retention Ponds – maintain permanent water; temporarily detain stormwater; construction of forebays into ponds reduces debris buildup

Wetlands, Constructed/ Wetlands, Natural and Restored – absorb nutrients, retain water, increase infiltration, trap sediments, minimize point and non-point source pollutants from downstream waters

Porous Pavement - to reduce imperviousness and minimize surface runoff; may be coarse asphalt or concrete usually laid over a thick base of granular material or may be modular, interlocking open-cell cement blocks laid over a base of coarse gravel; requires permeable soils with a deep water table and traffic must be restricted to exclude heavy vehicles

Infiltration Devices/Systems - include infiltration basins, infiltration trenches, porous pavement and dry wells; only be used where the soil is porous and can absorb the required quality of stormwater

Filter Strips – groups of close-growing vegetation between pollutant sources and receiving water; can include shrubs or woody plants that help to stabilize the grass strip, or can be composed entirely of trees and other natural vegetation; do not provide enough runoff storage or infiltration alone, therefore filter strips should be used as only one component in a stormwater management system

Grassed Swales - earthen channels covered with a dense growth of a hardy grass; used primarily in single-family residential developments, at the outlets of road culverts, and as highway medians; limited capacity to convey runoff from large or intense storms; often lead into concrete lined channels or other stable stormwater control structures

Media Filter (e.g., Sand Filters) – sand traps settle out particles in the pretreatment devices and strain out particles in the filter

Water Quality Inlets (e.g., Oil and Grease Trap Devices) - oil-water separators usually installed at industrial sites; oil and grease trap catch basin (or oil and grit separator) are underground devices usually to catch oil and fuel that leak from automobiles and trucks in parking lots, service stations, and loading areas; skimmer and control structures are used at the outlet of a sediment basin (forebay), typically prior to discharge into a larger detention device

Sediment Trapping Devices - include baffle boxes, continuous deflection separation units,

Vegetative Practices - reduce the velocity of stormwater, increases infiltration and settles particulates, and prevents erosion; vegetation in filter strips, grassed swales, riparian areas, and landscaping of wet, dry and infiltration basins

Level Spreader – e.g., shallow trench filled with crushed stone typically situated along the top edge of filter strips to disperse concentrated flows evenly over a larger area.

Bioretention Cell- general design starting from bottom and going to the top includes underdrain system, sand layer, planting soil, a top dressing of mulch, and followed by selected plant and tree species; based on natural filtration of water in a forest ecosystem.

Stream Bank Stabilization – see buffer section

Non-Structural BMP's

Education Programs – household disposal of hazardous materials, yard wastes, in-school stream restoration programs, drain stenciling programs, pet waste disposal; also includes:

- Landscaping and Lawn Maintenance Controls -- proper use of pesticides and fertilizers, landscape design, plant selection, water conservation measures, fertilization reduction, integrated pest management, recycling of yard waste, and care of turf grass and other vegetation
- Minimization of Pollutants –household use of alternative chemicals, recycling or reducing the use of polluting chemicals
- Debris Removal – litter and yard wastes managed, grates on inlets maintained by Town

Maintenance of Stormwater Drainage Facilities – regular periodic cleaning of public and private stormwater drainage facilities, such as:

- Catch Basin Cleaning – removal of debris buildup from catch basins; removal of floatables from BMP's
- Parking Lot And Street Cleaning Operations – reduces the amount of pollutants and sediments entering the stream channels
- Vegetation Maintenance – maintaining grass swales, filter strips, road medians, etc. to ensure adequate vegetation is available to uptake stormwater

Decreasing Connected Impervious Areas – includes land use design practices, such as:

- Buffers, Easements, Etc. – see buffer section
- Parking Lot Design (Retrofit and New Development) – designs that incorporate more green space (e.g., planted islands), porous pavements and on-site detention of runoff
- Increased Impervious Limits in Residential Conservation Districts, Planned Districts, etc. (Retrofit and New Development) – setting percent impervious limits on land uses
- Curb Elimination/ Street Width Reductions – curbs act as channels for stormwater, increasing velocities into stream channels

<u>Pollutant Reduction Limits on Redevelopment Activities (Retrofit)</u> – setting reduction standards on runoff for all new development

Structural BMP Expected Pollutant Removal Efficiency

BMP Type	Typical Pollutant Removal (percent)				
	Suspended Solids	**Nitrogen**	**Phosphorus**	**Pathogens**	**Metals**
Dry Detention Basins	30-65	15-45	15-45	<30	15-45
Retention Basins	50-80	30-65	30-65	<30	50-80
Constructed Wetlands	50-80	<30	15-45	<30	50-80
Infiltration Basins	50-80	50-80	50-80	65-100	50-80
Infiltration Trenches/ Dry Wells	50-80	50-80	15-45	65-100	50-80
Porous Pavement	65-100	65-100	30-65	65-100	65-100
Grassed Swales	30-65	15-45	15-45	<30	15-45
Vegetated Filter Strips	50-80	50-80	50-80	<30	30-65
Surface Sand Filters	50-80	<30	50-80	<30	50-80
Other Media Filters	65-100	15-45	<30	<30	50-80

Source: US EPA. 1993c. Handbook Urban Runoff Pollution Prevention and Control Planning. EPA 625-R-93-004. Washington, DC.

Recommended BMP Maintenance Schedule

BMP	Activity	Schedule
Retention Pond / Wetland	• Cleaning and removal of debris after major storm events • Harvest excess vegetation • Repair of embankment and side slopes • Repair of control structure	Annual or as needed
	• Removal of accumulated sediment from forebays or sediment storage areas	5-year cycle, or as needed
	• Removal of accumulated sediment from main cells of pond once the original volume has been significantly reduced	20-year cycle (although can vary)
Detention Basin	• Removal of accumulated sediment • Repair of control structure • Repair of embankment and side slopes	Annual or as needed
Infiltration Trench	• Cleaning and removal of debris after major storm events • Mowing 4 and maintenance of upland vegetated areas • Maintenance of inlets and outlets	Annual or as needed
Infiltration Basin	• Cleaning and removal of debris after major storm events • Mowing 4 and maintenance of upland vegetated areas	Annual or as needed
	• Removal of accumulated sediment from forebays or sediment storage areas	3- to 5- year cycle
Sand Filters	• Removal of trash and debris from control openings • Repair of leaks from the sedimentation chamber or deterioration of structural components • Removal of the top few inches of sand and cultivation of the surface when filter bed is clogged (only works for a few cycles) • Clean-out of accumulated sediment from filter bed chamber • Clean out of accumulated sediment from sedimentation chamber	Annual or as needed
Bioretention	• Repair of eroded areas • Mulching of void areas • Removal and replacement of all dead and diseased vegetation • Watering of plant material	Bi-Annual or as needed
	• Removal of mulch and application of a new layer	Annual
Grass Swale	• Mowing 4 and litter and debris removal • Stabilization of eroded side slopes and bottom • Nutrient and pesticide use management • De-thatching swale bottom and removal of thatching • Aeration of swale bottom	Annual or as needed
	• Scraping swale bottom, and removal of sediment to restore original cross section and infiltration rate • Seeding or sodding to restore ground cover (use proper erosion and sediment control)	5-year cycle
Filter Strip	• Mowing 4 and litter and debris removal • Nutrient and pesticide use management • Aeration of soil in the filter strip • Repair of eroded or sparse grass areas	Annual or as needed

Source: Preliminary Data Summary of Urban Stormwater Best Management Practices, EPA-821-R-99-012, August 1999

Sample Performance Benchmarks

Construction Erosion & Sediment Control Performance Benchmarks:

- reductions in the number of violations
- reductions in the total fines collected
- total number of developers and contractors certified or trained in ESC practices
- reduced number of citizen-reported incidences of violations

Public Outreach and Education Measures:

- numbers of flyers distributed per given time period
- number of radio or television broadcasts
- number of public workshops held per year
- the percentage of storm drains stenciled
- the number of volunteer monitoring formed

Recycling and Household Pollutant Reduction Program Measures:

- resident surveys on changed habits (e.g., picking up pet waste or disposing lawn debris)
- volumes of recycled materials such as used oil and antifreeze
- volume and types of household hazardous waste collected at community collection days
- number of illicit cross connections detected and eliminated
- total curb miles of streets that are swept annually
- reductions in pesticide and fertilizer usage

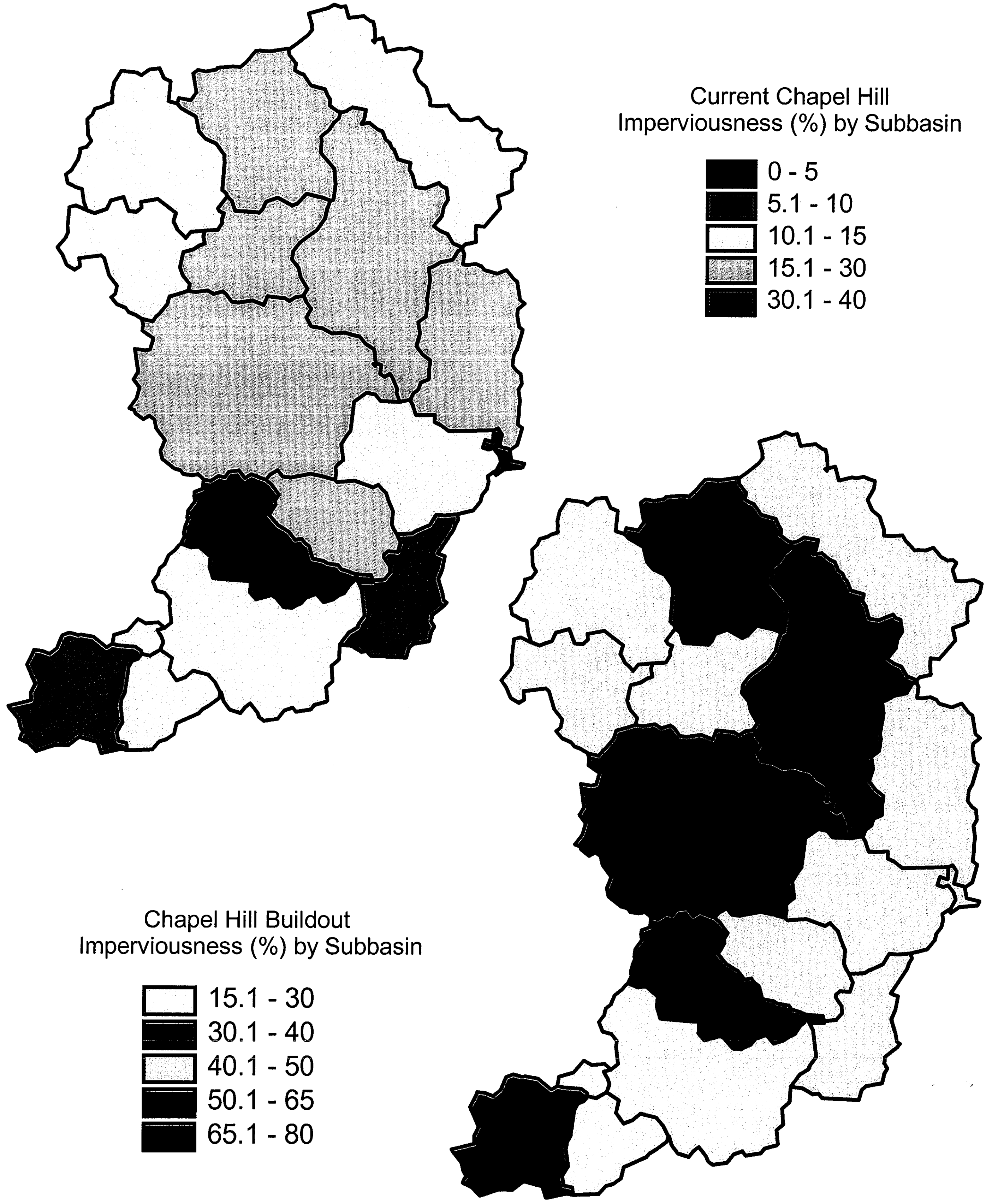
BMP Performance Benchmarks:

- inflow and outflow conditions
- stream sampling/monitoring
- biological indicators (Aquatic habitats)
- stream morphology

Water flow (quantity reduction) Benchmarks:

- rainfall depths (rain gauge stations)
- reductions in peak flow rate across the BMP;
- total storage volume provided in the BMP;
- infiltrative capacity of the BMP;
- retention time in the BMP;
- relationship of post-development hydrologic conditions to pre-development hydrology;
- retention volume necessary for receiving stream channel protection.

Map 1: Chapel Hill Imperviousness by Subbasin for Existing Conditions and Buildout



Map prepared by City and Regional Planning Graduate Student Workshop, April 2001