CITY OF NEW BERN, NORTH CAROLINA

Stormwater Management Manual

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1. Introduction

1.1 Purpose of the City of New Bern (City) Stormwater Program

New Bern is an important regional center that offers a wide range of employment opportunities, business and professional services, and important historical, cultural, and recreational attractions. New Bern residents desire to maintain the character of their community and to sustain and improve the excellent quality of life that the area provides. Residents and City officials favor growth and development that is environmentally responsible, well designed and located, and respectful of the character of the City. Future development is expected to involve a mix of residential development with varying densities and building styles, as well as new business, industrial, and institutional land uses. It is the purpose of the New Bern Stormwater Program to meet the current and anticipated needs for stormwater services and to protect public and private properties, the Neuse River, the Neuse Estuary, and all other streams, water bodies, and wetlands from unnecessary damage due to stormwater releases and nonpoint source pollution. The provision of those services will be based upon compatibility with the City's development plans, the City's taxpayers and developers financial capacities, and upon compliance with applicable Federal and State laws and regulations.

1.2 Summary of Goals and Elements of the New Bern Stormwater Program

The goals of the New Bern Stormwater Program are:

- Minimize the public's risk of injury and death and limit damages to private and public property caused by stormwater runoff within the City's jurisdiction.
- Maintain and increase the riparian buffers along the streams and waterbodies within the City's jurisdiction.
- Provide for the public's health, safety and welfare by protecting the water quality of the Neuse River, Neuse Estuary and other streams.
- Ensure City of New Bern compliance with all applicable Federal and State regulations.

In order to meet these goals, tthe City will require anyone proposing new developments within a 50-foot riparian buffer around all intermittent and perennical streams and other water bodies and anyone proposing new development that will result in disturbance of greater than % acre of land to obtain a Stormwater Permit. Obtaining a New Bern Stormwajer Permit requires property owners and developers to address five topics:

1.2.1 Protecting and Enhancing Riparian Areas

The Neuse Riparian Buffer Rule (NRBR) requires that the City protect riparian buffers on new developments. The New Bern Stormwater Program will ensure that a 50-foot riparian buffer will be maintained on all sides of intermittent and perennial streams and other water bodies within the City's jurisdiction. The program also will seek restoration and enhancement of impaired buffers within the City's jurisdiction. The City seeks to cooperate with other communities and with the North Carolina Wetlands Restoration Program to ensure that available funds are best used to protect water quality and provide attractive green space.

1.2.2 Controlling Peak Stormwater Discharges

Controlling the peak discharge rate of water leaving a developed area is one of the key factors in managing the impact of new development on the property of downstream landowners, on the City's roads, buildings, and stormwater facilities, and on local streams and other natural waterbodies.

The City's Stormwater Program requires that all new development within the jurisdictional limits of the City control water runoff so that there is no net increase in the peak discharge from the predevelopment conditions for the 1-year, 24-hour storm as defined in this Manual. Where this requirement places an undue hardship upon a property owner, variances from the requirement may be granted by the Stormwater Administrator to developments that meet one or both of the following requirements:

- The increase in peak flow for pre- and post-development conditions does not exceed 10 percent and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.
- The proposed new development does not cause the development parcel's total impervious area to exceed 15 percent, the remaining pervious portions of the site are utilized to the extent practical to convey and control the stormwater runoff, and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.

The City's Stormwater Program also requires that all new development within the jurisdictional limits of the City control water runoff so that there is no net increase ill.the peak discharge from the predevelopment conditions for the 10-year, 24-houTjtorm as defined in this Manual. Where this requirement places an undue hardship upon a property owner, variances from the requirement may be granted £y jtne Stormwater Administrator to developments that meet the following Requirement:

- The proposed new development appropriately uses the parcel's total remaining impervious area the extent practical to convey and control the stormwater runoff, and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.

1.2.3 Controlling Nitrogen Export

Owners and developers of all new developments that disturb an area greater than one-half acre in order to establish, expand or modify a residential, commercial, industrial, or institutional facility obtain a Stormwater Permit before any land disturbing activities occur. A Stormwater Permit requires each development to meet a nitrogen export performance standard of less than or equal to 3.6 pounds total nitrogen (TN) per acre per year (#/ac/yr). Where that standard cannot be reasonably achieved, there are provisions for variance and mitigation offsets. Except where there are substantial vested rights in place before the final enactment of the City Stormwater Ordinance, no new residential development will be permitted to export more than 6 #/ac/yr and no new non- residential development will be permitted to export more than 10 #/ac/yr. All applications for a Stormwater Permit must include calculations of the total nitrogen export from the proposed disturbance or development consistent with the methods specified in this Manual.

1.2.4 Use of Best Management Practices (BMPs)

The New Bern Stormwater Program seeks to encourage the use of modern design principles and management practices that will allow the community to grow and prosper while reducing the pollution of our land and water. The program encourages, and in some cases requires, the use of Best Management Practices (BMPs) from the conceptual design of a new development project through the project's construction and operation. Chapter 7 of this manual describes some of the project design BMPs that can be used to minimize the negative impacts of development. Chapter 8 describes some of the structural BMPs that can be used to reduce the remaining impacts.

1.2.5 Maintaining BMPs

In order to be effective, BMPs for stormwater control must be appropriately maintained. The New Bern Stormwater Program includes an annual inspection program under which City staff, or others working in their behalf, will inspect all BMPs and their maintenance records. The program provides procedures under which the City will accept the responsibility to maintain BMPs servicing residential properties and establishes the requirement that BMPs servicing non-residential properties be maintained by their owners. The City will have the authority and capacity to perform necessary maintenance of all BMPs and will charge delinquent owners for maintenance services that the City performs.

1.3 Disclaimer

This Manual is established to provide the City's Stormwater Administrator, property owners, developers, engineers, surveyors, and builders a better understanding of acceptable methods to meet the intent of the City's Stormwater Quality Management and Discharge Control Ordinance. Design of stormwater management for development requires experienced judgment by the designer. The City accepts no responsibility for any loss, damage, or injury as a result of the use of this manual.

2. Definitions

The terms used in this Manual shall have the following meanings:

(a) **Applicant:** An owner or developer of a site who executes the Stormwater Permit Application pursuant to the City's Stormwater Quality Management and Discharge Control Ordinance (hereinafter "Stormwater Ordinance").

(b) **Best Management Practices:** An activity, procedure, or structural or nonstructural management-based practice used singularly or in combination to prevent or reduce the discharge of pollutants directly or indirectly to the stormwater system and waters of the United States in order to achieve water quality protection goals. Best Management Practices include but are not limited to: treatment facilities to remove pollutants from stormwater; operating and maintenance procedures; facility management practices to control runoff, spillage or leaks of non-stormwater, waste disposal, and drainage from materials storage; erosion and sediment control practices; and the prohibition of specific activities, practices, and procedures and such other provisions as the City determines appropriate for the control of pollutants. Please refer to the City of New Bern Stormwater Management Manual, as discussed further under Section 1-16(c) herein, for specific requirements.

(c) **Bona Fide Farm:** Tract or tracts of land used for the production of plants and animals useful to man.

(d) **Built-upon area:** Built-upon areas shall include that portion of a development project that is covered by impervious or partially impervious cover including buildings, pavement, gravel roads, and recreation facilities.

(e) **Channel Bank:** The location of the upper edge of the active channel above which the water spreads into the overbanks on either side of the channel or the elevation of the two-year frequency storm. Where the channel bank is not well defined, the channel bank shall be considered the edge of the waterline during a two-year frequency storm.

(f) **City:** City of New Bern, North Carolina.

(g) **Clean Water Act:** The federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.), and any subsequent amendments thereto.

(h) **Cluster Developments:** Grouping of buildings in order to conserve land resources and provide for innovation in the design of the project including minimizing stormwater runoff impacts. This term includes nonresidential development, Planned Unit Developments (PUDs), and single-family residential and multi-family developments.

(i) **<u>Construction Activity</u>:** Activities subject to NPDES Construction Permits. These include construction projects resulting in land disturbance of one-half acre or more. Such activities include, but are not limited to, clearing and grubbing, grading, excavating, and demolition.

(j) **<u>Design Storm</u>:** The specific frequency and, if necessary, duration of the rainfall event to be used in design to meet the criteria established in the Stormwater Management Manual.

(k) **<u>Development</u>:** Means any of the following actions taken by a public or private individual or entity:

i. The division of a lot, tract, or parcel of land into two (2) or more lots, plots, sites, tracts, parcels or other divisions by plat or deed, or

ii. Any land change, including, without limitation, clearing, tree removal, grubbing, stripping, dredging, grading, excavating, transporting and filling of land.

(l) **<u>Drainage Structures</u>:** Shall include swales, channels, storm sewers, curb inlets, yard inlets, culverts, and other structures designed or used to convey stormwater.

(m) **<u>Hazardous Materials</u>:** Any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

(n) **<u>Illegal Discharge</u>:** Any unlawful disposal, placement, emptying, dumping, spillage, leakage, pumping, pouring, or other discharge of any substance other than stormwater into a stormwater conveyance system, the waters of the State or upon the land such that the substance is likely to reach a stormwater conveyance system or waters of the State constitutes an illegal discharge, except as exempted in Division II, Section 2.1 of the City of New Bern Stormwater Ordinance.

(o) **<u>Illicit Connections</u>: An** illicit connection is defined as either of the following:

i. Any drain or conveyance, whether on the surface or subsurface, which allows an illegal discharge to enter the stormwater system including but not limited to any conveyances which allow any non-stormwater discharge including sewage, process wastewater, and wash water to enter the stormwater system and any connections to the stormwater system from indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by a government agency; or

ii. Any drain or conveyance connected from a commercial or industrial land use to the stormwater system, which has not been documented in plans, maps, or equivalent records and approved by the City.

(p) **Industrial Activity:** Activities subject to NPDES Industrial Permits as defined in U.S. 40 CFR, Section 122.26 (b)(14).

(q) **Impervious Surface:** A surface composed of any material that impedes natural infiltration of water into the soil. Gravel areas shall be considered impervious.

(r) **Intermittent Streams:** A natural drainage way, which shows up as a blue line on the USGS 7.5-minute quadrangle maps and has a contributing drainage area of 300 acres or less, shall be considered an intermittent stream for the purposes of this Ordinance.

(s) **Land Disturbing Activities:** The use of land by any person that results in a change in the natural cover or topography that may contribute to or alter the quantity and or quality of stormwater runoff.

(t) **Major Subdivision:** The development or subdivision of a tract of land that:

i. Requires the development of public or private streets or right-of-ways; and/or

ii. Requires or includes the extension of public utilities or the recording of access easements; and/or

iii. Disturbs or subdivides an area of five (5) acres or more; and/or

iv. Results in the creation of five (5) or more lots.

(u) **Major Variance:** A variance issued by the City of New Bern that results in any one or more of the following:

i. The complete waiver of a management requirement;

ii. Any variance for which the City of New Bern must prepare documentation for, and receive approval from, the NC DENR/DWQ and/or the NC Environmental Management Commission before it may legally issue the requested variance.

(v) **Minor Subdivision:** Any development or subdivision of land that does not meet the description of a Major Subdivision.

(w) **Minor Variance:** A variance that does not qualify as a major variance.

(x) National Pollutant Discharge Elimination System (NPDES1 Stormwater Discharge Permits: General, group, and individual stormwater discharge permits that regulate facilities defined in federal NPDES regulations pursuant to the Clean Water Act.

(y) Natural Drainagewav: Shall mean an incised channel with a defined channel bed and banks that are part of the natural topography. Construction channels such as drainage ditches shall not be considered a natural drainage way unless the constructed channel was a natural drainage way that has been relocated, widened, or otherwise modified.

(z) Non-residential Development: All development other than residential development, agriculture, and silviculture.

(aa) Non-Stormwater Discharge: Any discharge to the stormwater system that is not composed entirely of stormwater.

(bb) perennial Stream: Perennial streams are streams that have essentially 'tofitinuous flows and are shown on the United States Geological Survey
24,0 (7.5 min.) scale topographic maps.

(cc) Plat: A map or plan of a parcel of land, which is to be, or has been subdivided or developed.

(dd) Pollutant: Anything, which causes or contributes to pollution. Pollutants may include, but are not limited to: paints, varnishes, and solvents; oil and other automotive fluids; non-hazardous liquid and solid wastes and yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects, articles, and accumulations, so that same may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; untreated commercial car wash water and industrial discharges, contaminated fountain drains, and cooling waters; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure (including but not limited to sediments, slurries, and concrete rinsates); and noxious or offensive matter of any kind.

(ee) Pollution: The human-made or human-induced alteration of the quality of waters by waste to a degree which unreasonably affects, or has the potential to unreasonably affect, either the waters for beneficial uses or the facilities which serve these beneficial uses.

(ff) Premises: Any building, lot, parcel of land, or portion of land whether improved or unimproved including adjacent sidewalks and parking strips.

(gg) Riparian Buffer: An area of trees, shrubs, or other vegetation, that is adjacent to a natural drainage way through which stormwater runoff flows in a diffuse manner so that the runoff does not become channelized and which provides for infiltration of the runoff and filtering of pollutants. Riparian buffers reduce the impact of upland sources by trapping, filtering, and converting nutrients, sediments, and other chemicals and maintain the integrity of the natural drainage way. For the purposes of this Ordinance, surface water shall be present if the feature is approximately shown on the most recent version of the 1:24,000 (7.5 min.) quadrangle topographic maps prepared by the United States Geological Survey or on the most recent version of the soil survey map prepared by the Natural Resources Conservation Service of the United States Department of Agriculture. The buffer shall be measured landward from the normal pool elevation of impounded structures and from the bank of each side of streams or rivers

(hh) Stormwater system: Publicly-owned facilities operated by the City by which Stormwater is collected and/or conveyed, including but not limited to any roads with drainage systems, streets, gutters, curbs, inlets, piped storm drains, pumping facilities, retention and detention basins, natural and human- made or altered drainage channels, reservoirs, and other drainage structures which are within the City and are not part of a publicly owned treatment works as defined at U.S. 40 CFR Section 122.2.

(ii) Stormwater: Any surface flow, runoff, and drainage consisting entirely of water from rainstorm events.

(jj) Stormwater Administrator: The person designated by the City Manager of the City of New Bern to have authority to review and approve Stormwater Permits and Stormwater Management Plans. The Stormwater Administrator shall also be responsible for inspecting development and making sure the provisions of this Ordinance are being followed and for reporting from time to time to the City Manager and to the Board of Aldermen on the progress, plans, and expectations of the City's stormwater program.

(kk) Stormwater Management Manual: The manual of design, performance, and review criteria adopted by Aldermen of the City of New Bern for the administration of the Stormwater Program.

(ll) Stormwater Facilities: Shall include devices designed specifically to detain or retain Stormwater for water quantity or water quality control. These devices shall not include those drainage structures that provide incidental water quantity or water quality control. These devices include but are not limited to wet ponds, dry ponds, bioretention areas, filter strips, infiltration trenches.

(mm) Stormwater Management Plans: A document, submitted as part of an application for a Stormwater Permit, which presents the design, operation, and maintenance specifications for one or more Drainage Structures, Best Management Practices, or other facilities and practices to be implemented for the management of stormwater quality and/or discharge control.

(nn) <u>Variance</u>: A permission to develop or use property granted by the City of New Bern relaxing or waiving a management requirement where that permission is granted at the discretion of the City under:

i. authority that it solely owns,

ii. authority delegated to it by the State of North Carolina and specifically the Environmental Management Commission, or

iii. the City's authority because of a direct action by the State of North Carolina and its Environmental Management Commission.

(oo) <u>Vegetative Buffer</u>: An area that has any combination of trees, samplings, shrubs, vines, and herbaceous plants that grow together in disturbed or undisturbed conditions, which provides for diffusion and infiltration of runoff and filtering of pollutants. This includes mature and successional forests as well as cutover stands.

(pp) <u>Vested Rights</u>: Vested right shall be based upon the following criteria:

i. Having an outstanding valid building permit in compliance with GS 153A-344.1 or GS 160A-385.1, or

ii. Having an approved site specific or phased development plan in compliance with GS 153A-344.1 or GS 160A-385.1.

iii. Projects that require a state permit, such as landfills, NPDES wastewater discharges, land application or residuals and road construction activities, shall be considered to have vested rights if a state permit was issued prior to the effective date of the adoption of the Stormwater Ordinance.

(qq) <u>Water Dependent Structures</u>: Those structures which require the access or proximity to, or sitting within surface waters to fulfill its basic purpose, such as boat ramps, boat houses, docks, and bulkheads. Ancillary facilities such as restaurants, outlets for boat supplies, parking lots, and commercial boat storage areas are not considered water-dependent structures.

(rr) <u>Waters of the United States</u>: Surface watercourses and water bodies as defined at U.S. 40 CFR § 122.2, including all natural waterways and definite channels and depressions in the earth that may carry water, even though such waterways may only carry water during rains and storms and may not carry Stormwater at and during all times and seasons.

J. Stormwater Permits

3.1 Stormwater Management and Site Plans

Persons proposing to conduct land disturbing activities that require a Stormwater Permit as identified in the City of New Bern Stormwater Ordinance shall submit a stormwater management plan that includes a site plan with the stormwater permit application.

3.1.1 Site Plan Requirements

The City may request all application documents (calculations, narrative, and drawings) be submitted digitally for archival and database entry. If requested, this information is to be submitted on a compact disc prior to final approval of the project. For the purpose of applying for a Stormwater Permit, the Site Plan shall include at minimum the following information:

- Address or Vicinity Map showing the location of the activity.
- Subdivision Name and the date of the approved subdivision plat, if applicable.
- The date of the subdivision’s approved Stormwater Permit, if applicable.
- The site boundaries.
- Street Right-of-Way.
- Street Name and State Road Number.
- Existing roadway width and pavement type.
- Existing and proposed structures and finish floor elevations.
- Existing and proposed driveway locations and types (gravel, asphalt, concrete, etc.)
- Existing and proposed stormwater facilities (swales, pipes, inlets, etc.)
- Indicate the general drainage patterns and provide a topographic map showing 1-foot (or smaller) contour intervals.
- Show any easements and identify type of easement.
- Show any natural drainage ways and direction of flow.
- Show the location and extent and label the name of any waterbody that is shown on the most recent revision of either the 7.5-minute USGS topographic map or the NRCS Soil Survey map.
- Show any flood boundaries and/or elevations.
- Show any phasing of land disturbing activities. If needed, a separate drawing can be provided for each phase.
- Other information that may be necessary to develop an understanding of the project.

A complete list of the drawing requirements is included on a reproducible sheet included in Appendix A. No text presented on the drawings and documents shall be in a font smaller than a 10-point type. The Stormwater Administrator may waive any of the format specifications and required items that are deemed not to be necessary for the review, reproduction, and storage of the documents.

All drawings and specifications that include Structural Best Management Practices such as stormwater detention ponds, sand filters, and other constructed elements must present the seal and signature of a registered professional engineer.

3.1.2 BMP Design and Operation Specifications

Each structural and non-structural BMP included in an applicant's stormwater management plan must be designed and operated according to appropriate, documented principles and practices. Specific design and operation details, to the satisfaction of the Stormwater Administrator, must be presented in the stormwater management plan. The nature of those details will vary with the type of BMP proposed. For example, for a Wet Detention Pond, details of the containment berm, outlet structures, sediment forebay, maintenance access area and safety features and facilities (e.g. side slopes, fencing) must be described in the plan. Additional necessary items may include plant species to be introduced and maintained. Soil and hydrologic calculations that verify maintenance of the depth of surface water necessary for the proper operation of the BMP also must be presented.

Each applicable BMP has a specific set of design, operation and maintenance principles and practices that must be followed. Appendix C of this manual provides many of these details for a range of BMPs. It is the applicant's responsibility to provide the Stormwater Administrator with sufficient documentation on the principles and practices of a proposed BMP to ensure the Administrator that the BMP will be constructed and will operate sufficient to provide the benefits claimed in the applicant's Stormwater Management Plan.

3.1.3 Supporting Calculations

The owner shall provide formulas, tables, and other forms of supporting calculations in hardcopy or electronic forms as may be required by the Stormwater Administrator to determine the accuracy of any of the items described in the Stormwater Management Plan, shown on the Site Plan, or otherwise represented in the application for a Stormwater Permit. There are specific requirements for the documentation of the control of peak discharges and for the calculation of nitrogen exports from developments. The acceptable methods of performing those calculations are outlined in Sections 5 and 6 of this manual.

3.1.4 Maintenance Plans

The effectiveness of each of the BMPs described in the previous section depends upon appropriate maintenance. Also, many of the health and safety concerns that arise when the BMPs are installed can be significantly reduced by a program of planned, regular maintenance. For those reasons, the applicant's Stormwater Management Plan must contain a maintenance plan, including schedule, for each of the BMPs incorporated into the stormwater system. The Plan must address the normal and emergency procedures that will be followed to avoid:

- Any condition, which blocks, hinders or obstructs, in any way the natural or intended flow of surface waters;
- The improper operation of any stormwater retention or impoundment device or any structure or device used for the improvement of the quality of surface runoff;
- Any condition that would damage the City's stormwater collection system or that would harm the quality of the City's waters;
- Any other conditions specifically declared to be a danger to the public health, safety, and general welfare of inhabitants of the City.

Failure to properly operate and maintain stormwater facilities and BMPs in accordance with the Stormwater Management Plan is a violation of the City's Stormwater Ordinance.

3.2 Maintenance Records and Inspections

Once the Stormwater Administrator has accepted the applicant's Stormwater Management Plan and the facilities have been constructed, the Stormwater Administrator will conduct an as-built inspection and will inspect, from time to time but at least annually, the BMP facilities. The Stormwater Permittee shall pay an inspection fee for each inspection in an amount approved by the City and available from the office of the Stormwater Administrator. Whenever inspections are conducted, the Stormwater Permittee shall make available records of the maintenance of all stormwater facilities and BMPs. At a minimum those records shall contain:

- Descriptions, including design drawings, of any structural changes to a BMP and the dates on which construction of those changes were begun and completed.
- Descriptions, including landscape drawings, of any changes in the drainage pathways included in the site's stormwater management plan and in any drainage pathways leading to or from a BMP.
- Descriptions, to include volumes and material descriptions, of any excavation or fill operations to or impacting a BMP or the drainage of stormwater to or

from a BMP and including the dates when those operations were begun and completed.

- Confirmation of completion over the previous year of all the routine maintenance items required by each BMP and documented in the Stormwater Management Plan.

Failure to perform required or emergency maintenance, or to maintain and provide the required records of that maintenance is a violation of the City's Stormwater Ordinance.

4. Riparian Buffers

4.1 Buffer Requirements

The New Bern Stormwater Program requires that 50-foot wide riparian buffers be maintained on all sides of intermittent and perennial streams, ponds, lakes, and estuaries in the City and its extraterritorial jurisdiction.

In order to obtain a Stormwater Permit an owner or developer must meet one or more of the following requirements:

1. Provide certification, acceptable to the Stormwater Administrator, that no development or other land disturbing activities will occur within 50-feet of the banks of a covered stream or other natural waterway as shown on the most recent version of the NRCS Soil Survey map(s) and those shown on the most recent 1:24,000 scale (7.5 minute) quadrangle topographic maps prepared by the USGS.
2. Provide certification, acceptable to the Stormwater Administrator, that the only development or other land disturbing activities that will occur within 50-feet of the banks of a covered stream or other natural waterway are exempt activities as shown within the Table of Uses contained in this manual.
3. Apply to the Stormwater Administrator and obtain a minor or major variance which allows the development or other activity and demonstrate that all the conditions of that variance, including all mitigation requirements will be met and that approval by the North Carolina Department of Environment and Natural Resources Division of Water Quality and/or the North Carolina Environmental Management Commission, has been obtained.

4.2 Riparian Buffer Map

The Stormwater Administrator will prepare, and will from time to time correct and update, a map portraying the riparian buffer areas covered by the New Bern Stormwater Ordinance. The map will be available in the office of the Stormwater Administrator, provided for the convenience of the public. It is the owner's responsibility to verify the accuracy of that map as it relates to development or other land disturbing activities on a specific parcel. The City of New Bern accepts no responsibility for any loss, damage, or injury as a result of the use of that map.

4.3 The Riparian Buffer

The New Bern Stormwater Program's for protection of riparian buffers follow the requirements set forth in the NRBR. The following tables define the two zones of a riparian buffer and set forth the types of exempt, allowable, allowable with mitigation, and prohibited activities that may occur in each zone.

ZONES OF THE RIPARIAN BUFFER. The protected riparian buffer shall have two zones as follows:

(a) Zone 1 shall consist of a vegetated area that is undisturbed except for uses provided for in Item (6) of this Rule. The location of Zone 1 shall be as follows:

(i) For intermittent and perennial streams, Zone 1 shall begin at the most landward limit of the top of bank or the rooted herbaceous vegetation and extend landward a distance of 30 feet on all sides of the surface water, measured horizontally on a line perpendicular to the surface water.

(ii) For ponds, lakes and reservoirs located within a natural drainage way, Zone 1 shall begin at the most landward limit of the normal water level or the rooted herbaceous vegetation and extend landward a distance of 30 feet, measured horizontally on a line perpendicular to the surface water.

(iii) For surface waters within the 20 Coastal Counties (defined in 15A NCAC 2B .0202) within the jurisdiction of the Division of Coastal Management, Zone 1 shall begin at the most landward limit of:

(A) the normal high water level;

(B) the normal water level; or

(C) the landward limit of coastal wetlands as defined by the Division of Coastal Management and extend landward a distance of 30 feet, measured horizontally on a line perpendicular to the surface water, whichever is more restrictive.

Zone 2 shall consist of a stable, vegetated area that is undisturbed except for activities and uses provided for in Item (6) of this Rule. Grading and revegetating Zone 2 is allowed provided that the health of the vegetation in Zone 1 is not compromised. Zone 2 shall begin at the outer edge of Zone 1 and extend landward 20 feet as measured horizontally on a line perpendicular to the surface water. The combined width of Zones 1 and 2 shall be 50 feet on all sides of the surface water, whichever is more restrictive.

DIFFUSE FLOW REQUIREMENT. Diffuse flow of runoff shall be maintained in the riparian buffer by dispersing concentrated flow and reestablishing vegetation.

(a) Concentrated runoff from new ditches or manmade conveyances shall be converted to diffuse flow before the runoff enters the Zone 2 of the riparian buffer.

(b) Periodic corrective action to restore diffuse flow shall be taken if necessary to impede the formation of erosion gullies.

TABLE OF USES. The following chart sets out the uses and their designation under this Rule as exempt, allowable, allowable with mitigation, or prohibited. The requirements for each category are given in Item (7) of this Rule.

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Airport facilities: - Airport facilities that impact equal to or less than 150 linear feet or one-third of an acre of riparian buffer ■ Airport facilities that impact greater than 150 linear feet or one-third of an acre of riparian buffer		X	X	
Archaeological activities	X			
Bridges		X		
Dam maintenance activities	X			
Drainage ditches, roadside ditches and stormwater outfalls through riparian buffers: • Existing drainage ditches, roadside ditches, and stormwater outfalls provided that they are managed to minimize the sediment, nutrients and other pollution that convey to waterbodies	X			

• New drainage ditches, roadside ditches and stormwater outfalls provided that a stormwater management facility is installed to control nitrogen and attenuate flow before the conveyance discharges through the riparian buffer ■ New drainage ditches, roadside ditches and stormwater outfalls that do not provide control for nitrogen before discharging through the riparian buffer * Excavation of the streambed in order to bring it to the same elevation as the invert of a ditch		X		X X
Drainage of a pond in a natural drainage way provided that a new riparian buffer that meets the requirements of Items (4) and (5) is established adjacent to the new channel	X			
Driveway crossings of streams and other surface waters subject to this Rule: • Driveway crossings on single family residential lots that disturb equal to or less than 25 linear feet or 2, 500 square feet of riparian buffer • Driveway crossings on single family residential lots that disturb greater than 25 linear feet or 2,500 square feel of riparian buffer • In a subdivision that cumulatively disturb equal to or less than 150 linear feet or one-third of an acre of riparian buffer • In a subdivision that cumulatively disturb greater than 150 linear feet or one-third of an acre of riparian buffer	X	X X	X	
Fences provided that disturbance is minimized and installation does not result in removal of forest vegetation	X			
Forest harvesting - see Item (11) of this Rule				
Fertilizer application: • One-time fertilizer application to establish replanted vegetation • Ongoing fertilizer application	X			X
Grading and revegetation in Zone 2 only provided that diffuse flow and the health of existing vegetation in Zone 1 is not compromised and disturbed areas are stabilized	X			
Greenway/hiking trails		X		
Historic preservation	X			
Landfills as defined by G.S. 130A-290				X
Mining activities: • Mining activities that are covered by the Mining Act provided that new riparian buffers that meet the requirements of Items (4) and (5) are established adjacent to the relocated channels ■ Mining activities that are not covered by the Mining Act OR where new riparian buffers that meet the requirements or Items (4) and (5) are not established adjacent to the relocated channels • Wastewater or mining dewatering wells with approved NPDES permit	X	X	X	
Non-electric utility lines: ■ Impacts other than perpendicular crossings in Zone 2 only[3] • Impacts other than perpendicular crossings in Zone 1[3]		X	X	
Non-electric utility line perpendicular crossing of streams				

and other surface waters subject to this Rule[1 2 3]: • Perpendicular crossings that disturb equal to or less 40 linear feet of riparian buffer with a maintenance corridor equal to or less than 10 feet in width • Perpendicular crossings that disturb greater than 40 linear feet of riparian buffer with a maintenance corridor greater than 10 feet in width • Perpendicular crossings that disturb greater than 40 linear feet but equal to or less than 150 linear feet of riparian buffer with a maintenance corridor equal to or less than 10 feet in width • Perpendicular crossings that disturb greater than 40 linear feet but equal to or less than 150 linear feet of riparian buffer with a maintenance corridor greater than 10 feet in width • Perpendicular crossings that disturb greater than 150 linear feet of riparian buffer	X	X X	X X	
On-site sanitary sewage systems - new ones that use ground absorption				X
Overhead electric utility lines: • Impacts other than perpendicular crossings in Zone 2 only[3] • Impacts other than perpendicular crossings in Zone 1 [1,2,3]	X X			
Overhead electric utility line perpendicular crossings of streams and other surface waters subject to this Rule[3] • Perpendicular crossings that disturb equal to or less than 150 linear feet of riparian buffer[1] • Perpendicular crossings that disturb greater than 150 linear feet of riparian buffer[1,2]	X	X		
Periodic maintenance of modified natural streams such as canals and a grassed travelway on one side of the surface water when alternative forms of maintenance access are not practical		X		

[1] Provided that, in Zone 1, all of the following BMPs for overhead utility lines are used. If all of these BMPs are not used, then the overhead utility lines shall require a no practical alternatives evaluation by the Division.

■ A minimum zone of 10 feet wide immediately adjacent to the water body shall be managed such that only vegetation that poses a hazard or has the potential to grow tall enough to interfere with the line is removed.

* Woody vegetation shall be cleared by hand. No land grubbing or grading is allowed.

■ Vegetative root systems shall be left intact to maintain the integrity of the soil. Stumps shall remain where trees are cut.

* Rip rap shall not be used unless it is necessary to stabilize a tower,

* No fertilizer shall be used other than a one-time application to re-establish vegetation.

* Construction activities shall minimize the removal of woody vegetation, the extent of the disturbed area, and the time in which areas remain in a disturbed state.

* Active measures shall be taken after construction and during routine maintenance to ensure diffuse flow of stormwater through the buffer.

« In wetlands, mats shall be utilized to minimize soil disturbance.

[2] Provided that poles or towers shall not be installed within 10 feet of a water body unless the Division completes a no practical alternatives evaluation.

[3] Perpendicular crossings are those that intersect the surface water at an angle between 75 degrees and 105 degrees.

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Playground equipment: • Playground equipment on single family lots provided that installation and use does not result in removal of vegetation • Playground equipment installed on lands other than single-family lots or that requires removal of vegetation	X	X		
Ponds in natural drainage ways, excluding dry ponds: • New ponds provided that a riparian buffer that meets the requirements of Items (4) and (5) is established adjacent to the pond • New ponds where a riparian buffer that meets the requirements of Items (4) and (5) is NOT established adjacent to the pond		X	X	
Protection of existing structures, facilities and slreambanks when this requires additional disturbance of the riparian buffer or the stream channel		X		
Railroad impacts other than crossings of streams and other surface waters subject to this Rule			X	
Railroad crossings of streams and other surface waters subject to this Rule: * Railroad crossings that impact equal to or less than 40 linear feet of riparian buffer * Railroad crossings that impact greater than 40 linear feet but equal to or less than 150 linear feet or one-third of an acre of riparian buffer * Railroad crossings that impact greater than 150 linear feet or one-third of an acre of riparian buffer	X	X	X	
Removal of previous fill or debris provided that diffuse flow is maintained and any vegetation removed is restored	X			
Road impacts other than crossings of streams and other surface waters subject to this Rule			X	
Road crossings of streams and other surface waters subject to this Rule: • Road crossings that impact equal to or less than 40 linear feet of riparian buffer • Road crossings that impact greater than 40 linear feet but equal to or less than 150 linear feet or one-third of an acre of riparian buffer • Road crossings that impact greater than 150 linear feet or one-third of an acre of riparian buffer	X	X	X	
Scientific studies and stream gauging	X			
Stormwater management ponds excluding dry ponds: • New stormwater management ponds provided that a riparian buffer that meets the requirements of Items (4) and (5) is established adjacent to the pond • New stormwater management ponds where a riparian buffer that meets the requirements of Items (4) and (5) is NOT established adjacent to the pond		X	X	
Stream restoration	X			
Streambank stabilization		X		

Temporary roads:				
• Temporary roads that disturb less than or equal to 2,500 square feet provided that vegetation is restored within six months of initial disturbance	X			
• Temporary roads that disturb greater than 2,500 square feet provided that vegetation is restored within six months of initial disturbance		X		
• Temporary roads used for bridge construction or replacement provided that restoration activities, such as soil stabilization and revegetation, are conducted immediately after construction		X		
Temporary sediment and erosion control devices:				
• In Zone 2 only provided that the vegetation in Zone 1 is not compromised and that discharge is released as. diffuse flow in accordance with Item (5)	X			
• In Zones 1 and 2 to control impacts associated with uses approved by the Division or that have received a variance provided that sediment and erosion control for upland areas is addressed to the maximum extent practical outside the buffer		X		
• In-stream temporary erosion and sediment control measures for work within a stream channel	X			
Underground electric utility lines:	X			
• Impacts other than perpendicular crossings in Zone 2 oniy	X			
* Impacts other than perpendicular crossings in Zone				
Underground electric utility line perpendicular crossings of streams and other surface waters subject to this Rule:[3]				
• Perpendicular crossings that disturb less than or equal to 40 linear feet of riparian buffer[3,4]	X			
• Perpendicular crossings that disturb greater than 40 linear feet of riparian buffer[3,4]		X		

[4] Provided that, in Zone 1, all of the following BMPs for underground utility lines are used. If all of these BMPs are not used, then the underground utility line shall require a no practical alternatives evaluation by the Division.

- Woody vegetation shall be cleared by hand. No land grubbing or grading is allowed.
- Vegetative root systems shall be left intact to maintain the integrity of the soil. Stumps shall remain, except in the trench, where trees are cut.

« Underground cables shall be installed by vibratory plow or trenching.

• The trench shall be backfilled with the excavated soil material immediately following cable installation.

- No fertilizer shall be used other than a one-time application to re-establish vegetation.
- Construction activities shall minimize the removal of woody vegetation, the extent of the disturbed area, and the time in which areas remain in a disturbed state.
- Active measures shall be taken after construction and during routine maintenance to ensure diffuse flow of stormwater through the buffer.
- In wetlands, mats shall be utilized to minimize soil disturbance.

	Exempl	Allowable	Allowable with Mitigation	Prohibited
Vegetation management:				

• Emergency fire control measures provided that topography is restored • Periodic mowing and harvesting of plant products in Zone 2 only • Planting vegetation to enhance the riparian buffer • Pruning forest vegetation provided that the health and function of the forest vegetation is not compromised • Removal of individual trees which are in danger of causing damage to dwellings, other structures or human life * Removal of poison ivy • Removal of understory nuisance vegetation as defined in: Smith, Cherri L. 1998. Exotic Plant Guidelines. Department of Environment and Natural Resources. Division of Parks and Recreation. Raleigh, NC. Guideline #30	X X X X X X X			
Water dependent structures as defined in 15A NCAC 2B .0202		X		
Water supply reservoirs: » New reservoirs provided that a riparian buffer that meets the requirements of Items (4) and (5) is established adjacent to the reservoir * New reservoirs where a riparian buffer that meets the requirements of Items (4) and (5) is NOT established adjacent to the reservoir		X	X	
Water wells	X			
Wetland restoration	X			

4.4 Restrictive Covenant

The protection and maintenance of the required riparian buffer is a condition under which the Stormwater Administrator can issue a City Stormwater Permit. The previous section of this manual set forth the uses and their designation under the Neuse Riparian Buffer Rule as exempt, allowable, and allowable with mitigation. An applicant's stormwater management plan must describe all use and maintenance items pertaining to the Riparian Buffer and the applicant must execute the Covenant Agreement contained in Appendix C of this manual, or other legal instrument acceptable to the Stormwater Administrator, before a City Stormwater Permit may be issued.

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tc

5. Controlling Peak Discharge

5.1 Peak Discharge Requirements.

The City, in compliance with the Neuse Stormwater Rule (NSR), requires that there be no net increase in peak discharge leaving a development site from the predevelopment conditions for the 1-year, 24-hour storm. Variance from the requirement may be provided to developments that meet one or all of the following requirements:

- The increase in peak flow between pre- and post-development conditions does not exceed ten percent.
- The proposed new development meets both of the following criteria:
  1. Overall impervious surface is less than fifteen percent, and
  2. The remaining pervious portions of the site are utilized to the maximum extent practical to convey and control the stormwater runoff.

The City also requires that all new development within the jurisdictional limits of the City control water runoff so that there is no net increase in the peak discharge from the predevelopment conditions for the 10-year, 24-hour storm as defined in this Manual. Where this requirement places an undue hardship upon a property owner, variances from the requirement may be granted by the Stormwater Administrator to developments that meet the following requirement:

- The proposed new development appropriately uses the parcel's total remaining total impervious area to the extent practical to convey and control the stormwater runoff, and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.

5.2 The 1 year, 24 hour design storm

The 1 year, 24 hour storm is defined to deliver a total volume of precipitation equal to 3.7 inches in 24 hours and having a temporal distribution of precipitation given by an SCS Type III distribution (SCS, 1985). Figure 5.1 presents the cumulative precipitation distribution for the SCS Type III distribution. Table 5.1 includes the ratio for accumulated to total precipitation in 24-hours for 0.2 hour (12 minute) time intervals. For purposes of peak discharge calculations, average antecedent moisture conditions are to be assumed.

5.3 The 10 year, 24 hour design storm

The 10 year, 24 hour storm is defined to deliver a total volume of precipitation equal to 7.0 inches in 24 hours and having a temporal distribution of precipitation given by an SCS Type III distribution (SCS, 1985). Figure 5.1 presents the cumulative precipitation distribution for the SCS Type III distribution. Table 5.1 includes the ratio for accumulated to total precipitation in 24-hours for 0.2 hour (12 minute) time intervals.

Table 5.1 SCS Type III Rainfall Distribution Curve Data

Time (hour)	Ratio Accumulated/ Total Precipitation	Time (hour)	Ratio Accumulated/ Total Precipitation	Time (hour)	Ratio Accumulated/ Total Precipitation	Time (hour)	Ratio Accumulated/ Total Precipitation
0.0	0.00000 -	6.0	0.07200	12.0	0.50000	18.0	0.92800
0.2	0.00200 -	6.2	0.07530	12.2	0.62670	18.2	0.93117
0.4	0.00400	6.4	0.07880	12.4	0.68570	18.4	0.93428
0.6	0.00600 .	6.6	0.08250	12.6	0.71344	18.6	0.93733
0.8	0.00800	6.8	0.08640	12.8	0.73356	18.8	0.94032
1.0	0.01000	7.0	0.09050	13.0	0.75000	19.0	0.94330
1.2	0.01200	7.2	0.09480	13.2	0.76412	19.2	0.94612
1.4	0.01400	7.4	0.09930	13.4	0.77728	19.4	0.94893
1.6	0.01600 -	7.6	0.10400	13.6	0.78948	19.6	0.95168
1.8	0.01800 -	7.8	0.10890	13.8	0.80072	19.8	0.95437
2.0	0.02000	8.0	0.11400	14.0	0.81100	20.0	0.95700
2.2	0.02203	8.2	0.11943	14.2	0.82057	20.2	0.95958
2.4	0.02412	8.4	0.12532	14.4	0.82968	20.4	0.96211
2.6	0.02627	8.6	0.13167	14.6	0.83833	20.6	0.96460
2.8	0.02848	8.8	0.13848	14.8	0.84652	20.8	0.96704
3.0	0.03080	9.0	0.14580	15.0	0.85430	21.0	0.96940
3.2	0.03308	9.2	0.15348	15.2	0.86152	21.2	0.97179
3.4	0.03547	9.4	0.16167	15.4	0.86833	21.4	0.97410
3.6	0.03792	9.6	0.17032	15.6	0.87468	21.6	0.97636
3.8	0.04043 -	9.8	0.17943	15.8	0.88057	21.8	0.97858
4.0	0.04300	10.0	0.18900	16.0	0.88600	22.0	0.98080
4,2	0.04563	10.2	0.19928	16.2	0.89110	22.2	0.98288
4.4	0.04832 '	10.4	0.21052	16.4	0.89600	22.4	0.98496
4.6	0.05107	10.6	0.22272	16.6	0.90070	22.6	0.98700
4.8	0.05388	10.8	0.23588	16.8	0.90520	22.8	0.98899
5.0	0.05670	11.0	0.25000	17.0	0.90950	23.0	0.99090
5.2	0.05968	11.2	0.26644	17.2	0.91360	23.2	0.99284
5.4	0.06267 ‘	11.4	0.28656	17.4	0.91750	23.4	0.99470
5.6	0.06572 •	11.6	0.31430	17.6	0.92120	23.6	0.99651
5.8	0.06883 ■	11.8	0.37330	17.8	0.92470	23.8	0.99828
						24.0	1.00000

5.4 Calculating the Peak Discharge

The City requires, for the purpose of computing the peak discharge from the above described design storms, that one of the following methods be used for all development purposes:

Table 5.2 Value of Runoff Coefficient (C) for Rational Formula			
Landuse	I C Value	| Landuse	C Value
Business:		Roofs	0.75-0.95
- Downtown areas	0.70-0.95		
- Neighborhood areas	0.05-0.70	*Lawns:*	
		- Sandy soil, flat, 2%	0.05-0.10
Residential:		- Sandy soil, average, 2-7%	0,10-0.15
- Single-family areas	0.30-0.50	- Sandy soil, steep, 7%	0.15-0.20
- Multi units, detached	0.40-0.60	- Heavy soil, fiat, 2%	0.13-0.17
- Multi units, attached	0.60-0.75	- Heavy soil, average, 2-7%	0.18-0.22
- Suburban	0.25-0.40	- Heavy soil, steep, 7%	0.25-0.35
Industrial:		*Agricultural Land:*	
- Light areas	0.50-0.80	Bare packed soil	
- Heavy areas	0.60-0.90	- Smooth	0.30-0.60
- Parks, cemeteries	0.10-0.25	- Rough	0.20-0.50
- Playgrounds	0.20-0.35	Cultivated Rows	
- Railroad yard areas	0.20-0.40	- Heavy soil no crop	0.30-0.60
- Unimproved areas	0.10-0.30	- Heavy soil with crop	0.20-0.50
		- Sandy soil no crop	0.20-0.40
Streets:		- Sandy soil with crop	0.10-0.25
- Asphalt	0.70-0,95	Pasture	
- Concrete	0.80-0.95	- Heavy soil	0.15-0.45
- Brick	0.70-0.85	- Sandy soil	0.05-0.25
- Drives and walks	0.75-0.85	- Woodlands	0.05-0.25

NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, sleep slopes, and sparse vegetation should be assigned highest C Values.

Source: American Society of Civil Engineers.

For consistent comparison, the same method must be applied for estimation of the pre- and post-development discharges.

Tables 5.3 and 5.4 can be used to determine the time of concentration (Tc) and peak rainfall intensity for the 1-year and 10-year, 24-hour design storms in New Bern, North Carolina.

Table 5.3 Mean Flow Velocity

Land Cover	Slope (ft/100ft)	Velocity[1] (ft per min.)
Pavement/Concrete	0.25	19.0
Graded/Bare Ground	0.25	15.5
Lawn	0.25	13.1
Pasture / Meadow	0.25	11.4
Woodland	0.25	8.5
Pavement/Concrete	0.5	26.8
Graded/Bare Ground	0.5	21.9
Lawn	0.5	18.6
Pasture / Meadow	0.5	16.1
Woodland	0.5	12.1
Pavement/Concrete	1	37.9
Graded/Bare Ground	1	31.0
Lawn	1	26.2
Pasture / Meadow	1	22.7
Woodland	1	17.1
Pavement/Concrete	2	53.6
Graded/Bare Ground	2	43.9
Lawn	2	37.1
Pasture / Meadow	2	32.2
Woodland	2	24.1
Pavement/Concrele	5	84.8
Graded/Bare Ground	5	69.3
Lawn	5	58.7
Pasture / Meadow	5	50.9
Woodland	5	38.1
Pavemenl/Concrete	10	119.9
Graded/Bare Ground	10	98.1
Lawn	10	83.0
Pasture / Meadow	10	71.9
Woodland	10	53.9
Pavement/Concrete	20	169.5
Graded/Bare Ground	20	138.7
Lawn	20	117.3
Pasture / Meadow	20	101.7
Woodland	20	76.3

[1] Assumes overland flow of 1-inch depth.

Table 5.4 Peak Rainfall Intensity vs. Time of Concentration

Time of Cone. (minutes)	1-year (in/hr)	10-year (in/hr)
10	2.46	4.66
20	2.34	4.43
30	1.93	3.64
45	1.57	2.98
60	1.33	2.52
90	1.04	1.96
120	0.58	1.09
240	0.36	0.68
360	0.26	0.50
480	0.21	0.40

Rational Method Sample Calculation

The Rational Method may only be used for single-family residential development where the final built-out development will impact less than 10 acres. A blank form (Form SW-006) for use while using the Rational Method is included in Appendix A. A description of the Rational Method is included in the North Carolina Stormwater Guidance Manual.

Given: Location: New Bern, North Carolina
Drainage area: 2.5 acres
Average slope: 0.5 percent
Maximum Slope Length: 320 feet

Find: For the watershed draining through the development, compute the design peak runoff rate for a 1-year, 24-hour storm and a 10-year, 24-hour storm both before and after the area is developed.

Step 1: Determine the drainage area, A, in acres.
2.5 acres

Step 2: Determine the runoff coefficient, C, for the type of soil/cover in the pre-development drainage area (see Table 5.2)

Pre-Development Conditions

Type of Land Use	C	Area (acre)	Cx A
Woodland	**0.20**	**2.0**	**0.40**
Pasture - Heavy Soil	**0.40**	**0.5**	**0.20**
Total		**2.5**	**0.60**

Area-weighted C = 0.60/2.5 = 0.24

Step 3: Determine the time of concentration, Tc, for the drainage area (i.e. the time of flow from the most remote point in the basin to the design point, in minutes) (see Table 5.3).

For an average slope of 0.5 percent and 80 percent woodland, 20 percent pasture land cover the weighted mean velocity is: 0.8(16.1) + 0.2(12.1) = 15.3 feet/minute

Time of concentration = Length of overland flow/weight mean velocity Tc = 320 feet/(15.3 feet/minute) = 20.9 minutes

Step 4: Determine the peak rainfall intensity (i), (Table 5.4).

Interpolate maximum intensity for 1-year, 24-hour storm,
I_f = 2.30 inches/hour

Maximum Intensity for 10-year, 24-hour storm, I_{10} = 4.4 inches/hour

Step 5: Determine the peak discharge, q (ft^3/sec), by multiplying the previously determined factors using the Rational formula: q=CiA

Peak flow for 1-year, 24-hour storm, q_1 = CiA = 0.24 x 2.3 x 2.5 =1.38 cfs Peak flow for 10-year, 24-hour storm, q_{10} = CiA = 0.24 x 4.4 x 2.5 = 2.64 cfs

Repeat Steps 2 through 5 for Post-development conditions.

Step 2: Determine the runoff coefficient, C, for the type of soil/cover in the postdevelopment drainage area (see Table 5.2)

Post-Development Conditions

Type of Land Use	**C**	Area (acre)	**Cx** A
Woodland	0.20	1.5	0.300
Pasture - Heavy Soil	0.40	0.5	------- 0.200 -
Lawn - heavy soil, flat	0.15	0.4	0.060
Roof	0.85	0.05	0.043
Driveway	0.75	0.05	0.038
Total		**2.5**	**0.641**

Area-weighted C = 0.641/2.5 = 0.26

Step 3: Determine the time of concentration, Tc, for the drainage area (i.e. the time of flow from the most remote point in the basin to the design point, in minutes) (see Table 5.3).

For an average slope of 0.5 percent and 60 percent woodland 20 percent pasture 16 percent lawn 2 percent roof 2 percent driveway The weighted mean velocity is: 0.8(16.1) + 0.2(12.1) + 0.16(18.6) + 0.02(26.8) + 0.02(26.8) = 19.3 feet/minute

Time of concentration = Length of overland flow/weight mean velocity Tc = 320 feet/(19.3 feet/minute) = 16.5 minutes

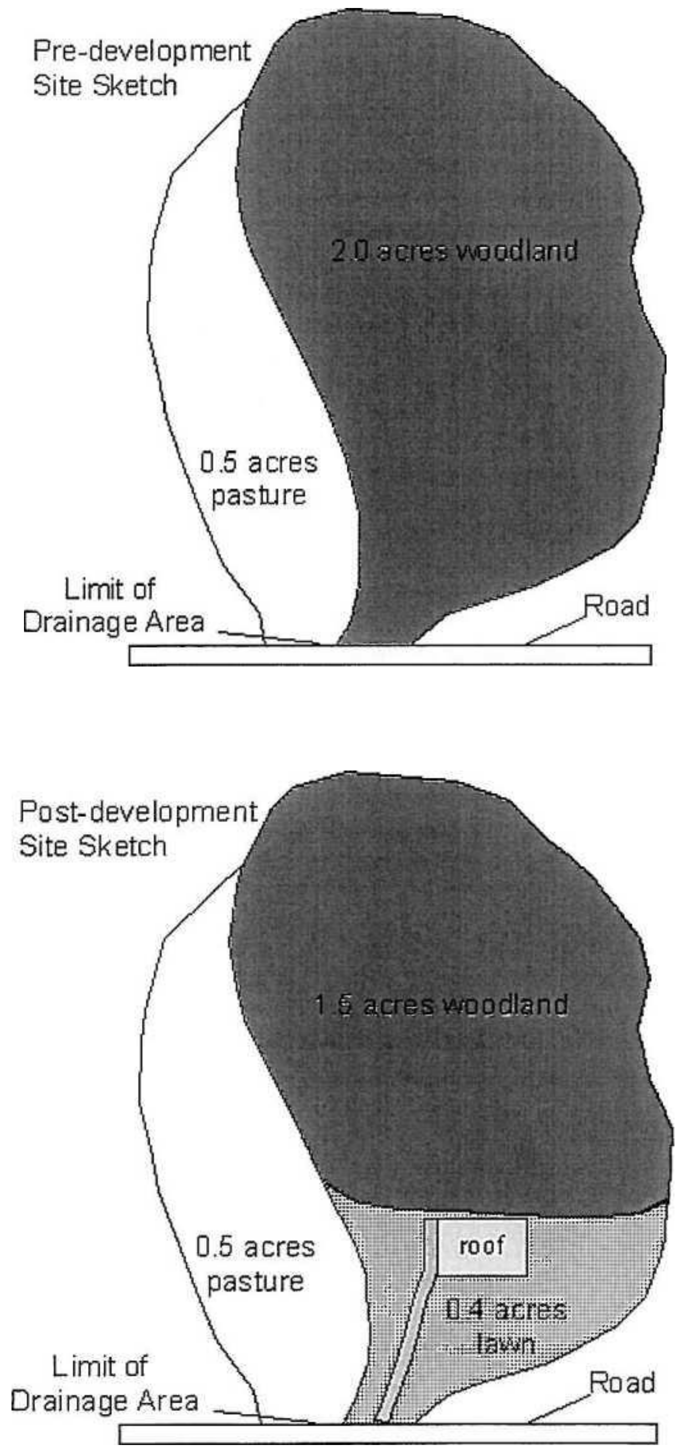
Step 4: Determine the peak rainfall intensity (i), (Table 5.4).

Interpolate maximum intensity for 1-year, 24-hour storm,
I_f = 2.38 inches/hour

Maximum Intensity for 10-year, 24-hour storm, I_{10} = 4.51 inches/hour

Step 5: Determine the peak discharge, q (ft^3/sec), by multiplying the previously determined factors using the Rational formula: q=CiA

Peak flow for 1-year, 24-hour storm, q_1 = CiA = 0.26 x 2.38 x 2.5 -1.55 cfs Peak flow for 10-year, 24-hour storm, q_{10} = CiA = 0.26 x 4.51 x 2.5 = 2.93 cfs



The SCS Peak Discharge Method Sample Calculation

The SCS Peak Discharge Method may be used to calculated peak discharge for any development. The following is a simplified example of the SCS Method. Details of this method are included in USDA-SCS Technical Release 55. Equally acceptable methods are given in the Hydrology section of the National Engineering Handbook and in the TR- 20 model, which is described in USDA Technical Release 20 (including its revisions and derivatives). Table 5.4 may be used to determine the area-averaged value of the runoff curve number (CN). A blank form (Form SW-007) for calculating peak runoff using the SCS Method is included in Appendix A.

Given: Location: New Bern, North Carolina Drainage
area: 21 acres Average slope: 1.0 percent
Maximum Hydraulic Slope Length: 3,000 feet
Hydrologic Soil Group: C

Find: For the watershed draining through the development, compute the design peak runoff rate for a 1-year, 24-hour storm and a 10-year, 24-hour storm both before and after the area is developed.

Step 1: Determine the drainage area, A.
A -21 acres

Determine the hydraulic length (distance from most remote point to design point).
L = 3,000 feet

Determine the average slope (percent) of the watershed.
S=1.0%

Step 2: Calculate the curve number, CN, for the drainage area (see Table 5.5).

Pre-Development Conditions

Type of Land Use	CN	% Imp.	Area (acre)	CN x A	Imp x A
Industrial	91	72	5	455	360
Single Family residential, 1/2 acre lots	80	25	8	640	200
Woodland	70	0	8	560	0
Total			**21**	**1,665**	**560**

Area-weighted CN = 1,665/21 =79.3 Overall percent Impervious = 560/21 = 26.7 %

Step 3: Select design storm and determine the runoff depth and volume.
1-year, 24-hour design rainfall amount: P_1 = 3.7 inches 10-year, 24-hour design rainfall amount: P_{10} -7.0 inches

Determine runoff depth: $Q = (P - 0.2S)^2/(P + 0.8S)$ for $S = (1000/CN) - 10$
S = *(1000/79.3) -10 = 2.61 inches*
Q, = *$(3.7-0.2(2.61))^2/(3J + 0.8(2.61))$ = 1.74 inches*
$Q_{10} = (7.0- 0.2(2.61))^2/(7.0 + 0.8(2.61))$ = 4.62 inches

Step 4: Determine the peak rate of runoff for the design storm by adjusting for watershed shape.

Equivalent drainage area, Ac for hydraulic length of 3,000 feet: Ac = 90 acres Total peak runoff rate for equivalent drainage are, Q_{Ac} *= 37 cfs/inch runoff:*

Q_t = *37 cfs/inch x 1.74 inch (21/90) = 15.0 cfs* Q_{10} *=*
37 cfs/inch x 4.62 inch (21/90) = 39.9 cfs

Step 5: Adjust peak discharge to account for impervious area and channel improvements.

Q_1 *= 15.0 cfs x 1.12 =16.8 cfs* Q_{10} *= 39.9 cfs x 1.12 = 44.7 cfs*
No improved channel adjustment necessary for pre-development conditions.

Step 6: Adjust the peak discharge based on the average watershed slope.

No watershed slope adjustment necessary for pre-development conditions.

Step 7: Adjust the peak discharge for ponding and swampy areas in the watershed.

No ponding and swampy area adjustment necessary for pre-development conditions.

Repeat Steps 2 though 7 for post-development conditions.

Step 2: Calculate the curve number, CN, for the drainage area (see Table 5.5).

Post-Development Conditions

Type of Land Use	CN	% Imp.	Area (acre)	CN x A	Imp x A
Industrial	91	72	6	546	432
Single Family residential, 1/2 acre lots	80	25	8	640	200
Woodland - good stand	70	0	0	0	0
Commercial	94	85	7	658	595
Total			**21**	**1,844**	**1,227**

Area-weighted CN = 1,84A1/21 = 87.8

Overall percent Impervious = 1,227/21 = 58.4 %

Step 3: Select design storm and determine the runoff depth and volume.

1-year, 24-hour design rainfall amount: P_1 *= 3.7 inches 10-year, 24-hour design rainfall amount:* P_{10} *= 7.0 inches*

Determine runoff depth: $Q = (P - 0.2S)^2/(P + 0.8S)$ for $S = (1000/CN) - 10$

S = (1000/87.8)- 10 = 1.38 inches

Q_1 *= (3.7- 0.2(1.38)f/(3.7 + 0.8(1.38)) =2.44 inches*

$Q_{10} = (7.0-0.2(1.38))^2/(7.0 + 0.8(1.38)) = 5.58$ *inches*

Step 4: Determine the peak rate of runoff for the design storm by adjusting for watershed shape.

Equivalent drainage area, Ac for hydraulic length of 3,000 feet: Ac = 90 acres Total peak runoff rate for equivalent drainage are, Q_{Ac} *= 37 cfs/inch runoff:*

Q_1 *= 49 cf s/inch x 2.44 inch (21/90) = 27.9 cfs* Q_{10} *=*
49 cf s/inch x 5.58 inch (21/90) = 63.8 cfs

Step 5: Adjust peak discharge to account for impervious area and channel improvements.

Q, *= 27.9 cfs x 1.20 = 33.5 cfs* Q_{10} *= 63.8 cfs x 1.20 = 76.6 cfs*

No improved channel adjustment necessary for post-development conditions.

Step 6: Adjust the peak discharge based on the average watershed slope.
No watershed slope adjustment necessary for post-development conditions.

Step 7: Adjust the peak discharge for ponding and swampy areas in the watershed. *No ponding and swampy area adjustment necessary for post-development conditions.*

Table 5.5 SCS Runoff Curve Numbers (CN)

Land Use/Cover		Hydrologic Soil Group A	B	C	D
		-----------CN-----------------			
Cultivated land					
- without conservation		72	81	88	91
- with conservation		62	71	78	81
Pasture land					
- poor condition		68	79	86	89
- good condition		39	61	74	80
Meadow					
- good condition		30	58	71	78
Wood or forest land					
- Thin stand - poor cover, no mulch		45	66	77	83
- Good stand - good cover		25	**55**	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
- Good condition: grass cover on 75% or more of the area		39	61	74	80
- Fair condition: grass cover on 50 to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[1]: Development completed and vegetation established					
Average lot size	Average % Impervious				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	[1] 20	51	68	79	84
2 acres	15	47	66	77	81
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads paved with curbs and storm sewers		98	98	98	98
- gravel		76	85	89	91
- dirt		72	82	87	89
Newly graded area		81	89	93	95
Residential: Development underway and no vegetation					
- Lot sizes of 1/4 acre		88	93	95	97
- Lot sizes of 1/2 acre		85	91	94	96
- Lot sizes of 1 acre		82	90	93	95
- Lot sizes of 2 acres		81	89	92	94

[1] Curve numbers are computed assuming the runoff from the house and driveway is directed toward the street.

Source: USDA-SCS

5.5 Restrictive Covenant

The proper design, installation, and maintenance of a stormwater facility plan is a condition under which the Stormwater Administrator can issue a City Stormwater Permit. This section of the manual set forth the requirements for the computation of pre- and post-development stormwater discharges and the criteria under which the Stormwater Administrator may issue a City Stormwater Permit. In order to ensure that the facilities maintained in a development result in compliance with the plan presented in the application the applicant must execute the Covenant Agreement contained in Appendix C of this manual, or other legal instrument acceptable to the Stormwater Administrator, before a City Stormwater Permit may be issued.

Note:

No summary forms or examples are provided in this manual for developers who want to use Green-Ampt or Horton infiltration functions and Kinematic or Dynamic Wave Routing methods for the calculation of runoff. When submitting calculations based on those methods an engineering summary of the calculations should be prepared and computer input and simulation results should be submitted to the Stormwater Administrator in both printed and electronic forms.

6. Calculating and Controlling Nitrogen Exports

6.1 The Nitrogen Control Program

The City, in compliance with the North Carolina Neuse River Stormwater Rule (NSR), has a goal of reducing the amount of total nitrogen leaving new developments within the City by 30 percent. The NSR expects to achieve this reduction by implementation of total nitrogen-reducing planning considerations and best management practices (BMPs). The NSR requires that all new developments meet a total nitrogen export performance standard of less than or equal to 3.6 pounds per acre per year (lbs/ac/yr). Total nitrogen loads from new developments that exceed the performance standard will be allowed only if one-time offset payments are made to the Ecosystem Enhancement Program in the amount of $850.50/lb/yr for the excess total nitrogen (TN) load. The City also requires payment of a one-time offset fee in the amount of $170/lb/yr for the excess total nitrogen (TN) load. No new development may be permitted where total nitrogen exports exceed 6 lbs/ac/yr for residential developments and 10 lbs/ac/yr for non-residential developments. If planned new development generates greater than the allowable limits, there are options for residential and commercial properties to reduce the total nitrogen load through the implementation and maintenance of wet detention ponds, constructed wetlands, and other BMPs.

In order to ensure that the total nitrogen export reductions occur, the City and the NSR requires a computation of the average potential total nitrogen export from each new development.

For purposes of total nitrogen export control the City defines new development as any activity that disturbs greater than 1/2 acre of land in order to establish, expand or modify a single family, duplex residential, multifamily residential, commercial, industrial, institutional development or a recreational facility. New development does not include agriculture, mining, or forestry activities. Land disturbance is defined as grubbing, stump removal, and/or grading.

6.2 Calculating Total Nitrogen Exports

The City allows two methods for calculating total nitrogen export.

- *Method 1* - For residential developments where lots are shown, but the actual footprints of buildings are not shown, on site plans. Impervious surface resulting from building footprints is estimated based on typical impervious areas associated with a given lot size.
- *Method 2* - For residential, commercial, and industrial developments when the entire footprint of the roads, parking lots, buildings, and any other built-upon area is shown on site plans. Commercial and industrial developments must use Method 2.

Regardless of which method is used, annual accounting of net changes of total nitrogen export from new developments must be reported to the City in the application for a Stormwater Permit. The accounting must include enumeration of:

- Pre-development total nitrogen export loads.
- Potential post-development total nitrogen export loads without BMPs.
- Estimated post-development total nitrogen export loads with the use of BMPs.
- The difference between potential and actual post-development total nitrogen export loads.
- Total nitrogen load to be paid for by offset fees.

Method 1

This method does not require calculation of the area of building footprints. Rather, the impervious surface resulting from building footprints is estimated based on typical impervious areas associated with a given lot size. This method is shown in Figure 2a, which was reproduced from the *Neuse River Basin: Model Stormwater Program for Nitrogen Control* (Model Program) (1999). The development of these methods is described in Appendix F of the *Appendices to the Neuse River Basin: Model Stormwater Program for Nitrogen Control* (1999).

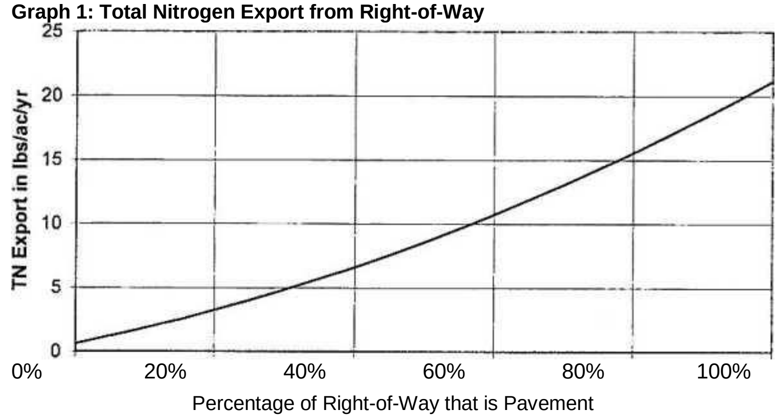
Figure 2a: Method 1 for Quantifying Total Nitrogen (TN) Export from Residential Developments when Building and Driveway Footprints are Not Shown*

Step 1	Determine area for each type of land use and enter in Column (2).
Step 2	Total the areas for each type of land use and enter at the bottom of Column (2).
Step 3	Determine the TN export coefficient associated with right-of-way using Graph 1.
Step 4	Determine the TN export coefficient associated with lots using Graph 2.
Step 5	Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter in Column (4).
Step 6	Total the TN exports for each type of land use and enter at the bottom of Column (4).
Step 7	Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2).

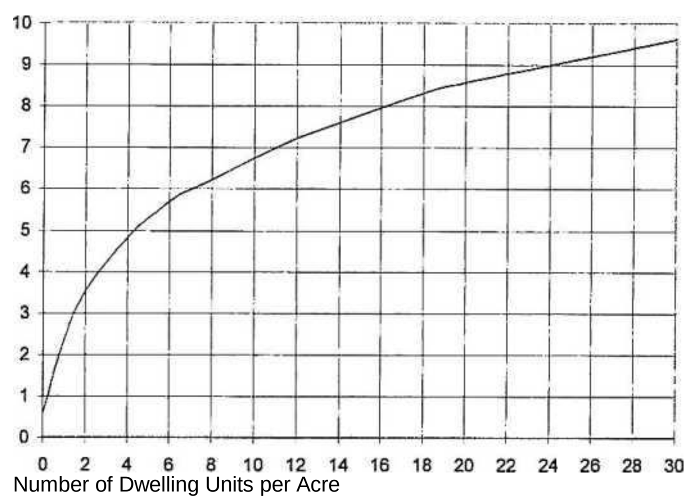
(D **Type of Land Cover**	**(2) Area (acres)**	**(3) TN export coeff. (lbs/ac/yr)**	**(4) TN export from use (lbs/yr)**
Permanently protected undisturbed Open space (forest, unmown		0.6	
Permanently protected managed Open space (grass, landscaping, etc.)		1.2	
Right-of-way (read TN export from Graph 1)			
Lots (read TN export from Graph 2)			
TOTAL		—	

'Reproduced from *Neuse River Basin: Model Stormwater Program for Nitrogen Control* (1999).

Graph 1: Total Nitrogen Export from Right-of-Way



Graph 2: Total Nitrogen Export from Lots



(Graphs 1 and 2 were reproduced from *Neuse River Basin: Model Stormwater Program for Nitrogen Control,* 1999).

Method 2

Method 2 is shown in Figure 2b, which was reproduced from the Model Program (1999).

Figure 2b: Method 2 for Quantifying TN Export from Residential/Industrial/Commercial Developments when Footprints of all Impervious Surfaces are Shown*

Step 1: Determine area for each type of land use and enter in Column (2).
Step 2: Total the areas for each type of land use and enter at the bottom of Column (2).
Step 3: Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter in Column (4).
Step 4: Total the TN exports for each type of land use and enter at the bottom of Column (4).
Step 5: Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2).

(1) Type of Land Cover	(2) Area (acres)	(3) TN export coeff. (lbs/ac/yr)	(4) TN export from use (lbs/yr)
Permanently protected undisturbed open space (forest, unmown meadow)		**0.6**	
Permanently protected managed open space (grass, landscaping, etc.)		1.2	
Impervious surfaces (roads, parking lots, driveways, roofs, paved storage areas, etc.)		21.2	
Total		—	

'Reproduced from *Neuse River Basin: Model Stormwater Program for Nitrogen Control (*1999).

The NSR requires that all new developments achieve a nitrogen export of less than or equal to 3.6 lbs/ac/yr. If the development contributes greater than 3.6 lbs/ac/yr of nitrogen, the mitigation options shown in Table 2a are available for residential or non- residential developments.

Table 2a: Nitrogen Export Reduction Options

Residential	**Commercial / Industrial**
If the computed export is less than 6.0 lbs/ac/yr, then the owner may either: 1. install BMPs to remove enough nitrogen to bring the development down to 3.6 lbs/ac/yr; 2. Pay a one-time offset payment of $850.50/lb to the State and $170/lb to the City to bring the nitrogen down to the 3.6 lbs/ac/yr; or, 3. Do a combination of BMPs and offset payments to achieve a 3.6 lbs/ac/yr export.	If the computed export is less than 10.0 lbs/ac/yr, then the owner may either: 1. Install BMPs to remove enough nitrogen to bring the development down to 3.6 lbs/ac/yr; 2. Pay a one-time offset payment* per pound to the State and $ 170/lb to the City to bring the nitrogen down to the 3.6 lbs/ac/yr; or, 3. Do a combination of BMPs and offset payment to achieve a 3.6 lbs/ac/yr export.
If the computed export is greater than 6.0 lbs/ac/yr, then the owner must use on-site BMPs to bring the development's export down to 6.0 lbs/ac/yr. Then, the owner may use one of the three options above to achieve the reduction between 6.0 and 3.6 lbs/ac/vr.	If the computed export is greater than 10.0 lbs/ac/yr, then the owner must use on-site BMPs to bring the development's export down to 10.0 lbs/ac/yr. Then, the owner may use one of the three options above to achieve the reduction between 10.0 and 3.6 lbs/ac/vr.

The table above discusses the option of using offset fees to meet the nitrogen export levels set for new development activities. These offset fees go to the North Carolina Ecosystem Enhancement Program (EEP). The EEP will utilize these fees in accordance with the EEPs Basinwide Wetlands and Riparian Restoration plans. An additional payment in the amount of $170/1 b/yr must be paid to the City before a Stormwater Permit can be issued.

Examples of Total Nitrogen calculations using Methods 1 and 2 are included on the following pages. Blank forms for calculating Total Nitrogen export are included in Appendix A.

Example 1 • Single Residential Lot

Given:

- Single Residential Lot
- 0.7 acres total, 2,000 sf house, 20'x30' driveway
- Overall expected impervious area = 8.5% (0.06 acres)
- Developed as single family residence

Use Method 2 (Form SW-005) because actual impervious area is known.

Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	0	0.6	0
Permanently protected managed open space (lawns, landscaped areas)	0.64	1.2	0.77
Impervious surfaces (roofs, roads, pavement, parking areas, etc.)	0.06	21.2	1.27
Totals	0.70	–	2.04

Total N export = 2.04 lbs/yr + 0.7 ac = 2.91 lbs/ac/yr

Total N export < 6 lbs/ac/yr (residential limit), no BMP's necessary. Total N export < 3.6 lbs/ac/yr, no Offset Payments necessary.

Example 2: Residential Multi-Lot Subdivision - Method 1

Given:

- Residential subdivision inside the Extra Territorial Jurisdiction (ETJ)
- 80 acres total, 33 lots, 9 acres in ROW with a 20' pavement width (90 percent impervious)
- Overall expected impervious area = 14% (11.2 acres)
- Length of Stream A = 1000' x 50' riparian buffer x 2 sides of stream = 2.3 acres
- Developed as 1 dwelling unit per 2 acres

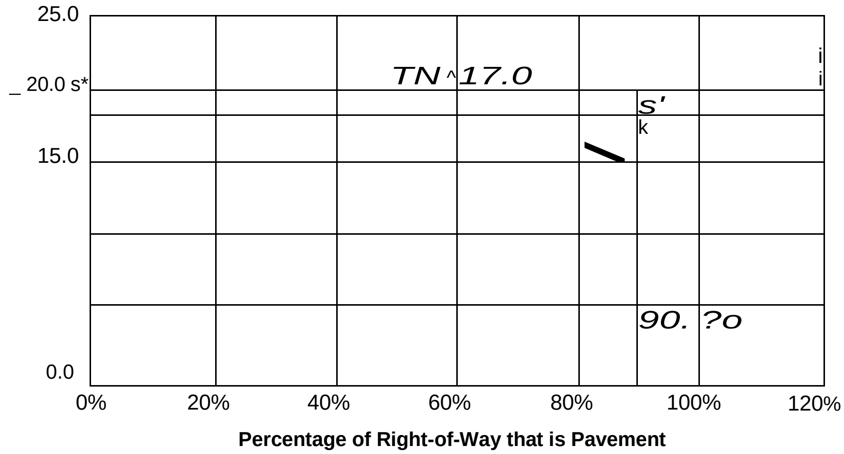
Use Method 1 (Form SW-004) because actual building footprints on lots are not known.

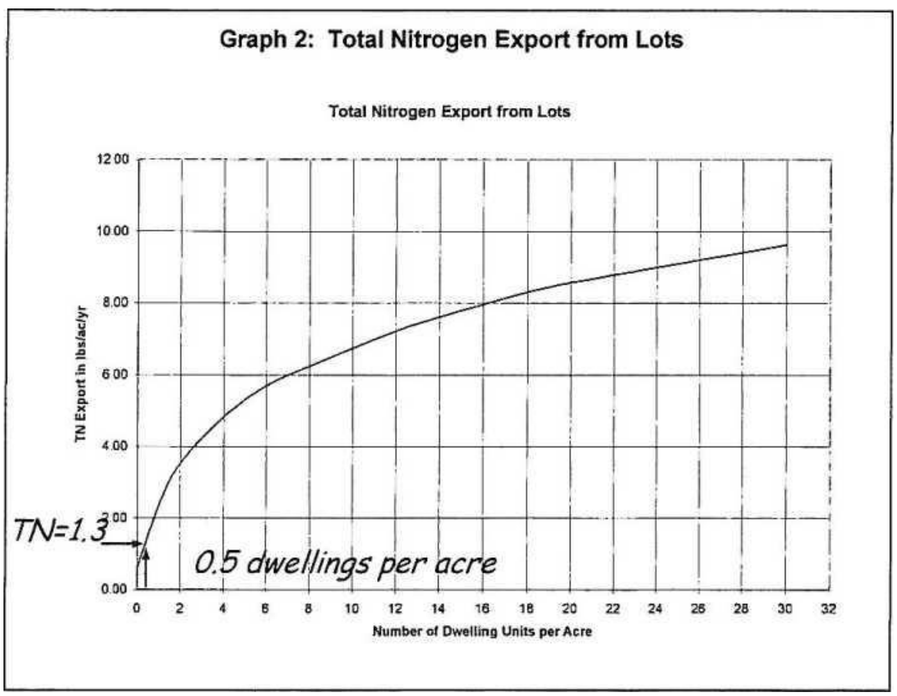
Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	2.3	0.6	1.4
Permanently protected managed open space (lawns, landscaped areas)	2.7	1.2	3.2
Right of Way (read TN export from Graph 1)	9.0	17.0	153.0
Lots (read TN export from Graph 2)	66.0	1.3	85.8
Totals	80.0		243.4

Total N export = 243.4 lbs/yr -5- 80.0 ac = 3.0 lbs/ac/yr

Total N export < 6 lbs/ac/yr (residential limit), no BMP's necessary. Total N export < 3.6 lbs/ac/yr, no Offset Payments necessary.

Graph 1: Total Nitrogen Export from Right-of-Way





Example 3: Residential Multi-Lot Subdivision - Method 1

Given:

- Residential subdivision inside the Extra Territorial Jurisdiction (ETJ)
- 80 acres total, 120 lots, 16 acres in ROW with a 20' pavement width (90 percent impervious)
- Overall expected impervious area = 20% (16.3 acres)
- Length of Stream A = 2000' x 50' riparian buffer along one bank = 2.3 acres
- Developed as 2 dwelling units per 1 acre

Use Method 1 (Form SW-004) because actual footprints of buildings on lots are unknown.

Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	2.3	0.6	1.4
Permanently protected managed open space (lawns, landscaped areas)	1.7	1.2	2.0
Right of Way (read TN export from Graph 1)	16.0	17.0	272.0
Lots (read TN export from Graph 1)	60.0	3.5	210.0
Totals	80.0		485.4

Total N export = 485.4 lbs/yr * 80.0 ac = 6.1 lbs/ac/yr
Total N export > 6 lbs/ac/yr (residential limit), BMP's necessary. Wet pond can be used for both detention and N reduction.

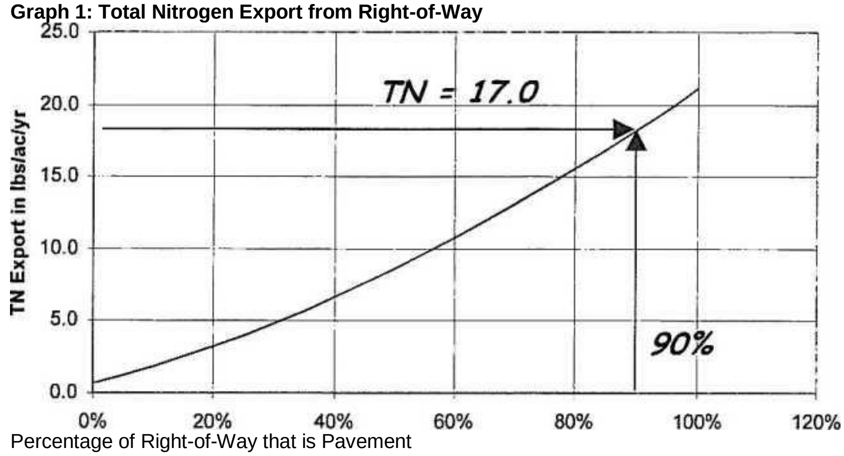
Option 1: Offset payment and wet detention BMP

- Install wet detention, providing 25% reduction of 6.1 = 4.6 lbs/ac/yr
- State Offset payment (4.6 lbs/ac/yr - 3.6 lbs/ac/yr) x $850.50/1b/yr x 80.0 ac = $68,040.00.
- City of New Bern Offset payment (4.6 lbs/ac/yr - 3.6 lbs/ac/yr) x $170 x 80.0 ac = $13,600.00
- **Total Offset Payments: $81,650.00**

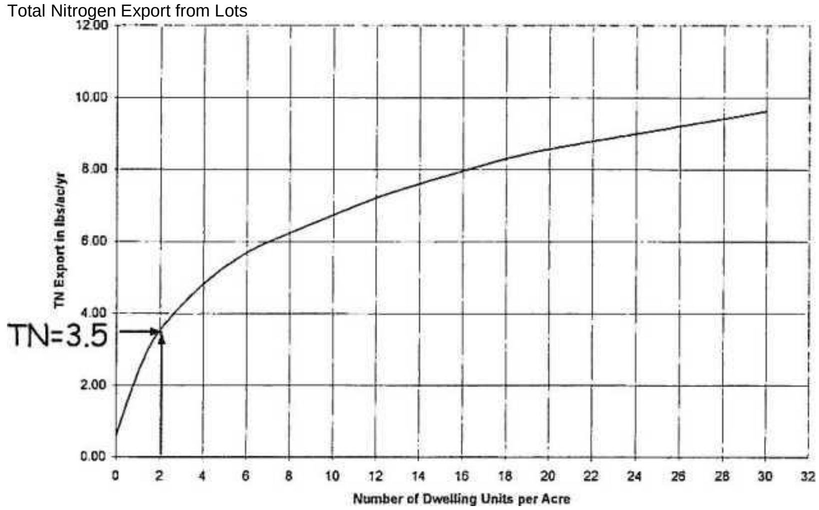
Option 2: Offset payment, filter strip BMP, and wet detention BMP

- Install Filter strips, providing 20% reduction of 6.1 = 4.9 lbs/ac/yr
- Install wet detention, providing 25% reduction of 4.88 = 3.7 lbs/ac/yr
- State Offset payment (3.7 lbs/ac/yr - 3.6 lbs/ac/yr) x $850.50/lb/yr x 80.0 ac = $6,804.00.
  City of New Bern Offset payment (3.7 lbs/ac/yr - 3.6 lbs/ac/yr) x $170 x 80.0 ac = $1,360.00 '
- **Total Offset Payments: $8,164.00**

Graph 1: Total Nitrogen Export from Right-of-Way



Graph 2: Total Nitrogen Export from Lots



Example 4: Residential Multi-Lot Subdivision with Detention - Method 2

Given:

- Residential subdivision inside the Extra Territorial Jurisdiction (ETJ)
- 40.2 acres total, 66 lots, 5.3 acres in ROW with a 20’ pavement width
- expected impervious area = 25%
- length of Stream A = 1800’ x 50’ riparian buffer = 2.1 acres
- developed as 2 dwelling units per acre

Use Method 2 because actual impervious area is known.

Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	2.1	0.6	1.3
Permanently protected managed open space (lawns, landscaped areas)	28.1	1.2	33.7
Impervious surfaces (roofs, roads, pavement, parking areas, etc.)	10.0	21.2	212.0
Totals	40.2		247.0

Total N export = 247.0 lbs/yr * 40.2 ac = 6.4 lbs/ac/yr

Requirements: If export > 6 lbs/ac/yr (residential limit), must use BMP’s to reduce to < 6.0 lbs/ac/yr.

Option 1: Offset payment and wet detention BMP

- Install Filter strips, providing 25% reduction = 4.6 lbs/ac/yr
- State Offset payment (4.6 lbs/ac/yr - 3.6 lbs/ac/yr) x $850.50/lb/yr x 40.2 ac = $34,190.00
- City of New Bern Offset payment (4.6 lbs/ac/yr - 3.6 lbs/ac/yr) x $170 lbs x 40.2 ac = $6,834.00
- **Total Offset Payments: $41,024.10**

Option 2: Offset payment, wet detention and filter strip (BMP’s in series)

- Install filter strips, providing 20% reduction = 4.9 lbs/ac/yr
- Install wet detention after filter strips, providing 25% reduction of 4.9 = 3.68 lbs/ac/yr
- State Offset payment (3.68 lbs/ac/yr - 3.6 lbs/ac/yr) x $850.50/lb/yr x 40.2 ac = $2,735.21
- City of New Bern Offset payment (3.68 lbs/ac/yr - 3.6 lbs/ac/yr) x $170 x 40.2 ac = $546.72
- **Total Offset Payments: $3,281.93**

Example 5: Residential Multi-Lot Subdivision without Detention

- Residential subdivision inside the ETJ
- Given: 101.96 developed acreage, 89 lots, ROW acreage = 6.58
- Site Plan presents impervious area = 15%
- 1100’ along buffer regulated stream x 50’ riparian buffer along one bank = 1.3 acres

Use Method 2 (Form SW-005) because actual impervious area is known.

Land Use	Area (acre)	TN Export Coefficient, (Ibs/ac/yr)	TN Export (Ibs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	1.3	0.6	0.8
Permanently protected managed open space (lawns, landscaped areas)	85.4	1.2	102.4
Impervious surfaces (roofs, roads, pavement, parking areas, etc.)	15.3	21.2	324.4
Totals	102.0		427.6

Total N export = 427.6 I bs/yr ^ 101.96 ac = 4.2 Ibs/ac/yr

Requirements: Offset payment or install BMP’s to reduce to 3.6 Ibs/ac/yr

Option 1: Offset payments only

- State Offset Payment: (4.2 Ibs/ac/yr - 3.6 Ibs/ac/yr) x $850.50/lb/yr x 101.96 ac = $52,030.19
- City of New Bern: (4.2 Ibs/ac/yr - 3.6 Ibs/ac/yr) x $170 x 101.96 ac. = $10,399.92
- **Total Offset Payments: $62,430.11**

Option 2: Open space non-structural BMP and offset payment

- Set aside 20 acres as open space within site to be undisturbed and perpetually protected.

Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	21.3	0.6	12.8
Permanently protected managed open space (lawns, landscaped areas)	65.4	1.2	78.4
Impervious surfaces (roofs, roads, pavement, parking areas, etc.)	15.3	21.2	324.4
Totals	102.0		415.6

- Total N export = 415.6 Ibs/ac/yr-*- 101.96 ac = 4.07 Ibs/ac/yr
- State Offset Payment: (4.07 Ibs/ac/yr - 3.6 Ibs/ac/yr) x $850.50/lb/yr x 101.96 ac = $40,756.98
- City of New Bern Offset payment (4.07 Ibs/ac/yr - 3.6 Ibs/ac/yr) x $170 x 101.96 ac = $8,146.60
- **Total Offset Payments: $48,903.58**

Option 3: Wet Detention Pond BMP
- Install wet detention pond, providing 25% reduction = 3.15 Ibs/ac/yr
- **No Offset Payments Required**

Example 6: Commercial Development

Given:

- Commercial Development inside the Extra Territorial Jurisdiction (ETJ)
- 10.0 acres total
- Site Plans present impervious area = 75%

Use Method 2 (Form SW-005) because it is a commercial development.

Land Use	Area (acre)	TN Export Coefficient, (lbs/ac/yr)	TN Export (lbs/yr)
Permanently protected, undisturbed open space (forest, existing riparian buffers)	0	0.6	0
Permanently protected managed open space (lawns, landscaped areas)	2.5	1.2	3.0
Impervious surfaces (roofs, roads, pavement, parking areas, etc.)	7.5	21.2	159.0
Totals	10.0		162.0

Total N export = 162.0 lbs/yr 10.0 ac = 16.2 lbs/ac/yr

Requirements: If export > 10 lbs/ac/yr (non-residential limit), must use BMP's to reduce to < 10.0 lbs/ac/yr.

Option 1: Offset payment, wet detention and filter strip (BMP's in series)

- Use two different BMPs for different sections of the development site.
  - Install filter strips along area draining 1/3 of impervious surfaces, reduce 1/3 of 180.2 lb TN/year by 20%.
    - Adjusted TN Export from 1/3 of impervious surfaces = 7.5/3*21.2*0.8 = 42.4lbs/yr
  - Install wet detention for area draining remaining area, reducing TN by 25%.
    - Adjusted TN Export from remaining 2/3 impervious surfaces and permanently protected managed open space= (2.5*1.2+ 7.5*2/3*21.2)*0.75 = 81.8 lbs/yr
  - Total Adjusted TN Export = 48.1 + 81.8 = 129.9 lbs/yr
  - Adjusted TN export per area = 129.9 lbs/yr 4-10.0 ac = 13.0 lbs/ac/yr
- Route water from wet detention pond through sand filter (third BMP), reduce TN export by 35%.
  - Total Adjusted TN export = 129.9 * 0.65 = 84.4 lbs/yr
  - Adjusted TN export per area = 84.4 lbs/yr 4-10.0 ac = 8.4 lbs/ac/yr
- State Offset payment (8.4 lbs/ac/yr - 3.6 lbs/ac/yr) x $850.50/lb/yr x 10 ac = $40,824.00
- City of New Bern Offset payment (8.4 lbs/ac/yr - 3.6 lbs/ac/yr) x $170 x 10.0 ac = $8,160.00
- **Total Offset Payments: $48,984.00**

6.3 Restrictive Covenant

The proper design, installation, and maintenance of a stormwater facility plan is a condition under which the Stormwater Administrator can issue a City Stormwater Permit. This section of the manual set forth the requirements for the computation of total nitrogen exports and the criteria under which the Stormwater Administrator may issue a City Stormwater Permit. The applicant's stormwater facility plan must specify the areas of impervious surface, undisturbed open space, and managed open space in the development. In order to ensure that the facilities maintained in a development result in compliance with the plan presented in the application the applicant must execute the Covenant Agreement contained in Appendix C of this manual, or other legal instrument acceptable to the Stormwater Administrator, before a City Stormwater Permit may be issued.

7. *Site Design Best Management Practices*

7.1 Low-impact Development (LID)

The City encourages developers and property owners to adopt the principles and practices of Low-impact development (LID) to achieve stormwater control and improve the quality of the runoff from developed areas. LID can be described as the effort to create a hydrologically functional landscape in a developed area that mimics the natural hydrologic regime. This objective is accomplished by:

- Minimizing stormwater impacts to the extent practicable. Techniques to accomplish this include reducing imperviousness, conserving natural resource and ecosystems, maintaining natural drainage courses, reducing use of pipes, and minimizing clearing and grading.
- Providing runoff storage measures dispersed uniformly throughout a site's landscape with the use of a variety of detention, retention, and runoff practices.
- Maintaining predevelopment time of concentration by strategically routing flows to maintain travel time and control the discharge.
- Implementing effective public education programs to encourage property owners to use pollution prevention measures and properly maintain the on-lot hydrologically function landscape management practices.

7.1.1 LID Strategies

The City is reviewing its ordinances, operations and practices in order to better manage stormwater from its' properties and the City expects developers and property owners applying for Stormwater Permits to use LID strategies in their site designs and stormwater management plans. Some of the strategies that can provide for improved stormwater management and for the reduction of the total nitrogen (TN) export required under the Neuse River Rule, include:

- **Reducing Road and Driveway Widths**

  Reducing road and driveways widths reduces the amount of impervious area of a site. Roads are often designed at widths that are excessive, and sometimes even counterproductive, for vehicular safety. Overly wide roads inadvertently increase impervious area that, in turn, increases storm runoff and the transport of nutrients and other pollutants. Applicants for stormwater permits should show that they have considered road and driveway widths and have appropriately reduced them while maintaining a minimum consistent with health, safety requirements, and the requirements of the City's Land Use Ordinance.

- **Reducing Parking Areas**

  Similar to road and driveway widths, parking areas (both the number and size of spaces) often are designed with no consideration of the stormwater and water quality impacts of those facilities. Some methods that may be used to reduce the impervious area created by parking facilities are use of angled parking and smaller parking spaces and the use of pervious parking materials.

Parking facilities do not have to be visually unappealing and, fortunately, many of the methods used to reduce the unpleasant visual impacts of parking facilities can be incorporated into its water quality mitigation plans. Depressed, rather than raised, parking lot islands and median strips not only enhance the aesthetic value of the area, but can also serve a functional purpose for water quality enhancement. These interruptions in the impervious parking lots can have vegetative filter strips to receive pavement runoff or contain bioretention areas or other engineered BMPs.

Porous pavements can be used in parking lots to reduce the amount of runoff and decrease the required size of associated BMP structures.

- **Minimizing Use of Curb and Gutter**

  Curb and gutter are often used in areas where they are not required for stormwater control and where alternative designs such as grass swales are feasible. In the application for a Stormwater Permit, the applicant should present information about the development's street design procedures and should show that alternatives to curb and gutter have been considered. Useful alternative approaches include designs that allow sidewalk, driveway, and parking lot flows to drain into grass swales or bioretention areas, away from street gutter and pipe systems. These systems should use flush surface curbstones that allow sheet flow off of the impervious surface while providing lateral support for the pavement. Where both curb and gutter are necessary, the use of frequent curb cuts, which divert a designed portion of the runoff onto vegetated areas, should be considered.

- **Cluster and Open-Space Developments and "Traditional" Neighborhood Developments.**

  Among the strategies listed in the NSR are the uses of innovative community and subdivision designs that can significantly reduce the impact of new development on water quality and on required municipal services. The City will encourage these innovations by review of its current Land Use Ordinance and require stormwater management BMP design review as part of the site review process. The NSR Model Program defines "traditional" neighborhoods as rectangular block development with mixed residential and commercial land use. Such neighborhoods can have the advantage of reducing automobile travel and promoting increased usage of alternative transportation modes, including mass transit and pedestrian.

- **Maintaining Green Space**

  How a development and its residents manage green space has an important impact on water quality. In dense urban settings, rain gardens can be used to reduce runoff from buildings and create a pleasant environment. Rain garden systems consist of piping roof storm water into a cistern that bleeds the water into a nearby, vegetated area. Filtration through the vegetation and the soil removes pollutants from the water and reduces the impacts of the impervious roof area. Developing City procedures to properly manage the application of fertilizers on City property and publishing guidelines on the use of fertilizers (and other chemicals) for residential and commercial properties are low-cost, highly effective methods of reducing TN exports to local waters.

- **Disconnecting Impervious Surfaces**
  One of the methods that can be used to reduce the amount of runoff from a development site is the disconnection of impervious surfaces. This BMP can be implemented in many ways, including:
  - Leaving a 2 or 3 feet wide pervious strip between the edge of a street and the beginning of driveways.
  - Using pervious pavement stones along strips of a parking lot and in sections of sidewalks.
  - Ensuring that rooftop drain water passes over a pervious strip before running onto a paved lot or into a stormwater collection system.

  These simple techniques are valuable methods for reducing both the quantity of stormwater leaving a project and improving the quality of that stormwater.

- **Other**
  Other areas in which City land use ordinances can have significant impacts on water quality are property setback requirements and lot size zoning. Excessive setback and lot size requirements have the impact of decreasing the compactness of development, which can increase the overall impervious area, decrease the applicability of some BMPs, and increase the use of automobile transportation. While large-lot zoning may be desirable for water quality impacts in some sensitive areas and for other reasons, it can negatively impact water quality when applied as a uniform standard.

References:

Low-Imoact Development Design Strategies. An Integrated Design Approach. Prince George's County, Maryland Department of Environmental Resources, January 2000.

Better Site Design. An Assessment of the Better Site Design Principles for Communities Implementing Virginia's Chesapeake Bay Preservation Act. Center for Watershed Protection, Inc, Ellicot City, Maryland 21043.

Principles of Low-Impact Design

Conservation of Natural Areas

1. Native Plant and Tree Conservation: Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street right-of-ways, parking lot islands, and other landscaped areas to promote natural vegetation.

2. Minimized Clearing and Grading: Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

Lot Development

3. Open Space Design: Promote open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.

4. Shorter Setbacks and Frontages: Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

5. Common Walkways: Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

6. Shared Driveways: Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

Residential Streets and Parking Lots

7. **Narrower Streets:** Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.

8. **Shorter Streets:** Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

9. **Narrower Right-of-Way Widths:** Residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

10. **Smaller and Landscaped Cul-de-Sacs:** Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

11. **Vegetated Open Channels:** Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

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12. **Reduced Parking Ratios:** The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to determine if lower ratios are warranted and feasible.

13. **Mass Transit and Shared Parking:** Parking codes should be revised to lower parking requirements where mass transit is available and enforceable shared parking arrangements are made.

14. Less Parking Lot Imperviousness: Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials (see lattice paving stones in photo to right) in the spillover parking areas where possible.

PHOTO BRUCE K. FERGUSON

15. Structured Parking: Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

16. Treated Parking Lot Runoff: Provide stormwater treatment for parking lot runoff using bioretention areas (see photos to right and below), filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

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PHOTO LARRY COFFMAN, PGC DEPT OF ENV. RESOURCES

Site Design Resources

Conservation Design for Stormwater Management (19971 Delaware Department of Natural Resources and Environmental Control, Sediment and Stormwater Program, 89 Kings Highway, Dover, DE 19901, Phone: (302) 739-4411.

Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks (1996) by Randal Arendt, American Planning Association, Planners Book Service, 122 S. Michigan Avenue, Suite 1600, Chicago, IL 60603, (312) 786-6344.

Low Impact Development Design Manual (1997), Low Impact Development Center, 3230 Bethany Lane, Suite 9, Ellicott City, MD 21042, (410) 418-8476.

Building Greener Neighborhoods: Trees as Part of the Plan (1995) by Jack Petit, Debra Bassert, and Cheryl Kollin, American Forests, PO Box 2000, Washington, DC 20013, (202) 667-3300.

The Wild Lawn Handbook: Alternatives to the Traditional Front Lawn (19951 by Steven Daniels.

Clearing and Grading: Strategies for Urban Watersheds (1995) by Kathleen Corish, Metropolitan Washington Council of Governments, Information Center, 777 North Capitol Street, NE, Suite 300, Washington DC, 20002, (202) 962-3256.

Site Planning for Urban Stream Protection (1995) by Thomas R. Schueler, Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043, (410) 461-8323.

Design bv Design (1992) by James W. Wentling and Lloyd Bookout, Urban Land Institute, 1025 Thomas Jefferson Street, NW, Suite 500 West, Washington, DC 20007, (800) 321-5011.

Best Development Practices: Doing the Right Thing and Making Money at the Same Time (1996) by Reid Ewing, American Planning Association, Planners Book Service, 122 S. Michigan Avenue, Suite 1600, Chicago, IL 60603, (312) 786-6344.

Flexible Parking Requirements (1984) b Thomas P. Smith, American Planning Association, Planners Book Service, 122 S. Michigan Avenue, Suite 1600, Chicago, IL 60603, (312) 786-6344.

The University of Washington Permeable Pavement Demonstration Project (1997) by Derek B. Booth, Jennifer Leavitt, and Kim Peterson, Center for Urban Water Resources Management, University of Washington, Civil and Environmental Engineering, Box 352700, Seattle, WA 98195. http://depts.washington.edu/cuwrm.

Design of Stormwater Filtering Systems (1996) by Richard A. Ciaytor and Thomas R. Schueler, Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043, (410)461-8323.

Watershed Determinants of Ecosystem Functioning (1996) by Richard R. Homer, Derek B. Booth, Amanda Azous, and Christopher W. May, (originally published in the conference proceedings of the Engineering Foundation conference, "Effects of Watershed Development and Management on Aquatic Ecosystems," August 4-9,1996). Subscriber price = $5.00 (publication no. K12), Center for Urban Water Resources Management, University of Washington, Civil and Environmental Engineering, Box 352700, Seattle, WA 98195. http://depts.washington.edu/cuwrm.

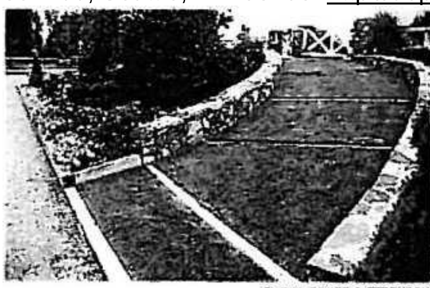


PHOTO BRUCE K FERGUSON

8. Structural Best Management Practices

8.1 Use of Structural Best Management Practices

While much can be done by planning and land use control, when development occurs it will generally be necessary to design and construct one or more facilities for stormwater and Nitrogen export control. The above-described Site Planning BMPs are useful in controlling the generation of storm runoff and reducing the concentrations of TN in the runoff. Constructed BMPs may then be used to collect, direct, filter, and biologically treat the runoff. Appendix C of this manual contains Storm Water Technology Fact Sheets on many of the structural BMPs that may be used to control stormwater runoff and quality. Stormwater Permit applicants should use the design criteria given in those fact sheets, in the latest version of the North Carolina Stormwater Management Guidance Manual (North Carolina Cooperative Extension Service and NC DENR), in the Maryland Stormwater Design Manual (Maryland Department of the Environment), and the information given below in their design of structural BMPs.

8.2 Allowable BMPs and Nitrogen Reduction Factors

The following items are among the constructed BMPs that may be used to further reduce and control runoff and nitrogen export and that may be incorporated into a applicant's stormwater facility plan.

8.2.1 Wet Detention Ponds (WDP)

These are ponds designed to have a permanent water pool with a 3-foot minimum average depth and a temporary pool that retains the volume of runoff produced by the first 1-inch of rainfall for a period of 2 to 5 days. When WDPs are incorporated into a project's stormwater management plan there are several health, safety, and aesthetic issues that must be addressed by the plan, including:

- Since a WDP maintains a minimum depth of 3 feet or more, there is the safety concern associated drowning. In some cases, fencing may be required to exclude children from the pond. Because of the requirements for a low- sloped shelf at the edges of a WDP, the safety concerns can often be limited to the pond forebay and outlet.
- Insect breeding within the WDP may create health and nuisance concerns. The Craven County Health Department recommends stocking certain fish species to reduce the number of nuisance insects.
- WDPs often attract wildlife. In many situations that is a positive impact, but it also may become a nuisance. This is particularly a problem with respect to waterfowl and the accumulation of large amounts of fecal matter. In some areas there may be concerns about the attraction of dangerous wildlife.

- Water and wind move debris and trash into the WDP and cause unsightly conditions. Routine maintenance should include a regular cleaning schedule and cleaning after significant storm events.
- For a WDP to continue operating, it is necessary to remove accumulated sediments every two to three years. This operation usually requires large equipment and the safety and noise concerns associated with that equipment should be recognized.

For purposes of computing the Total Nitrogen export reduction due to the installation of a WDP designed to retain the runoff from the first T‘ of rainfall, under normal antecedent moisture conditions, for a period of not less than 48 hours, a nitrogen export reduction of 25% may be assumed.

8.2.2 Stormwater Wetlands

A Stormwater Wetland is simply a WDP that has been designed to have longer water detention times and a shallower average depth. All of the health, safety, and aesthetic concerns for WDPs are relevant to Stormwater Wetlands. Despite their similarities, Stormwater Wetlands are generally more costly to design and construct than are Wet Detention Ponds. Much of the additional cost is related to the fact that much care is taken in developing a diverse, healthy, and ecologically stable wetland.

The health and safety issues listed in the above discussion of WDPs must also be addressed for stormwater wetlands.

For purposes of computing the Total Nitrogen export reduction due to the installation of a Stormwater Wetland designed to retain the runoff from the first 1” of rainfall, under normal antecedent moisture conditions, for a period of not less than 72 hours, a nitrogen export reduction of 40% may be assumed.

8.2.3 Extended Dry Detention Ponds

Dry Detention Ponds (DDPs) are a common stormwater management facility. When they are to be used for water quality purposes, the design criteria are modified to provide for longer detention times and for sediment trapping and removal. Extended DDPs are generally less expensive to construct and maintain than are Wet Detention Ponds and Stormwater Wetlands.

When a DDP or Extended DDP is incorporated into a stormwater management facility then the relevant health and safety issues must be addressed by the stormwater management plan.

For purposes of computing the Total Nitrogen export reduction due to the installation of an Extended DDP designed to retain the runoff from the first 1" of rainfall, under normal antecedent moisture conditions, for a period of not less than 48 hours, a nitrogen export reduction of 10% may be assumed.

8.2.4 Bioretention Areas (BAs)

Bioretention Areas use soils and vegetation to detain and reduce runoff volumes, and remove pollutants from storm water runoff. Runoff is conveyed as sheet flow to the BA, where it passes through a sand bed and into a vegetated shallow ponding area that exfiltrates the flow. Excess runoff is diverted away from the BA. BAs can take many forms and can be designed to fit a variety of site layouts. BAs are particularly suitable BMPs for median strips, parking lot islands, and swales where grading or excavation will already be occurring and there will be no additional environmental damage.

The aesthetic value of the BA is substantial, because several varieties of groundcover, bush, and tree species are suitable for different sections of the BA. The BA can provide shade and wind breaks, absorb noise, and improve the area's landscape. Strategic placement of BAs can significantly reduce costs by eliminating the need for extensive storm drainage pipe systems.

Limitations for site selection include avoiding areas with high water tables (< 6 ft below ground surface), unsuitable soils, or large slopes (> 20 percent). Some maintenance is recommended including periodic inspection of the overall condition and the health of vegetation, pruning, application of an alkaline product to counteract soil pH reduction by acidic storm water, and aesthetic maintenance such as weeding and replacing mulch.

Rain gardens are one particularly appropriate BA design for smaller scale areas such as commercial buildings or residential homes. Rain gardens consist of piping roof storm water drainage into a cistern that bleeds the water into a nearby vegetated area. Filtration through the vegetation and the soil removes pollutants from the water and reduces the impacts of the impervious roof area.

For purposes of computing the Total Nitrogen export reduction due to the installation of a Bioretention designed to fully retain the runoff from the first 1" of rainfall, under normal antecedent moisture conditions, a nitrogen export reduction of 30% may be assumed.

8.2.5 Riparian Buffers

A Riparian Buffer established and managed consistent with the NRBR (15A NCAC 2B. 0233) can be used as a nitrogen-reducing BMP. For purposes of computing the Total Nitrogen export reduction due to the establishment of a riparian buffer a nitrogen export reduction of 30% may be assumed for a project area not to exceed the area of the established riparian buffer. In order to qualify for the credit the stormwater management plan must demonstrate that runoff from the serviced project area will be supplied in a diffused manner to the edge of the riparian buffer.

8.2.6 Grassed Swales

Grassed Swales are shallow earthen channels covered with dense growths of a hardy grass. The major impacts of a grassed swale are to slow runoff, increase infiltration, and reduce the transport of solid particles to receiving waters.

For purposes of computing the Total Nitrogen export reduction due to the installation of a grassed swale designed to have a mean residence time of not less than 60 minutes for the runoff from the first 1” of rainfall, under normal antecedent moisture conditions, a nitrogen export reduction of 20% may be assumed.

8.2.7 Filter Strips

Filter Strips share many of the characteristics and concerns of the Bioretention Areas outlined above. They are gently sloping areas of natural vegetation that are designed to provide sheet flow throughout an area. They are used to separate runoff-producing areas from receiving waters and stormwater collection facilities. Runoff is evenly spread throughout the filter strip area allowing for infiltration, sediment and pollutant removal, and flow retardation.

For purposes of computing the Total Nitrogen export reduction due to the installation of a filter strip designed to have a mean residence time of not less than 60 minutes for the runoff from the first 1” of rainfall, under normal antecedent moisture conditions, a nitrogen export reduction of 20% may be assumed.

8.2.8 Sand Filters and other Infiltration Devices

Sand Filters and other Infiltration Devices capture stormwater runoff and allow it to infiltrate into the ground. They may be above or below ground structures with their design parameters being determined primarily from design runoff volumes, available space, and soil and groundwater conditions. Use is limited in areas with soils of low permeability and where the groundwater table is close to the ground surface. It is important to plan for maintenance, which often includes cleaning of sediment trapping forebays, stripping and replacement of sand materials, and vegetation management. Since this BMP depends on the rapid transfer of surface runoff into the ground, it cannot be used where there is a concern for contamination of groundwater drinking supplies.

For purposes of computing the Total Nitrogen export reduction due to the installation of a sand filters and other infiltration devices designed to fully retain the runoff from the first 1” of rainfall, under normal antecedent moisture conditions, and to allow subsurface drainage of that volume in not less than a 24- hour period, a nitrogen export reduction of 35% may be assumed.

8.2.9 Rain Barrels and Cisterns

Rain barrels and cisterns are low-cost, effective, and easily maintainable retention devices applicable to all types of development sites. They operate by retaining a predetermined volume of runoff from rooftops or other impervious areas. In order to receive credit as a nitrogen-reducing BMP the stormwater management plan must demonstrate effective long-term maintenance of the storage unit and an operational plan that empties the storage unit in not less than 2 days following a rainfall event and not more than 10 days.

For purposes of computing the Total Nitrogen export reduction due to the installation of a rain barrel or cistern, the discharge method and location must be considered. If the stored water is applied to a lawn, garden or other Bioretention area then a nitrogen export reduction percentage equal to 30% may be assumed. If the stored water is discharged to a grassy swale then a nitrogen export reduction equal to 15% may be assumed. If the stored water is discharged directly to a storm sewer, gutter, or other impervious device, then no nitrogen export reduction may be assumed.

8.2.10 Porous Pavement

Porous pavement is a special type of pavement that allows rain to pass through it, thereby reducing the runoff from a site and surrounding areas that drain to the pavement. In addition, porous pavement filters some pollutants from the runoff if it is properly maintained. Where appropriate, Stormwater Permit applicants should consider the use of porous pavement to reduce. runoff and nitrogen export. Credit for nitrogen export reductions may be obtained for the use of porous pavement. In order for credit to be obtained the design and maintenance specifications of the BMP must be provided to the Stormwater Administrator along with scientific evidence of the degree of TN removal to be expected by the porous pavement system. The Stormwater Administrator may, at his discretion, seek approval of the nitrogen export reduction credit from the NC DENR/DWQ. If approved by NC DENR then the use of porous pavement may be incorporated into the stormwater facilities plan and the approved credit used in the nitrogen export calculations.

8.2.11 Proprietary BMPs

Proprietary BMPs take various forms and are typically designed to accommodate specific pollutant types or site limitations. One example is underground concrete structures for oil or solid separation for high impact land uses, such as City vehicle maintenance yards or industrial locations. Most propriety BMPs are designed for high pollutant removal efficiency, safety, and ease of access for maintenance purposes. Credit for nitrogen export reductions may be obtained for the use of custom designed and other proprietary BMPs. In order for credit to be obtained the design and maintenance specifications of the BMP must be provided to the Stormwater Administrator along with scientific evidence of the degree of TN removal to be expected from that BMP. The Stormwater

Administrator may, at his discretion, seek approval of the BMP nitrogen export reduction credit from the NC DENR/DWQ. If approved by NC DENR then the BMP may be incorporated into the stormwater facilities plan and the approved credit used in the nitrogen export calculations.

8.3 Including BMPS in nitrogen export computations

If more than one BMP is installed in series on a development, then the removal rate shall be determined through serial rather than additive calculations. For example, if a wet detention area discharges through a riparian buffer, then the removal rate shall be estimated to be 47.5 percent. The pond removes 25 percent of the nitrogen and discharges 75 percent to the buffer. The buffer then removes 30 percent of the remaining nitrogen. The total nitrogen removal is calculated as: 25% + (0.75 * 30%) = 47.5%.

8.4 Restrictive Covenant

The proper design, installation, and maintenance of stormwater facility plan is a condition under which the Stormwater Administrator can issue a City Stormwater Permit. This section of the manual set forth the requirements for the computation of total nitrogen export reductions expected to result from structural BMPs and the criteria under which the Stormwater Administrator may issue a City Stormwater Permit. The applicant's stormwater facility plan must specify the details of design, installation and maintenance of all structural BMPs in sufficient detail to ensure the Stormwater Administrator of their proper performance. In order to ensure that the facilities maintained in a development result in compliance with the plan presented in the application the applicant must execute the Covenant Agreement contained in Appendix C of this manual, or other legal instrument acceptable to the Stormwater Administrator, before a City Stormwater Permit may be issued.

8.5 References

Stormwater Management Guidance Manual. North Carolina Cooperative Extension Service and North Carolina Department of Environment, Health and Natural Resources, 1993.

Maryland Stormwater Design Manual. Maryland Department of the Environment, 1998.

Low-Impact Development Design Strategies. An Integrated Design Approach. Prince George's County, Maryland Department of Environmental Resources, January 2000.

9. Fees

9.1 Purpose of Fees

Stormwater plan review fees vary based on the size and complexity of the development. These fees are established to assist in financing the stormwater plan review process and, in some cases, inspection of stormwater management structures.

9.2 Stormwater Permit Fee Schedule

Type of Development or Activity	**Disturbed Area**	**Standard Fee**	**Additional Fee**
Residential-individual single family	<=1/2 acre	Exempt - no fee	
Residential-individual single family	>1/2 acre	$100 per acre or part thereof. $400 maximum.	
Residential - single family subdivision	>1/2 acre	$400	
Residential-multi family	>1/2 acre	$400	
Non-Residential	<=1/2 acre	Exempt - no fee	
Non-Residential	>1/2 acre	$400	
Review of application for minor variance	Any	$100	
Review of application for major variance	Any	$400	$250 per fact-finding meeting
Technical Review of Structural BMPs in Stormwater Plan As-Built Inspection	Each Each	$200 $200	
Annual Inspection of Structural BMP	Each	$400	
Re-inspection Fee	Each	$400	

10. Duties of the Stormwater Administrator

10.1 Appointment of Stormwater Administrator

The New Bern City Manager shall appoint the Stormwater Administrator. It shall be the duty of the Stormwater Administrator to administer and enforce the provisions of the New Bern Stormwater Ordinance and the Stormwater Management Program. That responsibility includes all the duties presented in this section.

10.2 Riparian Buffer Program

It is the duty of the Stormwater Administrator to administer the City's Riparian Buffer Program as that program is described in Section 4 of this manual. Those duties include, but are not limited to, the following:

- Preparing a riparian buffer map and from time to time correcting and updating that map.
- Seeking to have the City's Riparian Buffer Program recognized as a delegated program under 15A NCAC 2B .0241.
- Ensuring, until such time as the City has been delegated the authority under NCAC 15A NCAC 2B .0241, that a City Stormwater Permit is not issued for any new and nonexempt development or activity that is proposed to take place within the first 50 feet adjacent to a waterbody that is shown on either the USGS topographic map or the NRCS Soil Survey maps unless the owner can show that the activity has been approved by DWQ. DWQ approval may consist of the following:

    - An Authorization Certificate that documents that DWQ has approved an allowable use such as a road crossing or utility line. A detailed list of allowable uses is included in Section 4 of this manual.
    - An opinion from DWQ that vested rights have been established for the proposed development activity.
    - A letter from DWQ documenting that a variance has been approved for the proposed development activity.

- Ensuring that all required riparian buffer areas are clearly identified on the site plans and specifications of the stormwater management facilities submitted in application for a City Stormwater Permit and that access to and maintenance of those areas is provided for under a maintenance covenant (see Appendix B).
- Preparing public information about the City's Riparian Buffer Program including the preparation of information that will assist in the operation of the City's Environmental Concerns Hotline.

- Seeking opportunities to protect and improve the City's riparian buffers. Examples of activities that the Stormwater Administrator may undertake in this area include:
  - Recommending that the City accept landowner donations of riparian lands and landowner grants of permanent environmental easements for riparian areas.
  - Recommending that the City purchase parcels that are deemed to be of particular value for stormwater control and water quality improvement.
  - Cooperating with agencies and foundations that may provide methods and funds for riparian protection and enhancement.
  - Using City personnel and equipment to perform improvements on the riparian areas of private properties where such improvements serve the public interests in stormwater control and water quality improvement and where the landowner has provided maintenance and environmental easements, guarantees of maintenance, and other assurances acceptable to the Stormwater Administrator.

10.3 Peak Discharge Calculations

The Stormwater Administrator has the responsibility to ensure that requirements presented in Section 5 of this manual are met before issuing a City Stormwater Permit for any new development exceeding 14 acre within the City's jurisdictional limits. To meet that responsibility the Stormwater Administrator shall:

- Review the information presented in each application for a City Stormwater Permit (see Appendix A: Forms SW-001, SW-006, and SW-007) to verify the accuracy of that information.
- Review all site plans and stormwater management plans submitted in support of a City Stormwater Permit and verify the technical adequacy of those plans.
- Ensure that all site plans, calculations, and other information requiring the seal and signature of a registered professional engineer have been properly executed.
- Consider, and grant or deny, petitions for variance from the requirements of controlling the peak discharge from the 1-year, 24-hour and the 10-year, 24-hour storms consistent with the criteria for variance presented in Section 5.
- Inspect constructed stormwater facilities to ensure that the as-built conditions are equivalent to the design included in the development's stormwater management plan.
- Ensure that the long-term maintenance requirements of all stormwater facilities covered under a City Stormwater Permit are incorporated into the development's stormwater management plan and that the plan is covered by and adhered to by the signing and recording of a restrictive maintenance covenant (Appendix B).
- Inspect, from time to time, developments operating under a City Stormwater Permit to ensure that the stormwater management facilities are properly

maintained and are performing their functions as specified in the development's stormwater management plan.

10.4 Nitrogen Export Calculations

The Stormwater Administrator has the responsibility to ensure that requirements are met as presented in Section 6 of this manual regarding the computation and documentation of the expected reductions in nitrogen exports that occur due to improved site planning and the use of best management practices. To meet that responsibility the Stormwater Administrator shall review the site plans and the nitrogen export calculations prepared by the applicant for a Stormwater Permit. No permit may be issued until the Stormwater Administrator is satisfied as to the technical accuracy of the submitted items and is satisfied that all the requirements of Section 6 have been met. To meet that responsibility the Stormwater Administration shall:

- Review and verify the accuracy of the information provided on forms SW-001, SW-002, and SW-003 (Appendix A) and supplemental submittals.
- Ensure that all required payments of Total Nitrogen Offset Fees have been made to the North Carolina Wetlands Restoration Program and to the City.
- Conduct an as-built inspection to ensure that the facilities and the areas that they service are equivalent to those described in the application and the stormwater management plan.

10.5 BMP Design Review

The design details of any Best Management Practices proposed as part of a development's stormwater management plan must be submitted in the Stormwater Permit application. Those details must be sufficient to determine the accuracy of the design parameters as they relate to stormwater detention and nitrogen removal. The site plan and BMP details must allow the Stormwater Administrator to determine, and the Stormwater Administrator shall verify:

- Areas to be drained to the BMP;
- Volume and geometry of the BMP;
- Inflow volume, peak outlet discharge, and mean hydraulic detention time under the 1 year, 24-hour and the 10-year, 24-hour design storms;
- Volumes and characteristics of filter materials, plant types and densities included in the design;
- Adequacy of outlet works and their operation, emergency spillways and other features effecting the BMPs operability and safety; and
- The signature and seal of a registered professional engineer on the BMP design plans and specifications.

A Stormwater Permit shall not be issued until the above information has been provided to the satisfaction of the Stormwater Administrator.

10.6 BMP Nitrogen Reduction Calculations

Whenever structural BMPs for nitrogen reduction are included in a proposed development's stormwater management plan, the Stormwater Administrator shall verify the accuracy of the applicant's calculation of the estimated nitrogen export reduction consistent with the methods and requirements of Sections 6 and 8 of this manual.

10.7 BMP Operation and Maintenance Plan Review

The Stormwater Administrator shall review the BMP operation and maintenance plan submitted by the applicant and shall determine the adequacy of that plan in providing and maintaining the design functions of the BMP.

10.8 BMP Inspections

It is the duty of the Stormwater Administrator to perform on-site inspections from time to time, but not less than annually, in order to verify the function of BMPs incorporated into a permitted development's stormwater management plan. Inspections shall include:

- Review of stormwater facility maintenance records since the last inspection;
- Observation of the drainage facilities to ensure that they are functionally equivalent to the facilities described on the permitting site plan and stormwater management plan; and
- Verification that all installed BMPs are in a condition to function in both the control of stormwater discharges and the reduction of nitrogen exports substantially as defined in the permitting stormwater management plan.

10.9 BMP Inventory

The Stormwater Administrator shall develop and maintain an inventory of BMPs that exist within the City's jurisdiction, that are installed under the City's Stormwater Permit program, or are otherwise developed in the City, including those installed and owned by the City. That inventory shall contain all the peak discharge and nitrogen export reduction information specified in Sections 5, 6, and 8 of this manual and will record summary information on the maintenance and inspection of each BMP.

10.10 Collection of Fees

The Stormwater Administrator shall collect all applicable fees as described in Section 9 of this manual.

10.11 Restrictive Covenants

Prior to issuing a City Stormwater Permit, the Stormwater Administrator shall verify that all required restrictive covenants have been signed and recorded.

10.12 Illegal Connections and Discharges Elimination Program

The City's stormwater collection system is vulnerable to receiving illegal discharges (even though the person responsible for the discharge may be unaware that it is illegal). Depending on their source, illegal discharges may convey pollutants such as nutrients, phenols, and metals to receiving waters. Table 3a identifies some potential flows to the stormwater collection system that may be allowable. Table 3b identifies some discharges that are not allowed.

Table 10a: Discharges that may be made to the stormwater collection system

Waterline Flushing	Landscape Irrigation	Diverted Stream Flows
Uncontaminated Rising Ground Water	Uncontaminated Ground Water Infiltration to stormwater collection system	Uncontaminated Pumped Ground Water
Discharges from potable water sources	Foundation Drains	Uncontaminated Air Conditioning Condensation
Irrigation Water	Springs	Water from Crawl Space Pumps
Footing Drains	Lawn Watering	Non-commercial Car Washing
Flows from Riparian Habitats and Wetlands	NPDES permitted discharges	Street wash water
Fire Fighting Emergency Activities	Wash Water from the Cleaning of Buildings	Dechlorinated backwash and draining associated with swimming pools

Table 10b: Types of Discharges that are not allowed to stormwater collection system

Dumping of oil, antifreeze, paint, cleaning fluids	Commercial Car Wash	Industrial Discharges
Contaminated Foundation Drains	Cooling water unless no chemicals added and has NPDES permit	Washwaters from commercial / industrial activities
Sanitary Sewer Discharges	Septic Tank Discharges	Washing Machine Discharges
Chlorinated backwash and draining associated with swimming pools		

The Stormwater Administration is responsible for the administration of a program to detect and eliminate illegal connections to, and illegal discharges into, the City's stormwater system. To accomplish this directive the Administrator shall:

- Collect City jurisdiction-wide information on the stormwater facilities and the potential for illegal discharges and illicit connections;
- Identify on maps of the City's hydrography and stormwater system the areas that are the most likely locations for illegal discharges;
- Prioritize areas of the City, not less than 10 percent of the City in each year beginning in 2002, in which to conduct dry weather field screening for illegal discharges;
- Complete field screening reports, and keep them on file for a minimum of 5 years, on all outfalls to the stormwater system in which dry weather flow is observed, documenting all of the elements specified in Table 10c;

Table 10c: Field Screening Report Information

General Information	Sheet Number Outfall ID Number Date Time Date, Time and Quantity of Last Rainfall Event	
Field Site Description	Location Type of Outfall Dominant Watershed Land Use(s)	
Visual Observations	Photograph Odor Color Clarity Floatables	Deposits/Stains Vegetation Condition Structural Condition Biological Flow Estimation
Sampling Analysis *	Temperature pH Nitrogen-Ammonia	Nitrogen-Nitrate/Nitrite Fluoride or Chlorine

* Analytical monitoring is required only if an obvious source of the dry weather flow cannot be determined through an investigation of the upstream stormwater collection system.

- Ensure that all detected illicit connections and illegal discharges are removed on a timely basis by following the notification and enforcement procedures specified in the City's Stormwater Ordinance;
- Maintain records of all compliance actions for a minimum of 5 years after complete removal of the illicit connection or illegal discharge;
- Maintain a map and related documentation that includes:
  - Points of identified illegal discharges,
  - Watershed boundaries of the outfalls where illegal discharges have been identified,
  - Summaries of the illegal discharges that have been identified that includes location, a description of pollutants(s) identified, and enforcement status.

The Stormwater Administration shall report to the Board of Aldermen and to the NC DENR/DWQ, at a minimum annually on or before October 30, on the illegal discharge elimination program. Those reports shall contain geographic information at three increasing levels of detail:

- The first, most cursory level is information that shall be collected for the entire jurisdiction. The associated requirements are discussed in this Section 10.13.
- The second level is a more detailed screening for high priority areas within the jurisdiction. The associated requirements are discussed in Section 10.14.
- The third level is a very detailed investigation that shall be done upon the discovery of an illegal discharge. The associated requirements are discussed in Section 10.15.

10.13 Jurisdiction-wide Screening for Illicit Discharges and Connections

The Stormwater Administrator shall compile jurisdiction-wide information about the City's stormwater facilities and shall present that information in a report and on maps on or before October 2002. The information to be mapped and reported shall include:

- Location of sanitary sewers in areas of the major stormwater collection systems and the location of areas that are not served by sanitary sewers;
- Waters that appear on the USDA - Natural Resources Conservation Service Soil Survey Maps and the U.S. Geological Survey 1:24,000 scale topographic maps;
- Land uses. Categories, at a minimum, should include undeveloped, residential, commercial, agriculture, industrial, institutional, publicly owned open space and others;
- Currently operating and known closed municipal landfills and other treatment, storage, and disposal facilities, including for hazardous materials;
- Major stormwater structural controls; and
- Known NPDES permitted discharges to the stormwater collection system.

Written descriptions should be provided for the map components as follows:

- A summary table of municipal waste facilities that includes the names of the facilities, the status (open/closed), the types, and addresses;
- A summary table of the NPDES permitted dischargers that includes the name of the permit holder, the address of the facility and permit number;
- A summary table of the major structural stormwater control structures that shows the type of structure, area served, party responsible for maintaining, and age of structure; and
- A summary table of publicly owned open space that identifies size, location, and primary function of each open area.

10.14 Mapping and Screening in High Priority Areas

As high priority areas are identified the Stormwater Administrator shall prepare maps of those areas. At a minimum the map that is produced shall include the following:

- Locations of the outfalls of any pipes from non-industrial areas that are greater than or equal to 36 inches diameter;
- Locations of the outfalls of any pipes from industrial areas that are greater than or equal to 12 inches diameter;
- Locations of drainage ditches that drain more than 50 acres of non-industrial lands; and
- Locations of drainage ditches that drain more than 2 acres of industrial lands.

The map must have an accompanying summary table listing the outfalls that meet the above criteria that includes Outfall ID numbers, geographic location, primary and supplemental classification of the receiving water, and use-support classification of the receiving water.

Each high priority area shall be dry weather field surveyed. The survey shall report on each outfall in the high priority area and where dry weather flows are identified a screening report shall be completed (See Appendix A, Form SW-020). Screening reports shall be kept on file for a minimum of five years. Where practicable, further field investigation should be used to identify the source of the dry weather flow. A summary of dry weather field surveys shall be incorporated into each annual report to the Board of Aldermen and the NC DWQ.

10.15 Identifying and Removing Illicit Discharges

When a dry weather discharge is identified, potential sources of that discharge should be investigated by systematic field investigation. That investigation may include:

- On-site investigation;
- Additional Chemical Analysis of the discharge;
- Flow Monitoring;
- Dye and/or Smoke Testing; and
- Television Inspection.

Whenever an illicit discharge or connection is identified the Stormwater Administration shall proceed under the provisions and procedures of the City Ordinance to have the illicit discharge stopped and illicit connections removed. Records of all enforcement actions shall be kept for five years with the associated screening reports and field investigation materials.

The Stormwater Administrator shall prepare and maintain a map that includes the following:

- Points of identified illicit discharges; and
- Watershed boundaries of the outfalls where illicit discharges have been identified.

The map must have an accompanying table that summarizes the illicit discharges and/or connections that have been identified, a description of pollutant(s) identified, and a summary of enforcement and corrective actions. A summary of illicit discharge and connection investigations and enforcement/corrective actions shall be incorporated into each annual report to the Board of Aldermen and the NC DWQ.

10.16 BMP Retrofit Locations

The Stormwater Administrator shall establish a program to identify a minimum of 2 locations annually within existing developed areas that are suitable for retrofitting of stormwater BMPs for the reduction of nitrogen exports. Those retrofit opportunities shall demonstrate:

- The retrofit, if implemented, clearly has the potential to reduce nitrogen loading to the receiving water;
- The watershed is clearly contributing nitrogen loading above background levels;
- The landowner where the retrofit is proposed is willing to have the retrofit installed on his property. Securing the landowner's cooperation is one of the most important tasks for the local government, as this is often the most difficult aspect of implementing a retrofit;
- There is adequate space and access for the retrofit; and
- It is technically practical to install a retrofit at that location.

The Stormwater Administrator shall submit a report on or before October 30 of each year starting in 2001 to the Board of Aldermen and to the NC DENR/DWQ on the identified retrofit opportunities. That report shall contain, at a minimum, the following information about each retrofit opportunity:

- Location description, including directions from a major highway
- Type and description of retrofit opportunity
- Current property owner
- Is the property owner willing to cooperate?
- Land area available for retrofit (sq. ft)
- Accessibility to retrofit site
- Drainage area size (acres)
- Land use in drainage area (percent of each type of land use)
- Average slope in drainage area (%)

- Environmentally sensitive areas in drainage area (steep slopes, wetlands, riparian buffers, endangered/ threatened species habitat)
- Approximate annual nitrogen loading from drainage area (Ibs/acre/year) *
- Potential nitrogen reduction (Ibs/ac/yr)
- Estimated cost of retrofit
- Receiving water
- DWQ classification of receiving water
- Use support rating for receiving water
- Other important information relevant to the opportunity

The Stormwater Administrator shall update, on or before October 30 of each year starting in 2001, the City's Stormwater Facility maps to show the locations of each reported retrofit opportunity. That mapping shall be adequate to determine, at a minimum, the following information:

- Drainage area to retrofit opportunity site.
- Land uses within the drainage area.
- Location of retrofit opportunity.
- Property boundaries in the vicinity of the retrofit opportunity.
- Significant hydrography (as depicted on U.S.G.S. topographic maps and USDA-RCS Soil Survey maps).
- Roads.
- Environmentally sensitive areas (steep slopes, wetlands, riparian buffers, endangered/ threatened species habitat - where available).
- Publicly owned parks, recreational areas, and other open lands.

10.17 Public Education Program

The Stormwater Administration shall establish and administer a public education program for the purposes of:

- Improving the ways that New Bern citizens manage stormwater on their property;
- Informing citizens of the need to maintain and improve riparian buffers; and
- Soliciting assistance in the identification and removal of illicit connections and illegal discharges to the stormwater system.

The education program shall be consistent with that outlined for the NC Environmental Management Commission in the City's application for delegation of authority under the Neuse River Stormwater Rule. The Stormwater Administrator shall annually update the City's public education program and submit the revised programs plans to NC DENR/DWQ.

10.18 Reports to the NC DENR/DWQ and the City Board of Aldermen

The Stormwater Administrator shall prepare an annual report and submit that report to the Board of Aldermen and to the NC DENR/DWQ on or before October 30 or each year, beginning in October 2001. That report shall document, at a minimum:

- Acres of new development and impervious surface based on plan approvals.
- Acres of new development and impervious surface based on certificates of occupancy.
- Summary of BMPs implemented and the City's use of mitigation offset fees.
- Computed baseline and net change in nitrogen export from new development that year.
- Summary of maintenance activities conducted on BMPs.
- Summary of any BMP failures and how they were handled.
- Summary of results from jurisdictional review of planning issues.
- Elements of the City's Stormwater Public Education Program completed during the year.
- Summary of land and easements or other legal assurances acquired for riparian buffer protection.

Appendix A - Application and Report Forms

CITY OF NEW BERN STORMWATER PERMIT APPLICATION FORM

(Form SW-001)

Name of Developer Name of Contact Person Phone Number Email Address Name of Development Location of

Development

Who will legally be responsible for or own the development after construction? Name
Address

Phone Number

Email Address

1. Total area disturbed by development ____________ acres
2. Is any part of the development within the limits of the Neuse Stormwater Rule riparian buffer? A copy of the Neuse Stormwater Rule Riparian Buffer Advisory Map (Riparian Buffer Map) is available in the office of the New Bern Stormwater Administrator. It is the responsibility of the Developer to verify the location of the development with respect to the most current Riparian Buffer Map.
   ____Yes - Development must comply with Neuse Stormwater Rule buffer requirements. Skip to Question 4.
   ____No - Continue to Question 3.

3. Is the disturbed area of development greater than 'A acre?
   ____Yes - Developer must have stormwater plans reviewed by City for approval of a Stormwater Permit.
   Continue to Question 4.
   ____No - Development is exempt from stormwater rules, unless it is within the limits of the Riparian Buffer.

4. Is the development solely residential?
   ____Yes - Developer must use Residential Stormwater Permit Application Form (SW-002).
   ____No - Developer must use General Stormwater Permit Application Form (SW-003).

<u>Certification</u>

I, (print name) hereby certify the information included on this and attached pages is true and correct to the best of my knowledge.

Signature ______________________________________ Date _____________

Official Use Only: Stormwater Permit No. Date Approved

CITY OF NEW BERN RESIDENTIAL STORMWATER PERMIT APPLICATION FORM
(Form SW-002, must be accompanied by completed Form SW-001)

Name of Developer

Name of Contact Person ____

Phone Number ____

Name of Development ____

1. Is the development solely residential?
   ____ Yes - This is the correct form, go on to next question.
   ____ No - You cannot use this form, go to the Non-residential Stormwater Permit Application Form (Form
   SW-003)

2. What kind of residential development is this?
   ____ Single lot with one single-family residential structure
   ____ Single-family residential subdivision with multiple lots
   ____ Multi-family residential
   ____ Mobile home development
   ____ Assisted living/congregate care facility
   ____ Other____

3. Calculate pre- and post-development stormwater runoff from the development for the 1-year, 24-hour storm with one of the approved methods specified in the City of New Bern Stormwater Management Manual.

   Pre-development peak runoff _________ cfs (1-year, 24-hour storm)

   Post-development peak runoff ________ cfs (1_year, 24-hour storm)

4. Does the post-development peak flow exceed the pre-development peak flow? (1-year, 24-hour storm)
   ____ Yes - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.
   ____ No - A flow control BMP is not required for this development. Continue to next question.

5. Does the development meet one or both of the following criteria: 1) the post-development peak runoff is less than 10 percent greater then the pre-development peak runoff (for the 1 year, 24-hour storm) or 2) the overall impervious surface is 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?
   ____ Yes - A flow control BMP is not required for this development but the New Bern Stormwater Administrator must approve a variance. Continue to next question.
   ____ No - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.

6. Calculate pre- and post-development stormwater runoff from the development for the 10-year, 24-hour storm with one of the approved methods specified in the City of New Bern Stormwater Management Manual.

   Pre-development peak runoff _________ cfs (10-year, 24-hour storm)

   Post-development peak runoff ________ cfs (10-year, 24-hour storm)

7. Does the post-development peak flow exceed the pre-development peak flow? (10-year, 24-hour storm)
   ____ Yes - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.
   ____ No - A flow control BMP is not required for this development. Continue to next question.

8. Where the requirement that the 10-year, 24-hour storm post-development peak flow not exceed the pre- development peak flow places an undue hardship upon a property owner, variances from the requirement may be granted by the Stormwater Administrator if the development meets the following requirement: *The proposed new development appropriately uses the parcel's total remaining total impervious area to the extent practical to convey and control the stormwater runoff, and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.* Is this requirement met for the proposed development?

_____ Yes - A flow control BMP is not required for this development but the New Bern Stormwater Administrator must approve a variance. Continue to next question.

_____ No - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.

9. Are the number of building footprints and sizes for the entire development, to the ultimate built out condition of the development, known?

_____ Yes - Use Method 2, Form SW-005 for Total Nitrogen export calculations.

_____ No - Use Method 1, Form SW-004 for Total Nitrogen export calculations.

10. From Step 8 of Form SW-004 or Step 6 of Form SW-005, the Total Nitrogen export load from the development is: ______ Ib/acre/year.

11. Does the Total Nitrogen export from the development exceed 6.0 Ib/acre/year?

_____ Yes - Developer must incorporate a single or combination of BMPs to reduce Total Nitrogen load, and recalculate Total Nitrogen export with Method 1 or 2 until it is less than 6.0 Ib/acre/year.

_____ No - Continue to next question.

12. Does the Total Nitrogen export from the development exceed 3.6 Ib/acre/year?

_____ Yes - The developer must either incorporate a single or combination of BMPs to reduce Total Nitrogen load or pay offset fees for difference between N export (less than 6.0 Ib/acre/year) and 3.6 Ib/acre/year. State offset fee is: $330/lb/year for each acre of disturbed area.

City of New Bern offset fee is: $170/lb/year for each acre of disturbed area.

_____ No - No offset fee payments or additional BMPs are required.

<u>FEES</u>

The Developer must-pay the Standard Stormwater fee plus any additional fees for Technical Review of Structural BMP designs and any offset fees to the City. A fee schedule is available from the Office of the City of New Bern's Stormwater Program Administrator.

1. Standard fee: $ ___________

2. Structural BMP Technical Review fee: ________ structural BMPs x $ ________ per BMP = $ ___________

3. Structural BMP As-Built inspection fee: _______ structural BMPs x $ ________ per BMP = $ ___________

4. State Offset fee:

(____ ib/ac/yr Total Nitrogen export - 3.6 Ib/ac/yr) x ___________________acres x $850.50

Ib/yr = offset payment to EEP = $ __________

5. City Offset fee:

(____ Ib/ac/yr Total Nitrogen export - 3.6 Ib/ac/yr) x___________acres x $170/lb/yr = $ ___________

Total Fee $ ___________

Is an application being submitted to the State of North Carolina Division of Land Quality for an Erosion and Sediment Control Permit for this development?

_____ Yes - Approval of a City of New Bern stormwater permit is contingent upon approval of the State of North Carolina's Erosion and Sediment Control Permit.

_____ No - What is the reason?

Is development <1 acre?

_____ Yes - A City of New Bern Stormwater Permit is still required if the disturbed area of the development is greater than *'A* acre.

_____ No - Both and City of New Bern Stormwater Permit and a State Erosion and Sediment Control Permit are required.

Other Reason: ____________________________________

CITY OF NEW BERN GENERAL STORMWATER PERMIT APPLICATION

FORM

(Form SW-003, must be accompanied by completed Form SW-001)

Name of Developer ___________________ _____________

Name of Contact Person

Phone Number ___________________ _ ____________

Name of Development __________________________________

1. Is the development solely residential?
   ____ Yes - You may use the Residential Application Form (Form SW-002).
   ____ No - this is the correct form. Go to the next question.

2. What kind of residential development is this?
   ____ Commercial
   ____ Industrial
   ____ Single lot with one single family residential structure
   ____ Single family residential subdivision with multiple lots

   Multi-family residential Mobile home development Assisted living/congregate care facility Multi Use (Residential and Commercial) Other_________________________

3. Calculate pre- and post-development stormwater runoff from the development for the 1-year, 24-hour storm with one of the approved methods specified in the City of New Bern Stormwater Management Manual.

   Pre-development peak runoff_________ cfs (1-year, 24-hour storm)
   Post-development peak runoff________ cfs (1_year, 24-hour storm)

4. Does the post-development peak flow exceed the pre-development peak flow? (1-year, 24-hour storm)
   ____ Yes - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.
   ____ No - A flow control BMP is not required for this development. Continue to next question.

5. Does the development meet one or both of the following criteria: 1) the post-development peak runoff is less than 10 percent greater then the pre-development peak runoff (for the 1 year, 24-hour storm) or 2) the overall impervious surface is 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?
   ____ Yes - A flow control BMP is not required for this development but the New Bern Stormwater Administrator must approve a variance. Continue to next question.
   ____ No - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.

6. Calculate pre- and post-development stormwater runoff from the development for the **10-year, 24-hour** storm with one of the approved methods specified in the City of New Bern Stormwater Management Manual.

   Pre-development peak runoff cfs (10-year, 24-hour storm)
   Post-development peak runoff________ cfs (10-year, 24-hour storm)

7. Does the post-development peak flow exceed the pre-development peak flow? (10-year, 24-hour storm)
   ____ Yes - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.
   ____ No - A flow control BMP is not required for this development. Continue to next question.

8. Where the requirement that the 10-year, 24-hour storm post-development peak flow not exceed the pre-development peak flow places an undue hardship upon a property owner, variances from the requirement may

be granted by the Stormwater Administrator if the development meets the following requirement: *The proposed new development appropriately uses the parcel's total remaining total impervious area to the extent practical to convey and control the stormwater runoff, and it is demonstrated, to the satisfaction of the Stormwater Administrator, that no damage to public or private properties, including to the City's stormwater facilities and to the quality of the public waters, will be caused by granting of the variance.* Is this requirement met for the proposed development?

_____ Yes - A flow control BMP is not required for this development but the New Bern Stormwater Administrator must approve a variance. Continue to next question.

_____ No - Implementation of an approved flow control Best Management Practice (BMP) is required to reduce peak flow to pre-development peak before continuing to next question.

9. Use Method 2, Form SW-005 for Total Nitrogen export calculations. From Step 8 of Form SW-005, the Total Nitrogen export load from the development is:

_____ Ib/acre/year.

10. Does the Total Nitrogen export from the development exceed 6.0 Ib/acre/year?

_____ Yes - Is this a solely residential development?

______Yes: Maximum allowable Total Nitrogen Export is 6.0 Ib/acre/year. Developer must incorporate a single or combination of BMPs to reduce Total Nitrogen Load, and recalculate Total Nitrogen export with Method 1 or 2 until it is less than that amount.

______No: Maximum allowable Total Nitrogen Export is 10.0 Ib/acre/year. Developer must incorporate a single or combination of BMPs to reduce Total Nitrogen' Load, and recalculate Total Nitrogen export with Method 2 until it is less than that amount. No - Continue to next question.

11. Does the Total Nitrogen export from the development exceed 3.6 Ib/acre/year?

____________ Yes - The developer must either incorporate a single or combination of BMPs to reduce Total

FEES

The Developer must pay the Standard Stormwater fee plus any additional fees for Technical Review of Structural BMP designs and any offset fees to the City of New Bern. A fee schedule is available from the Office of the City of

Nitrogen load or pay offset fees for difference between N export and 3.6 Ib/acre/year. State offset fee is: $330/lb/year for each acre of disturbed area. City of New Bern offset fee is: $170/lb/year for each acre of disturbed area.

_____ No - No offset fee payments or additional BMPs are required.

New Bern's Stormwater Program Administrator.

1. Standard fee: $ ____________
2. Structural BMP Technical Review fee: __________ structural BMPs x $ __________ per BMP = $ ____________
3. Structural BMP As-Built inspection fee: __________ structural BMPs x $ __________ per BMP = $ ____________
4. State Offset fee:

_____ Yes - Approval of a City of New Bern stormwater permit is contingent upon approval of the State of North Carolina's Erosion and Sediment Control Permit.

_____ No - What is the reason?

Is development <1 acre?

_____ Yes - A City of New Bern Stormwater Permit is still required if the disturbed area of the development is greater than *Vz* acre.

_____ No - Both and City of New Bern Stormwater Permit and a State Erosion and Sediment Control Permit are required.

(_____ . ib/ac/yr Total Nitrogen export - 3.6 Ib/ac/yr) x ________ acres x $850.50

Ib/yr = offset payment to EEP = $ ________

5. City Offset fee:

(_____ Ib/ac/yr Total Nitrogen export - 3.6 Ib/ac/yr) x ____________ acres x $170/lb/yr = $ ____________

Total Fee **$** ____________

Is an application being submitted to the State of North Carolina Division of Land Quality for an Erosion and Sediment Control Permit for this development?

Other Reason:

CITY OF NEW BERN STORMWATER PROGRAM DRAWING REQUIREMENTS

Submit one mylar and 12 reduced 8.5" x 11" copies of final site plan to the New Bern Stormwater Administrator prior to the regularly scheduled meeting of The Board of Aldermen in accordance with the subdivision review schedule. Following recording of the plan by the Craven County Registrar of Deeds, the Planning and Inspections Department receives one mylar and three full size copies for City distribution.

The final drawings must contain the following information:

a. General Information
   - i. Title
   - ii. Dale
   - iii. Name of developer and contact information
   - iv. Name of owner, surveyor, and land planner
   - v. Title block on each sheet

b. Location Information, Vicinity Plan
   - i. Project location
   - ii. North arrow, true north point
   - iii. Scale (Drawing scale: 1" = 100' or larger. Drawing sheet size: 18" x 24" or larger)
   - iv. All Paved Roads
   - v. Adjoining lakes, streams, or other drainage ways shown on either United States Geographical Society (USGS) quad maps or United States Department of Agriculture Soil Conservation Service (SCS) Soils maps

c. Site Features
   - i. North arrow
   - ii. Scale
   - iii. Legend
   - iv. All dimensions should be to the nearest 0.1 foot and angles to the nearest minute.
   - v. Accurate location of all monuments and markers.
   - vi. Names and locations of ail adjoining subdivisions and streets, and the location and ownership of adjoining unsubdivided property.
   - vii. Zoning classification of subdivision and adjacent properties.
   - viii. Reservations, easements, alleys, and any other areas to be dedicated to public use, conservation or other purposes.
   - ix. Restricted access easement on limited access streets
   - x. Boundaries of total tract
   - xi. Property lines
   - xii. Lot numbers and postal addresses, building numbers
   - xiii. Lot owners' names
   - xiv. Building envelopes in the case of Planned Unit Developments (PUD).
   - xv. Sufficient data to determine readily and reproduce on the ground, the location, bearing and length of every street, block line, building line, whether curved or straight, and including true north point. Include the radius, central angle, and tangent distance for the center line of curved streets and curved property lines that are not the boundary of curved streets.
   - xvi. Existing and proposed water mains, sanitary sewers, storm sewers, transmission lines, and other relevant utilities.
   - xvii. Site plan of existing conditions including wooded areas, marshes, wetlands, Neuse Riparian Buffer limits xviii. Existing topographic contours, one foot intervals based on sea level data
   - xix. Proposed topographic contours, one foot intervals based on sea level data
   - xx. Limit and acreage of disturbed area
   - xxi. Planned and existing buildings location and elevations
   - xxii. Planned and existing roads location and elevations xxiii. Land use of surrounding areas
   - xxiv. Rock outcrops
   - xxv. Welland limits - Written approval by Corps of Engineers with reference to wetlands, if applicable.
   - xxvi. Streams, lakes, ponds, drdinage ways, dams, seeps and springs xxvii. Borrow and/or waste areas
   - xxviii. Stockpiled topsoil or subsoil location

xxix. Location of structural Best Management Practices (BMPs) and their associated maintenance easements.

d. Site Drainage Features
    i. Existing and planned drainage patterns (include off-sile areas that drain through project)
    ii. Size of areas (acreage)
    iii. Size of location of culverts and sewers
    iv. Soils information (type, special characteristics), including below culvert and storm sewer outlets
    v. Name of receiving watercourse or name of municipal operator (only where stormwater discharges are to occur)
e. Erosion Control Measures
    i. Legend
    ii. Location of temporary and permanent measures
    iii. Construction drawings and details for temporary and permanent measures
    iv. Maintenance requirements during and after construction
f. Vegetative Stabilization
    i. Areas and acreage to be vegetatively stabilized
    ii. Layout of planned vegetation with details of plants, seed, mulch and fertilizer
g. Appropriate certificates and signatures

)

)

Nitrogen Export Calculations

Calculating Total Nitrogen Export from New Development

For the purposes of the City of New Bern Stormwater Program, new development shall be defined as to include the following:

> Any activity that disturbs greater than one-half acre of land in order to establish, expand or modify a single family or duplex residential development or a recreational facility.

New development shall NOT include agriculture, mining or forestry activities. Land disturbance is defined as grubbing, stump removal and/or grading.

Property owners that can demonstrate that they have vested rights as of the effective date of the New Bern Stormwater Ordinance (expected April 10, 2001) will not be subject to the requirements for new development. Vested rights may be based on at least one of the following criteria:

(a) substantial expenditures of resources (time, labor, money) based on a good faith reliance upon having received a valid local government approval to proceed with the project, or

(b) having an outstanding valid building permit in compliance with G.S. 153A-344.1 or G.S. 160A-385.1, or

(c) having an approved site specific or phased development plan in compliance with G.S. 153A-344.1 or G.S. 160A-385.1.

Projects that require a state permit, such as landfills, NPDES wastewater discharges, land application of residuals and road construction activities shall be considered to have vested rights if a state permit was issued prior to the effective date of the New Bern Stormwater Ordinance.

The rule requires that all new developments achieve a nitrogen export of less than or equal to 3.6 pounds per acre per year. If the development contributes greater than 3.6 Ibs/ac/yr of nitrogen, then the options shown in Table 1 are available based on whether the development is residential or non-residential.

Table 1: Nitrogen Export Reduction Options

Residential	Commercial / Industrial
If the computed export is less than 6.0 Ibs/ac/yr, then the owner may either: 1. Install BMPs to remove enough nitrogen to bring the development down to 3.6 Ibs/ac/yr. 2. Pay a one-time offset payment of $850.50/lb to bring the nitrogen down to the 3.6 Ibs/ac/yr. 3. Do a combination of BMPs and offset payment to achieve a 3.6 Ibs/ae/yr export.	If the computed export is less than 10.0 Ibs/ac/yr, then the owner may either: 1. Install BMPs to remove enough nitrogen to bring the development down to 3.6 Ibs/ac/yr. 2. Pay a one-time offset payment of $850.50/lb to bring the nitrogen down to the 3.6 Ibs/ac/yr. 3. Do a combination of BMPs and offset payment to achieve a 3.6 Ibs/ac/vr export.
If the computed export is greater than 6.0 Ibs/ac/yr, then the owner must use on-site BMPs to bring the development's export down to 6.0 Ibs/ac/yr. Then, the owner may use one of the three options above to achieve the reduction between 6.0 and 3.6 Ibs/ac/yr.	If the computed export is greater than 10.0 Ibs/ac/yr, then the owner must use on-site BMPs to bring the development's export down to 10.0 Ibs/ac/yr. Then, the owner may use one of the three options above to achieve the reduction between 10.0 and 3.6 Ibs/ac/vr.

Method 1 for Nitrogen Export Calculation (Form SW-004)

Method 1 is intended for residential developments where lots are shown but the actual <u>footprint of buildings are not shown on site plans</u>. This method does not require calculation of the area of building footprints. Rather, the impervious surface resulting from building footprints is estimated based on typical impervious areas associated with a given lot size.

Step 1: Determine area for each type of land use and enter in Column (2).

Step 2: Total the areas for each type of land use and enter at the bottom of Column (2).

Step 3: Determine the Total Nitrogen (TN) export coefficient associated with right-of-way using Graph 1.

Step 4: Determine the TN export coefficient associated with lots using Graph 2.

Step 5: Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter in Column (4).

Step 6: Total the TN exports for each type of land use and enter at the bottom of Column (4).

Step 7: Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2).

(1) Type of Land Cover	(2) Area (acres)	(3) TN export coeff. (lbs/acfyr)	(4) TN export from use (lbs/yr)
Permanently protected undisturbed open space (forest, unmown meadow)		0.6	
Permanently protected managed open space (grass, landscaping, etc.)		1.2	
Right-of-way (read TN export from Graph 1)			
Lots (read TN export from Graph 2)			
TOTAL			

Step 8: Calculate Total TN export from use (lb/yr) / Total Area (acre) =

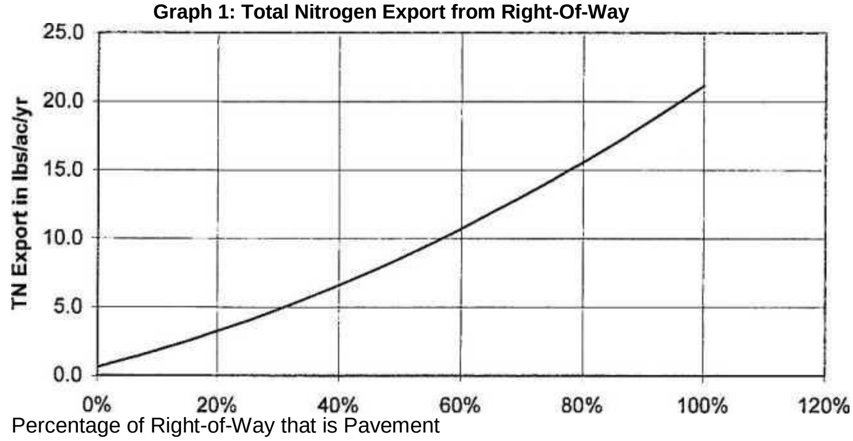
(lb/acre/year)

<u>Certification</u>

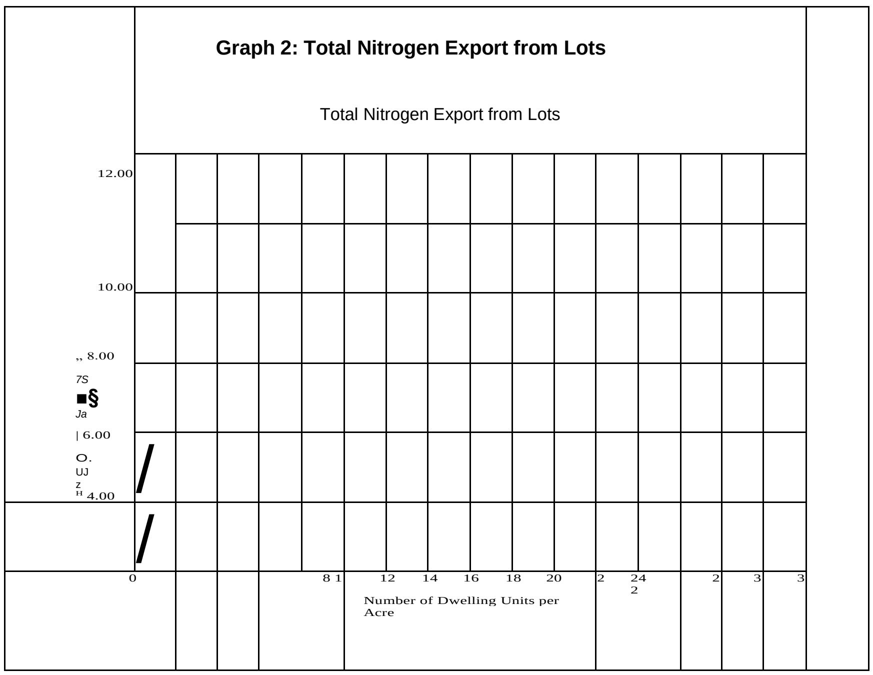
I,___________________________ (print name) hereby certify the information included on this and attached pages is true and correct to the best of my knowledge.

Signature Date

Graph 1: Total Nitrogen Export from Right-Of-Way



Graph 2: Total Nitrogen Export from Lots



Method 2 for Nitrogen Export Calculation
(Form SW-005)

Method 2 is for residential, commercial and industrial developments when tha entire footprint of the roads, parking lots, buildings and any other built-upon area is shown on the <u>site plans</u>.

Step 1: Determine area for each type of land use and enter in Column (2).

Step 2: Total the areas for each type of land use and enter at the bottom of Column (2).

Step 3: Multiply the areas in Column (2) by the Total Nitrogen (TN) export coefficients in Column (3) and enter in Column (4).

Step 4: Total the TN exports for each type of land use and enter at the bottom of Column (4).

Step 5: Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2).

(1) Type of Land Cover	(2) Area (acres)	(3) TN export coeff. (lbs/ac/yr)	(4) TN export from use (lbs/yr)
Permanently protected undisturbed open space (forest, unmown meadow)		0.6	
Permanently protected managed open space (grass, landscaping, etc.)		1.2	
Impervious surfaces (roads, parking lots, driveways, roofs, paved storage areas, etc.)		21.2	
TOTAL		...	

Step 6: Calculate Total TN export from use (lb/yr) / Total Area (acre) =

(lb/acre/year)

Certification

1, ___________________________ (print name) hereby certify the information included on this and attached pages is true and correct to the best of my knowledge.

Signature

Date

)

)

Peak Flow Calculations

Rational Method Peak Flow Calculation Form (SW-006)

The Rational Method may only be used for single-family residential developments where the final built-out development will impact less than 10 acres.

Location: ________________________

Drainage area (A): ________________________ acres

Average slope: percent

Maximum Slope Length: ________________________ feet

Pre-Development Conditions _________ _________ ___________________ _

Type of Land Use	C	Area (acre)	Cx A
Total			

Area-weiqhted C:

Heiqht of most remote outlet: feet

Maximum Lenath of travel: feet

To: min.

Intensity (i) for 1-yr, 24-hr storm: in/hr

Intensity (i) for 10-yr, 24-hr storm: in/hr

Pre-dev. peak flow for 1-year, 24-hour storm:

q = CiA =_______________ cfs

Pre-dev. peak flow for 10-year, 24-hour storm: q = CiA = _________ cfs

Type of Land Use	C	Area (acre)	C x A
Total			

Area-weiqhted C:

Heiaht of most remote outlet: feet

Maximum Lenqth of travel: feel

Tc: min.

Intensity (i) for 1-yr, 24-hr storm: in/hr

Intensity (i) for 10-vr, 24-hr storm: in/hr

Post-dev. peak flow for 1-year, 24-hour storm:

a = CiA = cfs

Post-dev. peak flow for 10-year, 24-hour storm:

a = CiA = cfs

Certification

1, ___________________________(print name) hereby certify the information included on this and attached
pages is true and correct to the best of my knowledge.

Signature_______________________________________ Date_____________

SCS Method Peak Flow Calculation Form (SW-007)

The SCS Method may be used for any development.

Location: ________________________

Drainage area (A):

acres

Maximum Slope Length: ________________________ feel

Pre-Development Conditions

Type of Land Use	CN	% Imp.	Area (acre)	CN x A	Imp x A
Total					

Average slope: ________________________ percent

Area-weighted CN:

Overall % Impervious:

Design rainfall for 1-year storm, P-p inches

Design rainfall for 10-year storm, inches

P_{10}: inches

Runoff depth Qi: inches

Runoff depth Q_{10}: acres

Equivalent Drainage area: cfs/inch

Peak runoff rate: cfs

Peak flow for 1-year, 24-hour storm, cfs

Peak flow for 10-year, 24-hour storm,

Adjustments for percent impervious surfaces, improved channels, average watershed slope, ponding, and swampy areas may be necessary. Refer to the North Carolina Cooperative Extension Service, North Carolina State University, and North Carolina Department of Environment, and Natural Resources *Stormwater Guidance Manual* design manual or the United States Department of Agriculture, Soil Conservation Service (USDA - SCS) - *Technical Release* 55 for details.

Adjusted Peak Flow for percent impervious surfaces and improved channels.
Peak flow: 1 -vr. 24-hr storm: cfs 1 Q-vr, 24-hr storm: cfs

Adjusted Peak Flow for average watershed slope.
Peak flow: 1-vr, 24-hr storm: cfs 10-yr, 24-hr storm: cfs

Adjusted Peak Flow for ponding and swampy areas.
Peak flow: 1 -vr, 24-hr storm: cfs 10-yr, 24-hr storm: cfs

Repeat the calculations for Post-Development Conditions.

Post-Development Conditions

Type of Land Use	CN	% Imp.	Area (acre)	CN x A	Imp x A
Total					

Area-weighted CN: Overall % Impervious:

Design rainfall for 1-year storm. Pi: inches

Design rainfall for 10-year storm, P_{10}: inches

Runoff depth Qi: inches

Runoff depth Q_{10}: inches

Equivalent Drainage area: acres

Peak runoff rate: cfs/inch

Peak flow for 1-vear, 24-hour storm, cfs

Peak flow for 10-year, 24-hour storm, cfs

Adjustments for percent impervious surfaces, improved channels, average watershed slope, ponding, and swampy areas may be necessary. Refer to the North Carolina Cooperative Extension Sen/ice, North Carolina State University, and North Carolina Department of Environment, and Natural Resources *Stormwater Guidance Manual* design manual or the United States Department of Agriculture, Soil Conservation Service (USDA - SCS) - *Technical Release 55* for details.

Adjusted Peak Flow for percent impervious surfaces and improved channels.
Peak flow: 1-vr. 24-hr storm: cfs 10-vr, 24-hr storm: cfs

Adjusted Peak Flow for average watershed slope.
Peak flow: 1-yr, 24-hr storm: cfs 10-yr, 24-hr storm: cfs

Adjusted Peak Flow for ponding and swampy areas.
Peak flow: 1-yr, 24-hr storm: cfs 10-yr, 24-hr storm: cfs

Certification

1, ___________________________(print name) hereby certify the information included on this and attached pages is true and correct to the best of my knowledge.

Signature _______________________________________ Dale _________

CITY OF NEW BERN STORMWATER PERMIT
(Form SW-010)

Development

Owner or Contact Person

Address

Date Issued: ____

This permit is provided under the City of New Bern Stormwater Ordinance and covers construction activities as submitted on the Stormwater Management Plan and accompanying drawings, calculations and other documentation for the period ending (2 years from date issued).

Inspection Requirement

Each structural component (Best Management Practice or BMP) constructed under this permit requires a final, as-built inspection prior to the use of the property as described in the Stormwater Management Plan. You must call the City of New Bern Stormwater Administrator's office to schedule that inspection. Failure to arrange for the required inspection prior to beginning the intended use of the property shall void this permit.

No Modifications

There shall be no modifications to the drainage patterns, structures, operation and maintenance, or other features approved in the Stormwater Management Plan without the prior approval of the Stormwater Administrator.

Additional Requirements

Additional requirements, conditions, variances, and approvals are included as part of this permit as attached and here referenced:

Please keep a copy of this Stormwater Permit at your site. This permit does not supersede any other permit requirements or approvals required for you development. Your cooperation is appreciated.

Sincerely, City of New Bern Stormwater Administrator or Representative

Official Use Only: Stormwater Permit No. Date Approved

City of New Bern

Structural BMP Inspection Report
(Form SW-015)

Reporter Name	Development Name	Date & Time	Date/Time of Last Rainfall

Site Description (Attach map if required)

Address	GPS Location	Type of BMP	Dominant Land Use

Visual Observations (Use as required. Attach photos if available)

Forebay Condition	Clarity of Detained Water (clear, turbid, milky)
Vegetation (healthy, dead, sparse, rich)	Floating Materials (dead fish, debris, plastic)
Outfall Structural Condition (broken, rusty)	Current Inflow and Outflow Estimates (cfs)
Drainage Modifications Found? Describe.	Other

Maintenance Record Review

Records reviewed? (YES/NO)	If NO, why not?
Entries contemporaneously made?	Special Modifications or Conditions

Stormwater Plan Review

Drainage areas on plan and from site inspection (SQ.FT, or ACRES)	Outlet agrees with Stormwater Plan Specifications?

Make additional notes and list additional maintenance requirements and dates on reverse site.

City of New Bern

Illicit Discharge Elimination Program
Field Screening Report (SW-020)

Reporter Name	Outfall ID	Date & Time	Date/Time of Last Rainfall

Site Description (Attach map if required)

Address	GPS Location	Type of Outfall	Dominant Land Use

Visual Observations (Attach photo if available)

Odor (septic, fishy, chlorine, rotten egg)	Color (light or dark brown, oily, reddish)
Clarity (clear, turbid, milky)	Floating Materials (dead fish, debris, plastic)
Deposits and Stains (color and extent)	Vegetation (healthy, dead, sparse, rich)
Outfall Structural Condition (broken, rusty)	Flow Estimate (cfs)
Biological Conditions (fish present, live bugs)	Other

Sampling & Analysis

Sample taken by:	Method:
Meter last calibrated (Date/Time):	Lab Analysis by:
Temperature (C):	pH :
COD (mg/l):	Nitrogen-Ammonia (mg/l)
Total Nitrogen (mg/l):	Fluoride or Chlorine (mg/l)

Make additional notes on reverse site.

Appendix B - Covenants

NORTH CAROLINA

DECLARATION OF COVENANTS FOR

STORM AND SURFACE CRAVEN COUNTY WATER FACILITY MAINTENANCE

THIS DECLARATION OF COVENANTS is made this _______________day of________________, 20 _, by _____________________________________ (“Covenantor^)*’) to and for the benefit of the City of New Bern, a North Carolina municipal corporation and its successors and assigns (“City”).

WITNESSETH:

THAT WHEREAS, the City is authorized and required to regulate and control the disposition of storm and surface waters within the City’s jurisdiction as set forth in the City of New Bern Stormwater Ordinance, Code Sections 15-501 *et seq.;* and

WHEREAS, Covenantor(s) is (are) the owner(s) of a certain tract or parcel of land more particularly described on the attached Exhibit A, being all or part of the land which it acquired by deed dated _____________ from _________________________ _ recorded in the Office of the Register of Deeds of Craven County in deed book ___________at page _____ , such property being hereinafter referred to as “the property”; and

WHEREAS, the Covenantors(s) desires to construct certain improvements on its property that will alter the extent of storm and surface water flow conditions on both the property and adjacent lands; and

WHEREAS, in order to accommodate and regulate these anticipated changes in existing storm and surface water flow conditions, the Covenantor(s) desires to build and maintain at its expense, a storm and surface water management facility and system more particularly described and shown on plans titled ___________________________________ and further identified under City approval/permit number ______________________________ ; and

WHEREAS, the City has reviewed and approved these plans subject to the execution of this agreement.

NOW, THEREFORE, in consideration of the benefits received by the Covenantor(s) as a result of the City's approval of its plans, Covenantor(s), with full authority to execute deeds, mortgages, other covenants, and all rights, title and interest in the property described above do hereby covenant with the City as follows:

1. Covenantor(s) shall construct and perpetually maintain, at its sole expense, the above-referenced storm and surface water management facility and system in strict accordance with the plan approval granted by the City.

2. Covenantor(s) shall, at its sole expense, make such changes or modifications to the storm and surface water management facility and system as may, at the City's discretion, be determined necessary to insure that the facility and system is properly maintained and continues to operate as designed and approved.

3. The City, its agents, employees and contractors shall have the perpetual right of ingress and egress over the property of the Covenantor(s), and the right to inspect at reasonable times and in reasonable manner, the storm and surface water facility and system, in order to insure that the system is being properly maintained and is continuing to perform in an adequate manner.

4. The Covenantor(s) agrees that should it fail to correct any defects in the above- described facility and system within ten (10) days from the issuance of written notice, or shall fail to maintain the facility in accordance with the approved design standards and with the law and applicable executive regulation or, in the event of an emergency as determined by the City in its sole discretion, the City is authorized to enter the property to make all repairs, and to perform all maintenance, construction and reconstruction as the City deems necessary. The City shall then assess the Covenantor(s) and/or all landowners served by the facility for the cost of the work, both direct and indirect, and applicable penalties. Said assessment shall be a lien against all properties served by the facility and may be placed on the property tax bills of said properties and collected as ordinary taxes by the City.

5. Covenantor(s) shall indemnify, save harmless and defend the City from and against any and all claims, demands, suits, liabilities, losses, damages and payments including attorney fees claimed or made by persons not parties to this Declaration against the City that are alleged or proven to result or arise from the

Covenantor(s) construction, operation, or maintenance of the storm and surface water facility and system that is the subject of this Covenant.

6. The covenants contained herein shall run with the land and the Covenantor(s) further agrees that whenever the property shall be held, sold and conveyed, it shall be subject to the covenants, stipulations, agreements and provisions of this Declaration, which shall apply to, bind and be obligatory upon the Covenantor(s) hereto, its heirs, successors and assigns and shall bind all present and subsequent owners of the property served by the facility.

7. The Covenantor(s) shall promptly notify' the City when the Covenantor(s) legally transfers any of the Covenantor(s) responsibilities for the facility. The Covenantor(s) shall supply the City with a copy of any document of transfer, executed by both parties.

8. The provisions of this Declaration shall be severable and if any phrase, clause, sentence or provision is declared unconstitutional, or the applicability thereof to the Covenantor is held invalid, the remainder of this Covenant shall not be affected thereby.

9. This Declaration shall be recorded in the Office of the Register of Deeds of Craven County at the Covenantor(s) expense.

10. In the event that the City shall determine in its sole discretion at a future time that the facility is no longer required, then the City shall at the request of the Covenantor(s) execute a release of this Declaration of Covenants which the Covenantor(s) shall record at its expense.

IN TESTIMONY HEREOF, the Covenantor has hereunto set his hand and adopted as his seal the typewritten word “Seal” appearing by his signature, the day and year first above written.

.(SEAL)

STATE OF NORTH CAROLINA

COUNTY OF CRAVEN

I, _ _____________ , Notary Public in and for said County and State, do hereby certify ________________________________, personally appeared before me this day and acknowledged the due execution of the foregoing and annexed instrument for the purposes therein expressed.

WITNESS my hand and official seal this the _______ day of __________ , 20_________ .

Notary Public

My Commission Expires:

STATE OF NORTH CAROLINA

COUNTY OF CRAVEN

The foregoing notary certificate is certified to be correct. This instrument was presented for registration on this day and hour, and duly recorded in the Office of the Register of Deeds of County, North Carolina in Book _____________________________ at Page _____ .

This the_____ day of, _____________, 20 __ , at ______ o'clock _.m.

Register of Deeds

By ___ ______ _ _________
Assistant Register of Deeds

EXHIBIT A

Appendix C - Storm Water Technology Fact Sheets and BMP Case Studies

ERA 832-F-99-048 Storm Water Technology Fact Sheet: Wet Detention Ponds EPA

832-F-99-025 Storm Water Technology Fact Sheet: Storm Water Wetlands EPA 832-F-

99-012 Storm Water Technology Fact Sheet: Bioretention EPA 832-F-99-019 Storm

Water Technology Fact Sheet: Infiltration Trench EPA 832-F-99-018 Storm Water

Technology Fact Sheet: Infiltration Drainfields EPA 832-F-99-023 Storm Water

Technology Fact Sheet: Porous Pavement

Excerpts from: Low-Impact Development Integrated Management Practices:

- Page 4-9: Bioretention Design Components
- Page 4-11: Dry Wells
- Pages 4-12 - 4-16: Filter Strips
- Pages 4-18 - 4-20: Rain Barrels and Cisterns

Summaries of Case Studies from Better Site Design, An Assessment of the Better Site Design Principles for Communities Implementing Virginia's Chesapeake Bay Preservation Act, Center for Watershed Protection, Eilicott City, MD, 2000.

United States
Environmental Protection
Agency

Office of Water
Washington, D.C.

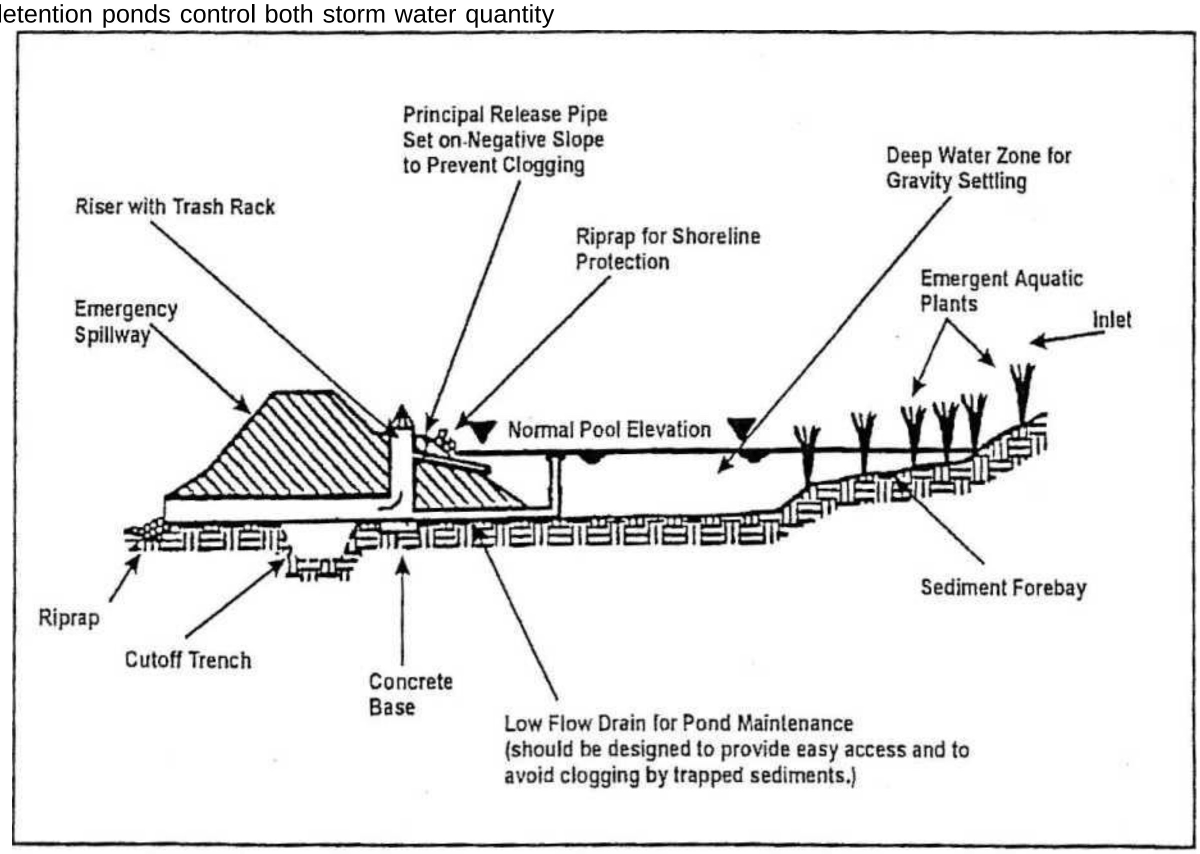
EPA 832-F-99-048
September 1999

&EPA Storm Water Technology Fact Sheet
Wet Detention Ponds

DESCRIPTION

Wet detention ponds are storm water control structures providing both retention and treatment of contaminated storm water runoff. A typical wet detention pond design is showm in Figure 1. The pond consists of a permanent pool of water into which storm water runoff is directed. Runoff from each rain event is detained and treated in the pond until it is displaced by runoff from the next storm.

By capturing and retaining runoff during storm events, wet detention ponds control both storm water quantity and quality. The pond's natural physical, biological, and chemical processes then work to remove pollutants. Sedimentation processes remove particulates, organic matter, and metals, while dissolved metals and nutrients are removed through biological uptake. In general, a higher level of nutrient removal and better stofm water quantity control can be achieved in wet



Source: Maryland Department of the Environment, 1986.
FIGURE 1 TYPICAL LAYOUT OF A WET DETENTION POND

detention ponds than can be achieved with other Best Management Practices (BMPs), such as dry ponds, infiltration trenches, or sand filters.

There are several common modifications that can be made to the ponds to increase their pollutant removal effectiveness. The first is to increase the settling area for sediments through the addition of a sediment forebay, as shown in Figure 1. Heavier sediments will drop out of suspension as runoff passes through the sediment forebay, while lighter sediments will settle out as the runoff is retained in the permanent pool. A second common modification is the construction of shallow ledges along the edge of the permanent pool. These shallow peripheral ledges can be used to establish aquatic plants that can impede flow and trap pollutants as they enter the pond. The plants also increase biological uptake of nutrients. In addition to their function as aquatic plant habitat, the ledges also have several other functions, which can include including acting as a safety precaution to prevent accidental drowning and providing easy access to the permanent pool to aid in maintenance. Finally, perimeter wetland areas can also be created around the pond to aid in pollutant removal.

APPLICABILITY

Wet detention ponds have been widely used throughout the U.S. for many years. Many of these ponds have been monitored to determine their performance. EPA Region V is currently performing a study on the effectiveness of 50 to 60 wet detention ponds. Other organizations, such as the Washington, D.C., Council of Governments (WMCOG) and the Maryland Department of the Environment, have also conducted extensive evaluations of wet detention pond performance.

ADVANTAGES AND DISADVANTAGES

Wet detention ponds provide both storm water quantity and quality benefits, and provide significant retrofit coverage for existing development. Benefits include decreased potential for downstream flooding and stream bank erosion and improved water quality due to the removal of suspended solids, metals, and dissolved nutrients.

While the positive impacts from a wet detention ponds will generally exceed any negative impacts, wet detention ponds that are improperly designed, sited, or maintained, may have potential adverse affects on water quality, groundwater, cold water fisheries, or wetlands. Improperly designed or maintained ponds may result in stratification and anoxic conditions that can promote the resuspension of solids and the release of nutrients and metals from the trapped sediments. In addition, precautions should be taken to prevent damage to wetland areas during pond construction. Finally, the potential for groundwater contamination should be carefully evaluated. However, studies to date indicate that wet detention ponds do not significantly contribute to groundwater contamination (Schueler, 1992).

The following limitation should also be considered when determining the feasibility of installing a wet detention pond:

1. Wet detention ponds must be able to maintain a permanent pool of water. Therefore, ponds cannot be constructed in areas where there is insufficient precipitation to maintain the pool or in soils that are highly permeable. In wetter regions, a small drainage area may be sufficient to ensure that there is enough water to maintain a permanent pool; whereas in more arid regions, a larger drainage area may be required. In some cases, soils that are highly permeable may be compacted or overlaid with clay blankets to make the bottom less permeable.

2. Land constraints, such as small sites or highly developed areas, may preclude the installation of a pond.

3. Discharges from ponds usually consist of warm water, and thus pond use may be limited in areas where warm water discharges from the pond will adversely impact a cold water fishery.

4. The local climate (i.e., temperature) may affect the biological uptake in the pond.
5. Without proper maintenance, the performance of the pond will drop off sharply. Regular cleaning of the forebays is particularly important. Maintaining the permanent pool is also important in preventing the resuspension

of trapped sediments. The accumulation of sediments in the pond will reduce the pond's storage capacity and cause a decline in its performance. Therefore, the bottom sediments in the permanent pool should be removed about every 2 to 5 years. In most cases, no specific limitations have been placed on disposal of sediments removed from wet detention ponds. Studies, to date indicate that pond sediments are likely to meet toxicity limits and can be safely landfilled (NVPDC, 1992). Some states have allowed sediment disposal on-site, as long as the sediments are deposited away from the shoreline to prevent their re-entry into the pond.

DESIGN CRITERIA

In general, pond designs are unique for each site and application. Criteria for selecting the site for installation of the pond should include the site's ability to support the pond environment, as well as the cost effectiveness of locating a pond at that specific site. In addition, the pond should be located where the topography of the site allows for maximum storage at minimum construction costs (NVPDC, 1992). Site-specific constraints for pond construction may include wetlands impacts, existing utilities (e.g., electric or gas) that would be costly to relocate, and underlying bedrock that would require expensive blasting operations to excavate.

The site must have adequate base-flow from the groundwater or from the drainage area to maintain the permanent pool. Typically, underlying soils with permeabilities of between 10^{-5} and 10^{-6} cm/sec will be adequate to maintain a permanent pool.

All local, state and federal permit requirements should be established prior to initiating the pond design. Depending on the location of the pond, required permits and certifications may include wetland permits, water quality certifications, dam safety permits, sediment and erosion control plans, waterway permits, local grading permits, land use approvals, etc.(Schueler, 1992). Since many states and municipalities are still in the process of developing or modifying storm water permit requirements, the applicable requirements should be confirmed with the appropriate regulatory authorities.

Wet detention ponds should be designed to meet both storm water quality and quantity control requirements. Storm water quantity requirements are typically met by designing the pond to control post-development peak discharge rates to pre-development levels. Usually the pond is designed to control multiple design storms (e.g. 2- and/or 10-year storms) and safely pass the 100-year storm event. However, the design storm may vary depending on local conditions and requirements.

Storm water quality control is achieved through pollutant removal in the permanent pool. Removal efficiency is primarily dependent on the length of time that runoff remains in the pond, which is known as the pond's Hydraulic Residence Time (HRT). As discussed above, wet detention ponds remove pollutants through both sedimentation and biological uptake processes, both of which increase with the length of time runoff remains in the pond. These processes can be modeled to determine a design HRT using either the solids settling method or the eutrophication method, respectively (Hartigan, 1988).

The calculated HRT will be dependent on the method selected. HRTs calculated by the eutrophication method can be up to three times greater than HRTs calculated by the solids settling method. The longer HRTs associated with the eutrophication method appear to be due to the slower reaction rates associated with the biological removal of dissolved nutrients (Hartigan, 1988).

Once the design HRT has been determined, the actual dimensions of the pond must be calculated to achieve the design HRT. The primary' factor contributing to a pond's HRT is its volume. Because many wet detention ponds are restricted in area, pond depth can be an important factor in the pond's overall volume. However, the depth of the pool also affects many of the pond's removal processes, and so it must be carefully controlled. It is important to maintain a sufficient permanent pool depth in order to prevent the resuspension of trapped sediments (NVPDC, 1992). Conversely, thermal stratification and anoxic conditions in the bottom layer might develop if permanent pool depths are too great. Stratification and anoxic conditions may decrease biological activity. Anoxic conditions may also increase the potential for the release of phosphorus and heavy metals from the pond sediments (NVPDC, 1992). These factors dictate that the permanent pool depth should not exceed 6 meters (20 feet). The optimal depth ranges between 1 and 3 meters (3 and 9 feet) for most regions, given a 2 week HRT (Hartigan, 1988).

Other key factors to be considered in the pond design are the volume and area ratios. The volume ratio, VB/VR, is the ratio of the permanent pool storage (VB) to the mean storm runoff (VR). Larger VBs and smaller VRs provide for increased retention and treatment between storm events. Low VB/VR ratios result in poor pollutant removal efficiencies.

The area ratio, A/As, is the ratio of the contributing drainage area (A) to the permanent pool surface area (As). The area ratio is also an indicator of pollutant removal efficiency. Data from previous studies indicates that area ratios of less than 100 typically have better pollutant removal efficiencies (MDDEQ, 1986).

The contours of the pond are also important. The pond should be constructed with adequate slopes and lengths. While a length-to-width ratio is usually not used in the design of wet detention ponds for storm water quantity management, a 2:1 length-to-width ratio is commonly used when water quality is of concern. In general, high length-to-width ratios (greater than 2:1) will decrease the possibility of short-circuiting and will enhance sedimentation within the permanent pool. Baffles or islands can also be added within the permanent pool to increase the flow' path (Hartigan, 1988). Shoreline slopes between 5:1 and 10:1 are common and allow easy access for maintenance, such as mowing and sediment removal (Hartigan, 1988). In addition, wetland vegetation is difficult to establish and maintain on slopes steeper than 10:1. Ponds should be wedge-shaped so that flow enters the pond and gradually spreads out. This minimizes the potential for zones with little or no flow (Urbonas, 1993).

The design of the wet pond embankment is another key factor to be considered. Proper design and construction of the embankments will prolong the integrity of the pond structure. Subsidence and settling will likely occur after an embankment is constructed. Therefore during construction, the embankment should be overfilled by at least 5 percent (SEWRPC, 1991). Seepage through the embankment can also affect the stability of the structure. Seepage can generally be minimized by adding drains, anti-seepage collars, and core trenches. The embankment side slopes can be protected from erosion by using minimum side slopes of 2:1 and by covering the embankment with vegetation or rip-rap. The embankment should also have a minimum top width of 2 meters (6 feet) to aid in maintenance.

Finally, the internal flow control of the pond must be considered. Discharge from the pond is controlled by a riser and an inverted release pipe. Normal flows will be discharged through the wet pond outlet, which' consists of a concrete or corrugated metal riser and barrel. The riser is a vertical pipe or inlet structure that is attached to the base with a watertight connection. Risers are typically placed in or adjacent to the embankment rather than in the middle of the pond. This provides easy access for maintenance and prevents the use of the riser as a recreation spot (e.g. diving platform for kids) (Schueler, 1988). The barrel is a horizontal pipe attached to the riser that conveys flow under the embankment.

Typically, flow passes through an inverted pipe attached to the riser, as shown in Figure 1, while higher flows will pass through a trash rack installed on the riser. The inverted pipe should discharge water from below the pond water surface to prevent floatables from clogging the pipe and to avoid discharging the warmer surface water. Clogging of the pipe could result in overtopping of the embankment and damage to the embankment (NVPDC, 1992). Flow is conveyed through the near horizontal barrel and is discharged to the receiving stream. Rip-rap, plunge pools, or other energy dissipators, should be placed at the outlet to prevent scouring and to minimize erosion. Rip-rap also provides a secondary benefit of re-aeration of the pond discharges.

Planners should consider both the design storm and potential construction materials when designing and constructing the riser and barrel. Generally, the riser and barrel are sized to meet the storm water management design criteria (e.g. to pass a 2-year or a 10-year storm event). In many installations, the riser and barrel are designed to convey multiple design storms (Urbonas, 1993). To increase the life of the outlet, the riser and barrel should be constructed of reinforced concrete rather than corrugated metal pipe (Schueler, 1992). The riser, barrel, and base should also provide have sufficient weight to prevent flotation

(NVPDC, 1992).

In most cases, emergency spillways should be included in the pond design. Emergency spillways should be sized to safely pass flows that exceed the design storm flow's. The spillway prevents pond w'ater levels from overtopping the embankment, wʳhich could cause structural damage to the embankment. The emergency spillway should be located so that downstream buildings and structures will not be negatively impacted by spillway discharges. The pond design should include a low flow drain, as shown in Figure 1. The drain pipe should be designed for gravity' discharge and should be equipped with an adjustable gate valve.

PERFORMANCE

The primary pollutant removal mechanism in a wet detention pond is sedimentation. Significant loads of suspended pollutants, such as metals, nutrients, sediments, and organics, can be removed by sedimentation. Other pollutant removal mechanisms include algal uptake, w'etland plant uptake, and bacterial decomposition (Schueler, 1992). Dissolved pollutant removal also occurs as a result of biological and chemical processes (NVPDC, 1992).

The removal rates of conventional wet detention ponds (i.e., without the sediment forebay or peripheral ledges) are well documented and are shown in Table 1. The w'ide range in the removal rates is a result of varying hydraulic residence times (HRTs), which is further discussed in the Design Criteria section. Increased pollutant removal by biological uptake and sedimentation is correlated with increased HRTs. Proper design and maintenance also effect pond performance.

Studies have shown that more than 90 percent of the pollutant removal occurs during the quiescent period (the period between the rainfall events) (MD DEQ, 1986). However, some removal occurs during the dynamic period (w'hen the runoff enters the pond). Modeling results have indicated that two-thirds of the sediment, nutrients and trace metal loads are removed by sedimentation within 24 hours. These projections are supported .by the results of the EPA's 1993 National Urban Runoff Program (NURP) studies. However, other studies indicate that an HRT of two weeks is required to achieve significant phosphorus removal (MD DEQ, 1986).

TABLE 1 REMOVAL EFFICIENCIES FROM WET DETENTION PONDS

Parameter	Percent Removal	
	Schueler, 1992	Hartigan, 1988
Total Suspended Solid	50-90	80-90
Total Phosphorus	30-90	
Soluble Nutrients	40-80	50-70
Lead	70-80	
Zinc	40-50	
Biochemical Oxygen Demand or Chemical Oxygen Demand	20-40	

1 hydraulic residence time varies
2 hydraulic residence time of *2* weeks

Source- Schueler. 1992 & MD DEQ. 1986.

The pond’s treatment efficiency can be enhanced by extending the detention time in the permanent pool to up to 40 hours. This allows for a more gradual release of collected runoff, resulting in both increased pollutant removal and control of peak flows (Hartigan, 1988).

OPERATION AND MAINTENANCE

Wet detention ponds function more effectively when they are regularly inspected and maintained. Routine maintenance of the pond includes mowing of the embankment and buffer areas and inspection for erosion and nuisance problems (e.g. burrowing animals, weeds, odors) (SEWRPC, 1991). Trash and debris should be removed routinely to maintain an attractive appearance and to prevent the outlet from becoming clogged. In general, wet detention ponds should be inspected after every storm event. The embankment and emergency spillway should also be routinely inspected for structural integrity, especially after major storm events. Embankment failure could result in severe downstream flooding. When any problems are observed during routine inspections, necessary repairs should be made immediately. Failure to correct minor problems may lead to larger and more expensive repairs or even to pond failure. Typically, maintenance includes repairs to the embankment, emergency spillway, inlet, and outlet; removal of sediment; and control of algal growth, insects, and odors (SEWRPC, 1991). Large vegetation or trees that may weaken the embankment should be removed. Periodic maintenance may also include the stabilization of the outfall area (e.g. adding rip-rap) to prevent erosive damage to the embankment and the stream bank. In most cases, sediments removed from wet detention ponds are suitable for landfill disposal. However, where available, on-site use of removed sediments for soil amendment will reduce maintenance costs.

COSTS

Typical costs for wet detention ponds range from S17.50-S35.00 per cubic meter (SO.50-51.00 per cubic foot) of storage area (CWP, 1998). The total cost for a pond includes permitting, design and construction, and maintenance costs. Permitting costs may vary depending on state and local regulations. Typically, wet detention ponds are less costly to construct in undeveloped areas than to retrofit into developed areas. This is due to the cost of land and the difficulty in finding suitable sites in developed areas. The cost of relocating pre-existing utilities or structures is also a major concern in developed areas. Several studies have shown the construction cost of retrofitting a wet detention pond into a developed area may be 5 to 10 times the cost of constructing the same size pond in an undeveloped area. Annual maintenance costs can generally be estimated at 3 to 5 percent of the construction costs (Schueler, 1992). Maintenance costs include the costs for regular inspections of the pond embankments, grass mowing, nuisance control, debris and liter removal, inlet and outlet maintenance and inspection, and sediment removal and disposal. Sediment removal cost can be decreased by as much as 50 percent if an on-site disposal areas are available (SEWRPC, 1991).

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United States
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Office of Water
Washington,
D.C.

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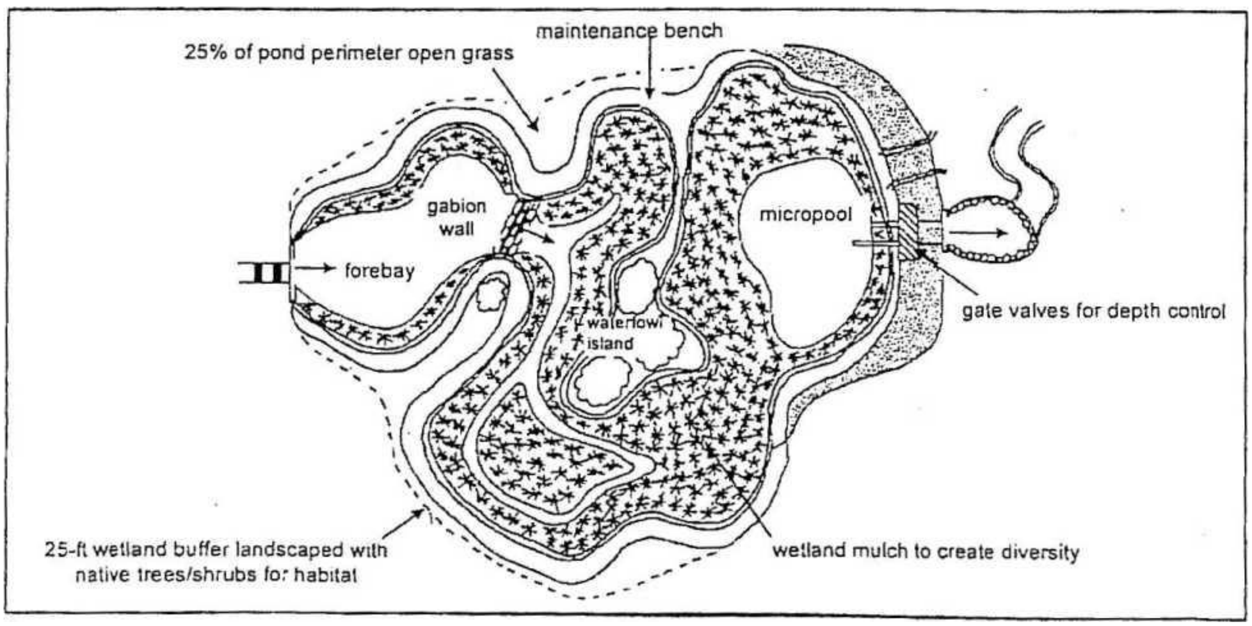
<>EPA Storm Water Technology Fact Sheet
Storm Water Wetlands

DESCRIPTION

Wetlands are those areas that are typically inundated with surface or ground water and that support plants adapted to saturated soil conditions. Atypical shallow marsh wetland is shown in Figure I. Wetlands have been described as "nature's kidneys" because the physical, chemical, and biological processes that occur in wetlands break down some compounds (e.g., nitrogen-containing compounds, sulfate) and filter others (Hammer, 1989). The natural pollutant-removal capabilities of wetlands have brought them increased attention as storm water best management practices (BMPs).

Wetlands used for storm water treatment can be incidental, natural, or constructed. Incidental wetlands are those wetlands that were created as a result of previous development or human activity'. The use of natural wetlands for storm water treatment is discouraged by many experts and/or public interest groups, and may not be an option in many areas. However, some states allow wetlands to be used as storm water BMPs, but only in very restricted circumstances. For example, the State of Florida allows the use of natural wetlands that have been severely degraded or wetlands that are intermittently connected to other waters (i.e., they are connected only when groundwater rises above ground level) (Livingston, 1994). Conversion of natural wetlands to storm water wetlands is done on a case-by-case basis and requires the appropriate state and federal permits (e.g., 401 water quality certification and 404 wetland permit).

Two types of constructed wetlands have been used



Source: MWCOG, 1992a.

FIGURE 1 SHALLOW MARSH WETLAND

successfully for wastewater treatment: the subsurface flow (SF) constructed wetland and the free water surface (FWS) constructed wetland. In the FWS wetland, runoff flows through the soil- lined basin at shallow depths. The wetland consists of a shallow pool planted with emergent vegetation (vegetation which is rooted in the sediment but with leaves at or above the water surface).

In contrast to the FWS wetland, the SF wetland basin is lined with a pre-designed amount of rock or gravel, through which the runoff is conveyed. The water level in an SF wetland remains below the top of the rock or gravel bed. Studies have indicated that the SF wetland is well suited for the diurnal flow pattern of wastewater; however, the peak flows from storm water or combined sewer overflows -(CSOs) may be several orders of magnitude higher than the baseflow. The cost for a gravel bed to contain the peak storm event would be very high, which may preclude the use of SF wetlands for storm water or CSO treatment. Therefore, the remainder of this fact sheet addresses the FWS constructed wetland or natural and incidental wetlands for use in storm water applications.

There are four basic designs of FWS constructed wetlands: shallow marsh, extended detention wetland, pond/wetland system, and pocket wetland. As shown in Figure 2, these wetlands store runoff in a shallow basin vegetated with wetland plants. The selection of one design over another will depend on various factors, including land availability, level and reliability of pollutant removal, and size of the contributing drainage area.

The shallow marsh design requires the most land and a sufficient baseflow to maintain water within the wetlands. The basic shallow marsh design can be modified to store extra water above the normal pool elevation. This wetland, known as an extended detention wetland, attenuates flows and relieves downstream flooding.

The pond/wetland system has two separate cells: a wet pond and a shallow marsh. The wet pond traps sediments and reduces runoff velocities prior to entry into the wetland. Less land is required for a pond/wetland system than for the shallow marsh system.

Still less land is required for a pocket wetland. Pocket wetlands should be designed with contributing drainage areas of 0.4 to 4 hectares (1 to 10 acres) and usually require excavation down to the water table for a reliable water source. Unreliable water sources and fluctuating water levels result in low plant diversity and poor wildlife habitat value (MWCOG, 1992b).

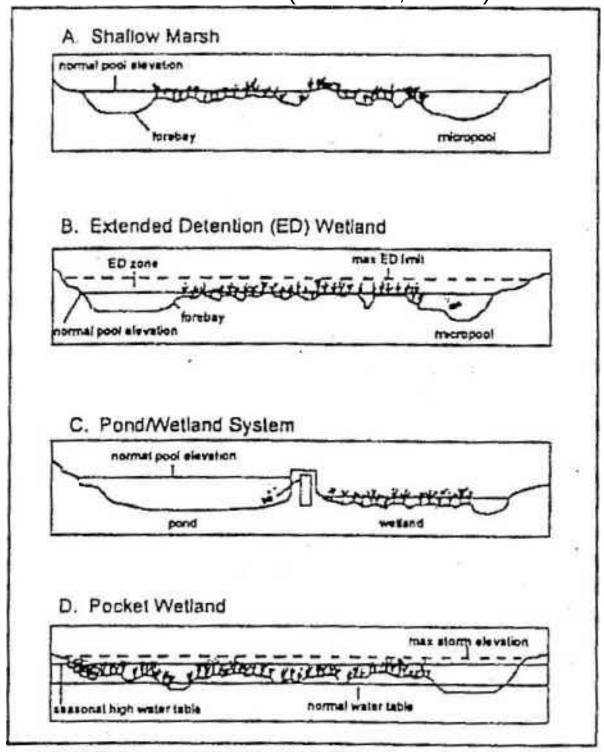


FIGURE 2 COMPARATIVE PROFILES OF FOUR STORM WATER WETLAND DESIGNS

Cross-sectional profiles of the four storm water wetlands not drawn to scale. In Panel A, most of the shallo w marsh is shallow, supporting emergent wetland plants. In extended detention wetlands (Panel B), the runoff storage of the wetland is augmented by temporary, vertical extended detention storage. The pond/wetland system (Panel C) is composed of a deep and a shallow pool. Pocket wetlands (Panel D) are excavated to the groundwater table to keep water elevation more consistent.

Source: MWCOG, 1992b.

APPLICABILITY

Wetlands improve the quality of storm water runoff, and can also control runoff volume (e.g., extended detention wetland). Wetlands are one of the more reliable BMPs for removing pollutants and are adaptable to most locations in the U.S. Locations with existing wetlands used for storm water treatment include Alabama, California, Colorado, Florida, Illinois, Maine, Maryland, Michigan, Minnesota, Virginia, and Washington. Wetlands have been used to treat runoff from agricultural, commercial, industrial, and residential areas.

In the past, the natural ability of wetlands to remove pollutants from water has primarily been harnessed to treat wastewater. However, the utilization of wetlands to treat stormwater has gained attention in recent years, and many storm water wetlands treatment systems are now operational. Ongoing evaluations are being conducted to determine the effectiveness of wetlands in pollutant removal and to determine the level of maintenance required to sustain their performance, while other studies are evaluating the potential for design modifications to improve wetland performance.

ADVANTAGES AND DISADVANTAGES

Environmental benefits associated with storm water wetlands include improvements in downstream water and habitat quality, enhancement of diverse vegetation and wildlife habitat in urban areas, and flood attenuation. Downstream water quality is improved by the partial removal of suspended solids, metals, nutrients, and organics from urban runoff. Habitat quality is also improved as reduced sediment loads are carried downstream and the erosion of stream banks associated with peak storm water flows is reduced. Wetlands can support a diverse wildlife population, including species such as sandpipers and herons, and can attenuate runoff and alleviate downstream flooding (particularly extended detention wetlands).

Storm water wetlands can cause adverse environmental impacts upstream of the wetland, within the wetland itself, and downstream of the wetland. Storm water wetlands located in a large watershed (larger than 40 hectares (100 acres)) may degrade upstream headwaters, which receive no effective hydrologic control (MWCOG, 1992b), The wetland designer can incorporate upstream modifications to relieve this negative impact.

Possible adverse effects within the wetland itself are the potential for blocking fish passage, potential habitation by undesirable species, and potential groundwater contamination. A wetland constructed in the stream channel may block fish access to part of the stream, thereby decreasing fish diversity in the stream.

Geese and mallards may become undesirable year-round residents of the wetland if structural complexity is not included in the wetland design (i.e., features that limit deep and open water areas and open grassy areas that are favored by these birds). These animals will increase the nutrient and coliform loadings to the wetland and may also become a nuisance to local residents. The takeover of vegetation by invasive nuisance plants is also a potential negative impact. Invasive species pose a threat to native species and may adversely affect the wetland’s ability to treat storm water. Maintaining and/or planting upland buffer zones can help to reduce the introduction of nuisance plant species. Planting emergent vegetation may also reduce nuisance algal blooms (Carr, 1995).

The issue of groundwater contamination resulting from the migration of polluted sediments to the groundwater has been considered a potential negative environmental impact However, studies indicate that there is little risk of groundwater contamination (MWCOG, 1992b).

A storm water wetland can act as a heat sink, especially during the summer, and can discharge warmer waters to downstream water bodies. The increased temperatures can affect sensitive fish species (such as trout and sculpins) and aquatic insects downstream. Therefore, it is not recommended to construct storm wetlands upstream of temperature-sensitive fish populations. Regardless of the sensitivity of downstream species, the designer should always take precautions to reduce the potential w'arming effects of wetlands construction.

Communities may be opposed to a wetland for fear of mosquitoes and other nuisances, or because of wetlands’ appearance. However, wetlands can be designed attractively and features (e.g., fish and vegetation) can be adapted to control mosquitoes and other nuisances. The use of *Gambusia* fish for mosquito control has become a common practice in ■warmer climates, while colder climates use the black striped topminnow *(Notrophus fundulus*) (U.S. EPA, 1995). To minimize the protection from predators offered by taller plants, the use of low growing plants is recommended where pests are a concern (U.S. EPA, 1996).

Wetlands may remove pollutants less effectively during the non-growing season and in localities ■with lower temperatures. Decreases in some pollutant-removal efficiencies have been observed when wetlands are covered with ice and when they receive snow melt runoff.

Finally, because of the large land requirement for storm water wetlands systems (See Design Criteria), their use may be precluded in urban settings and established communities.

Several possible remedies to these impacts are discussed in the publication *Design of Storm Water Wetland Systems* (MWCOG, 1992).

DESIGN CRITERIA

Local, state and federal pennit requirements should be determined prior to wetland design. Required permits and certifications may include 401 water quality certifications, 402 storm water National Pollutant Discharge Elimination System (NPDES) permits, 404 wetland permits, dam safety permits, sediment and erosion control plans, waterway disturbance permits, forest-clearing permits, local grading permits, and land use approvals.

A site appropriate for a wetland must have an adequate water flow and appropriate underlying soils. The baseflow from the drainage area or groundwater must be sufficient to maintain a shallow pool in the wetland and support the wetlands' vegetation, including species susceptible to damage during dry periods. Underlying soils that are type B , C, or R (zone of accumulation, partially altered parent material and unaltered parent material, respectively) will have only small infiltration losses. Sites with type A soils (soils rich in organic matter) may have high infiltration rates. These sites may require geotextile liners or a 15 centimeter (6 inch) layer of clay. After any necessary excavation and grading of the wetland, at least 10 centimeters (4 inches) of soil should be applied to the site. This material, which may be the previously-excavated soil or sand and other suitable material, is needed to provide a substrate in which the vegetation can become established and to which it can become anchored. The substrate should be soft so that plants can be inserted easily.

The Metropolitan Washington Council of Governments (MWCOG, 1992b) has recommended basic sizing criteria for wetland design. The volume of the wetland is determined as the quantity of runoff generated by 90 percent of the runoff- producing storms. This volume will vary throughout the U.S. due to different rainstorm patterns. In the Mid-Atlantic Region, for example, a 1.25-inch storm is used as the sizing criterion.

Watershed imperviousness will also impact the runoff volume generated from a storm. The following equations are used to determine the treatment volume (Vt):

(1) $Rv = 0.05 + 0.009 (I)$

where:

Rv = storm runoff coefficient

I = % (as decimal) site imperviousness

(2) $Vt= [(1.25)(Rv)(A)/12](43{,}560)$

where:

Vt = treatment volume (cubic feet)

A = contributing area (acres)

Sizing criteria for wetlands *vary,* with some states having their own methods. For example, shallow wetland basins constructed in Maryland are designed to maximize basin surface area. The surface area should be a minimum of 3 percent of the area of the watershed draining to it. Maryland recommends designing for extended detention, using 24-hour detention of the 1-year storm for design purposes. In contrast, the Washington State Department of Ecology sizes wetlands using the runoff generated from the 6-month, 24-hour rainfall event. The minimum surface area established by MWCOG for shallow marshes is 2 percent of the wetland area. The remaining three wetland designs should have wetland to watershed ratios greater than I percent.

TABLE 1 GUIDELINES FOR ALLOCATING WETLAND SURFACE AREA AND TREATMENT VOLUME

Target Allocations	Shallow Marsh	Extended Detention Wetland	Pond/Wetiand	Pocket Wetland
Percent of Wetland Surface Area				
Forebay	5	5	0	0
Micropool	5	5	5	0
Deepwater	5	0	40	5
Low Marsh	40	40	25	50
High Marsh	40	40	25	40
Semi-Wet	5	10	5	5
Percent of Treatment Volume				
Forebay	10	10	0	0
Micropool	10	10	10	0
Deepwater	10	0	60	20
Low Marsh	45	20	20	55
High Marsh	25	10	10	25
Semi-Wet	0	50	0	0

Depth:
Deepwater -0.5-2 meters (1,5 to 6 feet) below normal pool level Low Marsh - 0.17- 0.5 meters (0.5 to 1.5 feet) below normal pool level High Marsh -0.5 feet below normal pool level

Semi-Wet - 0 to 2 feet above normal pool level (includes Extended Detention) Source: Modified from MWCOG, 1992b.

MWCOG has also established criteria for water balance, maximum flow path, allocation of treatment volume, minimum surface area, allocation of the surface area, and extended detention. As previously discussed, during dry weather, flow must be adequate to provide a baseflow and to maintain the vegetation. The flow path should be maximized to increase the runoffs contact time with plants and sediments. The recommended minimum length to width ratio of the wetland is 2:1. If a ratio of less than 2:1 is necessary, the use of baffles, islands, and peninsulas can minimize short circuiting (allowing runoff to escape treatment) by ensuring a long distance from inlet to outlet.

A suggestion for allocating treatment volumes is shown in Table 1. The wetland surface area is allocated to four different depth zones: deepwater (0.5 to 2 meters, or 1.5 to 6 feet, below normal pool), low marsh (0.17 to 0.5 meters, or 0.5 to 1.5 feet, below normal pool), high marsh (up to 0.17 meters, or 0.5 feet, below normal pool), and semi-wet areas (above normal pool). The allocation to the various depth zones will create a complex internal topography that will maximize plant diversity and increase pollutant removal. The State of Maryland requires that 50 percent of the shallow marsh be less than 0.17 meters (0.5 feet) deep, that 25 percent range from 0.17 to 0.33 meters (0.5 feet to 1 foot) deep, and that the remaining 25 percent range from 0.67 to 1 meter (2 to 3 feet) deep.

Extending detention within the wetland increases the time for sedimentation and other pollutant- removal processes to occur and also provides for attenuation of flows. Up to 50 percent extra treatment volume can be added into the wetland system for extended detention. However, to prevent large fluctuations in the water level that could potentially harm the vegetation, Extended Detention elevation should be limited to 11 meters (33 feet) above the normal pool elevation. The Extended Detention volume should be detained between 12 and 24 hours.

Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. The forebays provide the additional benefits of creating sheet flow, extending the flow path, and preventing short circuiting. The forebav should contain at least 10 percent of the wetland's treatment volume and should be 2 to 3 meters (4 to 6 feet) deep. The State of Maryland recommends a depth of at least 1 meter (3 feet). The forebay is typically separated from the wetland by gabions or by an earthen berm (MWCOG, 1992b).

Flow from the wetland should be conveyed through an outlet structure that is located within the deeper areas of the wetland. Discharging from the deeper areas using a reverse slope pipe prevents the outlet from becoming clogged. A micropool just prior to the outlet will also prevent outlet clogging. The micropool should contain approximately 10 percent of the treatment volume and be 2 to 3 meters (4 to 6 feet) deep. An adjustable gate-controlled drain capable of dewatering the wetland within 24 hours should be located within the micropool. A typical drain may be constructed with an upward-facing inverted elbow with its opening above the accumulated sediment. The dewatering feature eases planting and follow-up maintenance (MWCOG, 1992b).

Vegetation can be established by any of five methods: mulching; allowing volunteer vegetation to become established; planting nursery vegetation; planting underground dormant parts of a plant; and seeding. Donor soils from existing wetlands can be used to establish vegetation within a wetland. This technique, known as mulching, has the advantage of quickly establishing a diverse wetland community'.
However, with mulching, the types of species that grow within the wetland are unpredictable.

Allowing species transmitted by wind and waterfowl to voluntarily become established in the wetland is also unpredictable. Volunteer species are usually well established within 3 to 5 years. Wetlands established with volunteers are usually characterized by low plant diversity with monotypic stands of exotic or invasive species. A higher- diversity wetland can be established when nursery plants or dormant rhizomes are planted. Vegetation from a nursery should be planted during the growing season - not during late summer or fall - to allow vegetation time to store food reserves for their dormant period. Separate underground parts of vegetation are planted during the plants' dormant period, usually October through April, but the months will vary with local climate. Another planting technique, the spreading of seeds, has not been very successful and therefore is not widely practiced as a principal planting technique.

Appropriate plant types vary' with locations and climate. The wetland designer should select five to seven plants native to the area and design the depth zones in the wetland to be appropriate for the type of plant and its associated maximum water depth. Approximately half of the wetland should be planted. Of the five to seven species selected, three should be aggressive plants or those that become established quickly. Examples of aggressive species used in the Mid-Atlantic Region include softstem bulrush *(Stirpus validus*) and common three-square *(Scirpus americanus).* Aggressive plants as well as other native wetland plants are available from numerous nurseries. Most vendors require an advance order of 3 to 6 months.

After excavation and grading the wetland should be kept flooded until planting. Six to nine months after being flooded and two weeks before planting, the wetland is typically drained and surveyed to ensure that depth zones are appropriate for plant growth. Revisions may be necessary to account for any changes in depth. Next, the site is staked to ensure that the planting crew spaces the plants within the correct planting zone. Species are planted in separate zones to avoid competition. The State of Maryland recommends planting two aggressive or primary species in four specific areas and planting an additional 40 clumps (one or more individuals of a single species) per acre of each primary species over the rest of the wetland. Three secondary species are planted close to the edge of the wetland at an application rate of 10 clumps of 5 individual plants per acre of wetland, for a total of 50 individuals of each secondary species per acre of wetland. At least 48 hours prior to planting, the wetland should be drained; within 24 hours after planting, it should be re-flooded.

The wetland design should include a buffer to separate the wetland from surrounding land. Buffers may alleviate some potential ■ wetland nuisances, such as accumulated floatables or odors. MWCOG recommends a buffer of 8 meters (25 .feet) from the maximum water surface elevation, plus an additional 8 meters (25 feet) when wildlife habitat is of concern. Leaving trees undisturbed in the buffer zone will minimize the disruption to wildlife and reduce the chance for invasion of nuisance vegetation such as cattails and primrose willow. If tree removal is necessary, the buffer area should be reforested. Reforestation also discourages the settlement of geese, which prefer open areas.

PERFORMANCE

Wetlands remove pollutants from storm water through physical, chemical, and biological processes. Chemical and physical assimilation mechanisms include sedimentation, adsorption, filtration, and volatilization.

Sedimentation is the primary removal mechanism for pollutants such as suspended solids, particulate nitrogen, and heavy metals. Particulate settling is influenced by the velocity of the runoff through the wetland, the particle size, and turbulence. Sedimentation can be maximized by creating sheet flow conditions, slowing the velocities through the wetland, and providing morphology and vegetation conducive to settling. The vegetation and its root system will also decrease the resuspension of settled particles.

Some pollutants, including metals, phosphorus, and some hydrocarbons, are removed by adsorption- the process whereby pollutants attach to surfaces of suspended or settled sediments and vegetation. For this removal process to occur, adequate contact time between the surface and pollutant must be provided in the design of the system.

Wetland plants filter trash, debris, and other floatables. Particulates (e.g., settleable solids and colloidal solids) are also filtered mechanically as water passes through root masses. Filtration can be enhanced by slow velocities, sheet flow, and sufficient quantities of vegetation. By increasing detention and contact time and providing a surface for microbial growth, wetland plants also increase the pollutant removal achieved through sedimentation, adsorption, and microbial activity.

Volatilization plays a minor role in pollutant removal from wetlands. Pollutants such as oils and hydrocarbons can be removed from the wetland via evaporation or by aerosol formation under windy conditions.

Biological processes that occur in wetlands result in pollutant uptake by wetland plants and algae. Emergent wetland plants absorb settled nutrients and metals through their roots, creating new sites in the sediment for pollutant adsorption. During the fall the plants'above-ground parts typically die back and the plants may potentially release the nutrients and metals back into the water column (MWCOG, 1992b). Recent studies, however, indicate that most pollutants are stored in the roots of aquatic plants, rather than the stems and leaves (CWP, 1995). Additional studies are required to determine the extent of pollutant release during the fall die- back.

Microbial activity helps to remove nitrogen and organic matter from wetlands. Nitrogen is removed by nitrifying and denitrifying bacteria; aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can deplete oxygen levels in the top layer of-wetland sediments. The low oxygen levels and the decomposed organic matter help immobilize metals.

Soluble forms of phosphorus, as well as ammonia, are partially removed by planktonic or benthic algae. The algae consume the nutrients and convert them into biomass, which settles to the bottom of the wetland.

The removal effectiveness of shallow marsh and pond/wetland systems has been fairly well documented, while the amount of removal efficiency data for Extended Detention wetlands and pocket wetlands is limited. Average long-term pollutant removal rates for constructed wetlands, as a whole, are presented in Table 2 (CWP, 1997).

TABLE 2 PERFORMANCE OF STORM WATER WETLANDS

Pollutant	Removal Rate
Total Suspended Solids	67%
Total Phosphorus	49%
Total Nitrogen	28%
Organic Carbon	34%
Petroleum Hydrocarbons	87%
Cadmium	36%
Copper	41%
Lead	62%
Zinc	45%
Bacteria	77%

Source: CWP, 1997.

As shown, petroleum hydrocarbons (87%), total suspended solids (TSS) (67%), lead (62%), and bacteria (77%) have the highest removal rates. Lower removal rates have been documented for nutrients, organic carbon, and other heavy metals. The removal rates will vary with the loadings to the wetland, retention time in the BMP, and other factors such as BMP geometry, site characteristics, and monitoring methodology (CWP, 1997). Excessive pollutant loadings (e.g., suspended solids) may exceed the wetlands' removal capabilities.

In general, wetlands remove pollutants about as effectively as do conventional pond systems. Constructed storm water wetlands are more effective than natural wetlands, probably because of their intricate design and continued monitoring and maintenance (MWCOG, 1992). The wetlands' effectiveness seems to improve after the first few years of use as the vegetation becomes established and organic matter accumulates.

OPERATION AND MAINTENANCE

Well-designed and maintained wetlands can function as designed for 20 years or longer. However, wetland maintenance must actually begin during the construction phase. During construction and excavation, many constructed wetlands lose organic matter in the soils. The organic matter provides exchange sites for pollutants, and, therefore, plays an important role in pollutant removal. Replacing or adding organic matter after construction improves performance.

After the wetland has been constructed, its vegetation must be maintained on a regular basis. Maintenance requirements for constructed wetlands are particularly high while vegetation is being established (usually the first three years) (U.S. EPA, 1996). Monitoring during these first years is crucial to the future success of the wetland as a storm water BMP. Inspections should be conducted at least twice per year for the first three years and annually thereafter. Maintenance requirements may also include replacement planting, sediment removal, and possibly plant harvesting. Wetland design should include access to facilitate these maintenance activities.

Vegetative cover on embankments and spillways should be dense and healthy. Replacement planting may be required during the first several years if the original plants do not flourish. First year wetland vegetation growth at the water's edge and on the side slopes of the wetland can be protected from birds by surrounding the open water area of the wetland with wire to limit access to the vegetation. The embankment and maintenance bench should be mowed twice each year. Other areas surrounding the wetland should not require mowing. Mowing and fertilizing help promote vigorous growth of plant roots that resist erosion. Mowing also' prevents the growth of unwanted woody vegetation. Additional routine maintenance that can be conducted on the same schedule should include removal of accumulated trash from trash racks, outlet structures, and valves, as well as debris on plants that could inhibit growth.

Constructed wetlands should be inspected after major storms during the first year of establishment. The inspector should assess bank stability', erosion damage, flow channelization, and sediment accumulation within the wetland. The inspector shall also take note of species distribution/survival, damage to embankments and spillways from burrowing animals, water elevations, and outlet condition. Water elevations can be raised or lowered by adjusting the outlet's gate valve if plants are not receiving an appropriate water supply.

Accumulated sediments will gradually decrease wetland storage and performance. There are two options to mitigate the effects of accumulated sediments: either the sediments should be removed as necessary or the water level in the wetland should be raised (i.e., the outlet should be adjusted to increase discharge elevation).

The construction of a sediment forebay will decrease the accumulation of sediments within the wetland and increase the wetland's longevity. The forebay will likely require sediment to be cleaned out every three to five years. The forebay design should allow drainage so that a skid loader or backhoe can be used to remove the accumulated deposits (MWCOG, 1992). Accumulation of organic matter can be reduced by plant harvesting or seasonal drawdown to allow' organic material to oxidize (U.S. EPA, 1996).

A number of studies have been performed to determine the toxicity of pond sediments and whether they can be landfilled or land applied without having to meet hazardous waste requirements. Many studies to date have found sediments are not hazardous. However, one study showed that toxic levels of zinc had accumulated in sediment from the pretreatment pond (SFWMD, 1995). If toxic levels of metals have not accumulated in the sediment, then on-site land application of the sediments away from the shoreline will probably be the most cost-effective disposal method (no transportation costs or disposal fees are incurred). Wetlands that receive flow from a drainage area containing commercial or industrial land use and/or activities associated with hazardous waste may contain toxic levels of heavy metals in the sediments. Testing may be required for these sediments prior to land application or disposal.

COSTS

Costs incurred for storm water wetlands include those for permitting, design, construction and maintenance. Permitting costs vary depending on state and local regulations, but permitting, design, and contingency costs are estimated at 25 percent of the construction cost. Construction costs for an emergent wetland with a sediment forebay range from $65,000 to $137,500 per hectare ($26,000 to $55,000 per acre) of wetland. This includes costs for clearing and grubbing, erosion and sediment control, excavating, grading, staking, and planting. The cost for constructing the wetland depends largely upon the amount of excavation required at a site and plant selection. The cost for forested wetlands could be double that of an emergent wetland. Maintenance costs for wetlands are estimated at 2 percent per year of the construction costs (CWP, 1998).

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United States
Environmental Protection
Agency

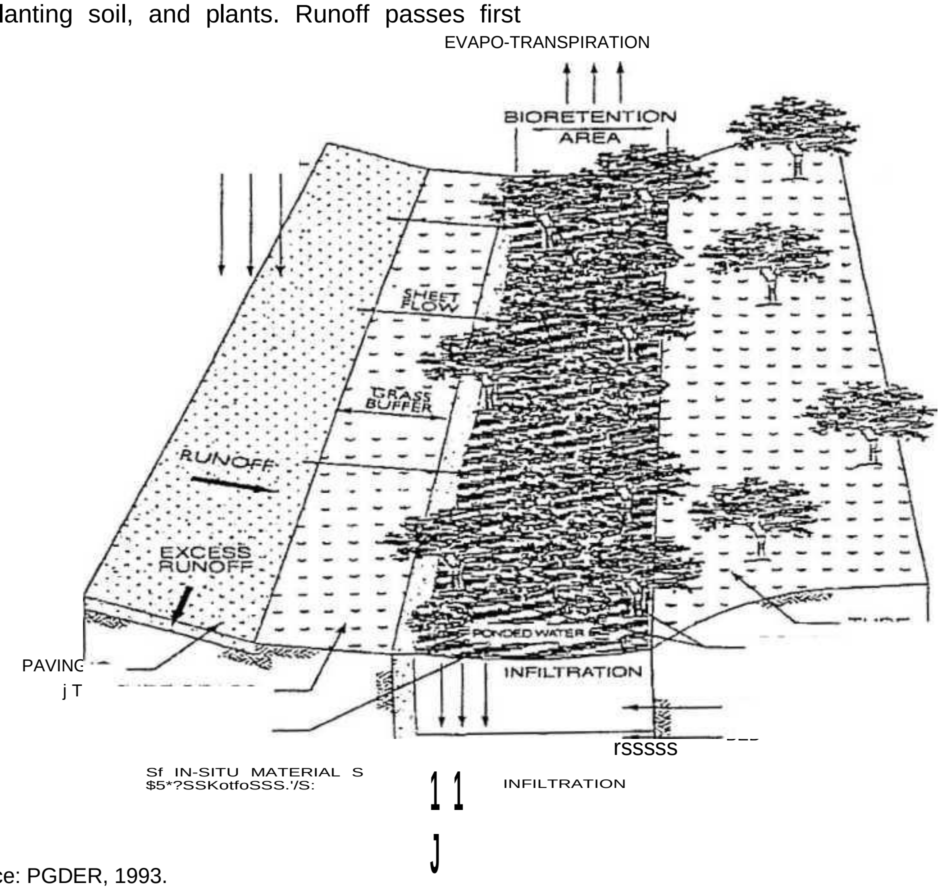
Office of Water
Washington, D.C.

EPA 832-F-S9-012
September 1999

4>EPA Storm Water Technology Fact Sheet
Bioretention

DESCRIPTION

Bioretention is a best management practice (BMP) developed in the early 1990's by the Prince George's County, MD, Department of Environmental Resources (PGDER). Bioretention utilizes soils and both woody and herbaceous plants to remove pollutants from storm water runoff. As shown in Figure 1, runoff is conveyed as sheet flow to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff passes first over or through a sand bed, which slows the runoffs velocity, distributes it evenly along the length of the ponding area, which consists of a surface organic layer and/or ground cover and the underlying planting soil. The ponding area is graded, its center depressed. Water is ponded to a depth of 15 centimeters (6 inches) and gradually infiltrates the bioretention area or is



Source: PGDER, 1993.

FIGURE 1 BIORETENTION AREA

evapotranspired. The bioretention area is graded to divert excess runoff away from itself. Stored water in the bioretention area planting soil exfiltrates over a period of days into the underlying soils.

The basic bioretention design shown in Figure 1 can be modified to accommodate more specific needs. The City of Alexandria, VA, has modified the bioretention BMP design to include an underdrain within the sand bed to collect the infiltrated water and discharge it to a downstream sewer system. This modification was required because impervious subsoils and marine clays prevented complete infiltration in the soil system. This modified design makes the bioretention area act more as a filter that discharges treated water than as an infiltration device. Design modifications are also being reviewed that will potentially include both aerobic and anaerobic zones in the treatment area. The anaerobic zone will promote denitrification.

APPLICABILITY

Bioretention typically treats storm water that has run over impervious surfaces at commercial, residential, and industrial areas. For example, bioretention is an ideal storm water management BMP for median strips, parking lot islands, and swales. These areas can be designed or modified so that runoff is either diverted directly into the biorelention area or conveyed into the bioretention area bv a curb and gutter collection system. Bioretention is usually best used upland from inlets that receive sheet flow from graded areas and at areas that will be excavated. The site must be graded in a manner that minimizes erosive conditions as sheet flow is conveyed to the treatment area, maximizing treatment effectiveness. Construction of biorelention areas is best suited to sites where grading or excavation will occur in any case so that the bioretention area can be readily incorporated into the site plan without further environmental damage. Bioretention should be used in stabilized drainage areas to minimize sediment loading in the treatment area. As with all BMPs, a maintenance plan must be developed.

Bioretention has been used as a storm water BMP since 1992. In addition to Prince George's County and Alexandria, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

ADVANTAGES AND DISADVANTAGES

Biorelention is not an appropriate BMP at locations where the water table is within 1.8 meters (6 feet) of the ground surface and where the surrounding soil stratum is unstable. In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil. The BMP is also not recommended for areas with slopes greater than 20 percent, or where mature tree removal would be required. Clogging may be a problem, particularly if the BMP receives runoff with high sediment loads.

Bioretention provides storm water treatment that enhances the quality of downstream water bodies. Runoff is temporarily stored in the BMP and released over a period of four days to the receiving water. The BMP is also able to provide shade and wind breaks, absorb noise, and improve an area's landscape.

DESIGN CRITERIA

Design details have been specified by the Prince George's County DER in a document entitled *Design Manual for the Use of Bioretention in Storm Water Management* (PGDER, 1993). The specifications were developed after extensive research on soil adsorption capacities and rates, water balance, plant pollutant removal potential, plant adsorption capacities and rates, and maintenance requirements. A case study was performed using the specifications at three commercial sites and one residential site in Prince George's County, Maryland.

Each of the components of the bioretention area is designed to perform a specific function. The grass buffer strip reduces incoming runoff velocity and filters particulates from the runoff. The sand bed also reduces the velocity', filters particulates, and spreads flow over the length of the bioretention area. Aeration and drainage of the planting soil are provided by the 0.5 meter (18 inch) deep sand bed. The ponding area provides a temporary storage location for runoff prior to its evaporation or infiltration. Some particulates not filtered out by the grass filter strip or the sand bed settle within the ponding area.

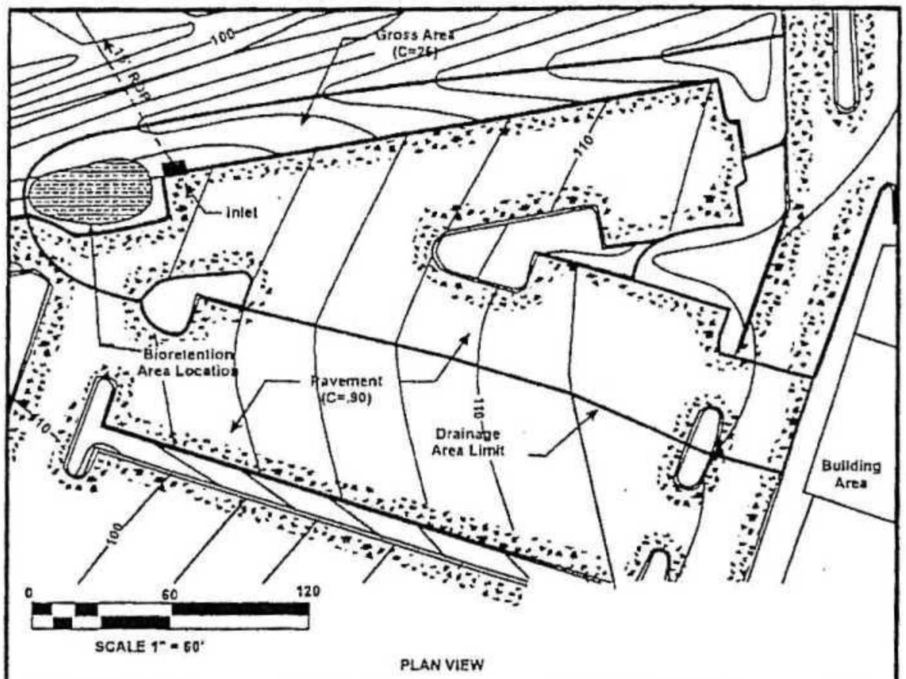
The organic or mulch layer also filters pollutants and provides an environment conducive to the growth of microorganisms, which degrade petroleum-based products and other organic material. This layer acts in a similar way to the leaf litter in a forest and prevents the erosion and drying of underlying soils. Planted ground cover reduces the potential for erosion as well, slightly more effectively than mulch. The maximum sheet flow velocity prior to erosive conditions is 0.3 meters per second (1 foot per second) for planted ground cover and 0.9 meters per second (3 feet per second) for mulch.

The clay in the planting soil provides adsorption sites for hydrocarbons, heavy metals, nutrients and other pollutants. Storm water storage is also provided by the voids in the planting soil. The stored water and nutrients in the water and soil are then available to the plants for uptake.

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered. Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil. An unstable surrounding soil stratum (e.g., Marlboro Clay) and soils with a clay content greater than 25 percent may preclude the use of bioretention, as would a site with slopes greater than 20 percent or a site with mature trees that would be removed during construction of the BMP. Bioretention can be designed to be off-line or on-line of the existing drainage system. The "first flush" of runoff is diverted to the off-line system. The first flush of runoff is the initial runoff volume that typically contains higher pollutant concentrations than those in the extended runoff period. On-line systems capture the first flush but that volume of water will likely be washed out by subsequent runoff resulting in a release of the captured pollutants. The size of the dramage area for one bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Multiple bioretention areas may be required for larger drainage areas. The maximum drainage area for one bioretention area is determined by the amount of sheet flow generated by a 10-year storm. Flows greater than 141 liters per second (5 cubic feet per second) may potentially erode stabilized areas. In Maryland, such a flow generally occurs with a 10-year storm at one-acre commercial or residential sites. The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area is a function of the drainage area and the runoff generated from the area. The size should be 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient, "c," determined for the site. The 5 percent specification applies to a bioretention area that includes a sand bed; 7 percent to an area without one. An example of sizing a facility is shown in Figure 2. For this discussion, sizing specifications are based on 1.3 to 1.8 centimeters (0.5 to 0.7 inches) of precipitation over a 6-hour period (the mean storm event for the Baltimore-Washington area), infiltrating into the bioretention area. Other areas with different mean storm events will need to account for the difference in the design of the BMP. Recommended minimum dimensions of the bioretention area are 4.6 meters (15 feet) wide by 12.2 meters (40 feet) in length. The minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established that replicates a natural forest and creates a microclimate. This enables the bioreiention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 7.6 meters (25 feet), with a length of twice the width. Any facilities wider than 6.1 meters (20 feet) should be twice as long as they are wide. This length requirement promotes the distribution of flow and decreases the chances of concentrated flow.

The maximum recommended ponding depth of the
bioretention area is 15 centimeters (6 inches). This



BIORETENTION AREA SIZING COMPUTATION

DEVELOPMENT	AREA SQ. FT.	"C" FACTOR	C X AREA
PAVEMENT	23,800	0.90	21,400
GRASS	10,100	0.25	2,500
TOTALS	33,900		23,900

BIOTENTION AREA SIZE

1. With Sand Bed (5% Sum of C x Area)
   = 05 x 23,900 = 1,195 OR SAY 1,200 sq. ft.
2. Without Sand Bed (7% Sum of C x Area)
   = 07 x 23,900 = 1,1673 OR SAY 1,700 sq. ft.

* SEE CHAPTER IV. PRINCE GEORGES COUNTYSTORMWATER MANAGEMENT MANUAL

Source: PGDER, 1993.

FIGURE 2 BIORETENTION AREA SIZING

depth provides for adequate storage and prevents water from standing for excessive periods of time. Because of some plants' water intolerance, water left to stand for longer than four days restricts the type of plants that can be used. Further, mosquitoes and other insects may start to breed if water is standing for longer than four days.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent. The soil should have infiltration rates greater than 1.25 centimeters (0.5 inches) per hour, which is typical of sandy loams, loamy sands, or loams. Silt loams and clay loams generally have rates of less than 0.68 centimeters (0.27 inches) per hour. The pH of the soil should be between 5.5 and 6.5, Within this pH range, pollutants (e.g., organic nitrogen and phosphorus) can be adsorbed by the soil and microbial activity can flourish. Other requirements for the planting soil are a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts. In addition, criteria for magnesium, phosphorus, and potassium are 39.2 kilograms per acre (35 pounds per acre), 112 kilograms per acre (100 pounds per acre), and 95.2 kilograms per acre (85 pounds per acre), respectively. Soil tests should be performed for every' 382 cubic meters (500 cubic yards) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area.

Planting soil should be 10.1 centimeters (4 inches) deeper than the bottom of the largest root ball and
1.2 meters (4 feet) altogether. This-depth will provide adequate soil for the plants' root systems to become established and prevent plant damage due to severe wind. A soil depth of 1.2 meters (4 feet) also provides adequate moisture capacity. To obtain the recommended depth, most sites will require excavation. Planting soil depths of greater than 1.2 meters (4 feet) may require additional construction practices (e.g., shoring measures). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. The bioretention area should be vegetated to resemble a terrestrial forest community ecosystem, which is dominated by understory trees (high canopy trees may be destroyed during maintenance) and has discrete soil zones as well as a mature canopy and a distinct sub-canopy of understory trees, a shrub layer, and herbaceous ground covers. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For example, a 4.6 meter (15 foot) by 12.2 meter (40 foot) bioretention area (55.75 square meters or 600 square feet) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1. On average, the trees should be spaced 3.65 meters (12 feet) apart and the shrubs should be spaced 2.4 meters (8 feet) apart. In the metropolitan Washington, D.C., area, trees and shrubs should be planted from mid-March through the end of June or from mid-September through mid-November. Planting periods in other areas of the U.S. will vary. Vegetation should be watered at the end of each day for fourteen days following its planting.

Native species that are tolerant to pollutant loads and varying wet and dry conditions should be used in the bioretention area. These species can be determined from several published sources, including *Native Trees, Shrubs, and Vines for Urban and Rural America* (Hightshoe, 1988). The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures (e.g., provide a soil breach) to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities.

The optimal placement of vegetation within the bioretention area should be evaluated by the designers. Plants should be placed at irregular intervals to replicate a natural forest. Shade and shelter from the wind will be provided to the bioretention area if the designer places the trees on the perimeter of the area. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. Species that are more tolerant to cold winds (e.g., evergreens) should be placed in windier areas of the site.

After the trees and shrubs are placed, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted during the spring of the year. Mulch should be placed immediately after trees and shrubs are planted. Five to 7.6 cm (2 to 3 inches) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion. Mulch depths should be kept below 7.6 centimeters (3 inches) because more would interfere with the cycling of carbon dioxide and oxygen between the soil and the atmosphere. The mulch should be aged for at least six months (one year is optimal), and applied uniformly over the site.

PERFORMANCE

Bioreiention removes storm water pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization. Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Therefore, the infiltration rale of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and some hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover and planting soil. The media trap particulate matter and allow water to pass through. The filtering effectiveness of the bioretention area may decrease over time. Common particulates removed from storm water include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter (e.g., petroleum). Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated.

Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

Volatilization also plays a role in pollutant removal. Pollutants such as oils and hydrocarbons can be removed from the wetland via evaporation or by aerosol formation under windy conditions. The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic storm water runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals an nutrients are shown in Table 1. As shown, the BMP removed between 93 and 98 percent of metals, between 68 and 80 percent of TKN and between 70 and S3 percent of total phosphorus. For all of the pollutants analyzed, results of the laboratory study were similar to those of field experiments. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants levels (Davis et al, 1998). For other parameters, results from the performance studies for infiltration BMPs, which are similar to bioretention, can be used to estimate bioretention's performance. These removal rates are also shown in Table 1. As shown, the BMP could potentially achieve greater than 90 percent removal rates for total suspended solids, organics, and bacteria. The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

TABLE 1 LABORATORY AND ESTIMATED BIORETENTION

Pollutant	Removal Rate
Total Phosphorus	70%-83% [1]
Metals (Cu, Zn, Pb)	93%-98%[1]
TKN	6B%-80% [1]
Total Suspended Solids	90% [2]
Organics	90% [2]
Bacteria	90% [2]

Source: [1]Davis et al. (1998)
[2]PGDER (1993)

OPERATION AND MAINTENANCE

Recommended maintenance for a bioretention area includes inspection and repair or replacement of the treatment area components. Trees and shrubs should be inspected twice per year to evaluate their health and remove any dead or severely diseased vegetation. Diseased vegetation should be treated as necessary using preventative and low-toxic measures to the extent possible. Pruning and weeding may also be necessary to maintain the treatment area’s appearance. Mulch replacement is recommended when erosion is evident or when the site begins to look unattractive. Spot mulching may be adequate when there are random void areas; however, once even,' two to three years the entire area may require mulch replacement. This should be done during the spring. The old mulch should be removed before the new mulch is distributed. Old mulch should be disposed of properly.

The application of an alkaline product, such as limestone, is recommended one to two times per year to counteract soil acidity resulting from slightly acidic precipitation and runoff. Before the limestone is applied, the soils and organic layer should be tested to determine the pH and therefore the quantity of limestone required. When levels of pollutants reach toxic levels which impair plant growth and the effectiveness of the BMP, soil replacement may be required (PGDER, 1993).

COSTS

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development. Recently- constructed 37.16 square meter (400 square foot) bioretention areas in Prince George's County, MD cost approximately S500. These units are rather small and their cost is low. The cost estimate includes the cost for excavating 0.6 to 1 meters (2 to 3 feet) and vegetating the site with 1 to 2 trees and 3 to 5 shrubs. The estimate does not include the cost for the planting soil, which increases the cost for a bioretention area. Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site m Maryland (Kettering Development) with 15 bioretention areas were estimated at $111,600.

The use of bioretention can decrease the cost for storm water conveyance systems at a site. A medical office building in Maryland was able to reduce the required amount of storm drain pipe from 243.8 meters (800 feet) to 70.1 meters (230 feet) with the use of bioretention. The drainage pipe costs were reduced by $24,000, or 50 percent of the total drainage cost for the site (PGDER.
1993). Landscaping costs that would be required at a development regardless of the installation of the bioretention area should also be considered when determining the net cost of the BMP.

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

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ADDITIONAL INFORMATION

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United States
Environmental Protection
Agency

Office of Water
Washington, D.C.

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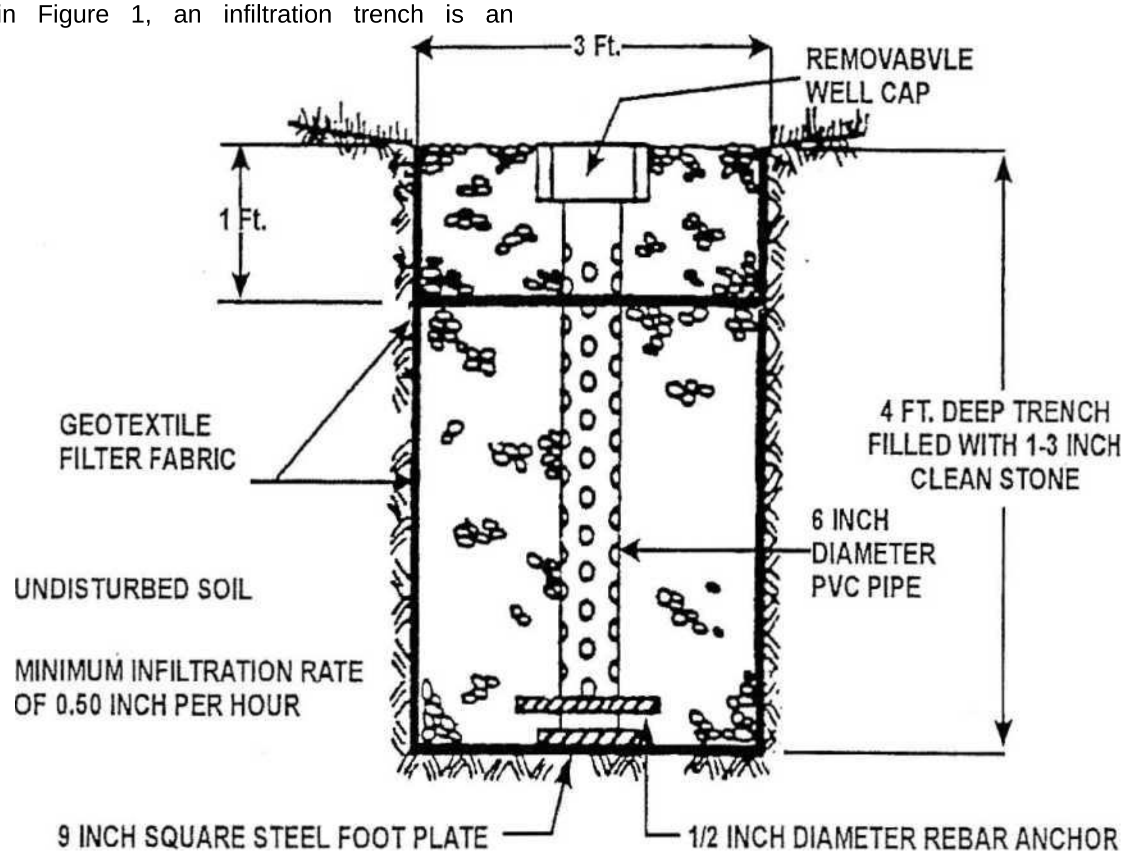
s&EPA Storm Water Technology Fact Sheet
Infiltration Trench

DESCRIPTION

Urban development is significantly increasing surface runoff and contamination of local watersheds. As a result, infiltration practices, such as infiltration trenches, are being employed to remove suspended solids, particulate pollutants,
colifonn bacteria, organics, and some soluble forms of metals and nutrients from storm water runoff. As shown in Figure 1, an infiltration trench is an excavated trench, 0.9 to 3.7 meters (3 to 12 feet) deep, backfilled with a stone aggregate, and lined with filter fabric. A small portion of the runoff, usually the first flush, is diverted to the infiltration



Source: Southeastern Wisconsin Regional Planning Commission., 1391.

FIGURE 1 TYPICAL INFILTRATION TRENCH

trench, which is located either underground or at grade. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils. Infiltration trenches also provide groundwater recharge and preserve baseflow in nearby streams.

APPLICABILITY

Infiltration trenches are often used in place of other Best Management Practices where limited land is available. Infiltration trenches are most widely used in warmer, less arid regions of the U.S. However, recent studies conducted in Maryland and New Jersey on trench performance and operation and maintenance have demonstrated the applicability of infiltration trenches in colder climates if surface icing is avoided (Lindsey, et al, 1991).

Infiltration trenches capture and treat small amounts of runoff, but do not control peak hydraulic flows. Infiltration trenches may be used in conjunction with another Best Management Practice (BMP), such as a detention pond, to provide both water quality control and peak flow control (Harrington, 1989). Figure 2 is an example of such a combined technology. This type of infiltration trench has a concentrated input, as opposed to dispersed input (as shown in Figure 1). This system stores the entire stonn water volume with the water quality (BMP) volume connected to the infiltration system. This is commonly achieved with a slow release of the storm water management volume through an orifice set at a specified level in the storage facility. As a result the BMP water quality volume will equal the storm water detention area below the orifice level which must infiltrate to exit.

Runoff that contains high levels of sediments or hydrocarbons (oil and grease) that may clog the trench are often pretreated with other BMPs. Examples of some pretreatment BMPs include grit chambers, water quality inlets, sediment traps, swales, and vegetated filter strips (SEWRPC, 1991, Harrington, 1989).

ADVANTAGES .AND DISADVANTAGES

Infiltration trenches provide efficient removal of suspended solids, particulate pollutants, coliform bacteria, organics and some soluble forms of metals and nutrients from storm water runoff. The captured runoff infiltrates the surrounding soils and increases groundwater recharge and baseflow in nearby streams.

Negative impacts include the potential for groundwater contamination and a high likelihood of early failure if not properly maintained.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not interact with the groundwater should be considered. The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench.

Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench. The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater tables. Site characteristics, such as excessive slope of the drainage area, fine-particled soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. The slope of the surrounding area should be such that the runoff is evenly distributed in sheet flow as it enters the trench unless specifically designed for concentrated input. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill. The trench should be located well above the water table so that the runoff can filter through the trench and into the surrounding soils and eventually into the groundwater. In addition, the drainage area should not convey heavy levels of sediments or hydrocarbons to the trench. For this reason, trenches serving parking lots must be preceded by appropriate pretreatment such as an oil-grit separator. This measure will make effective maintenance feasible. Generally, trenches that are constructed under parking lots must provide access for maintenance.

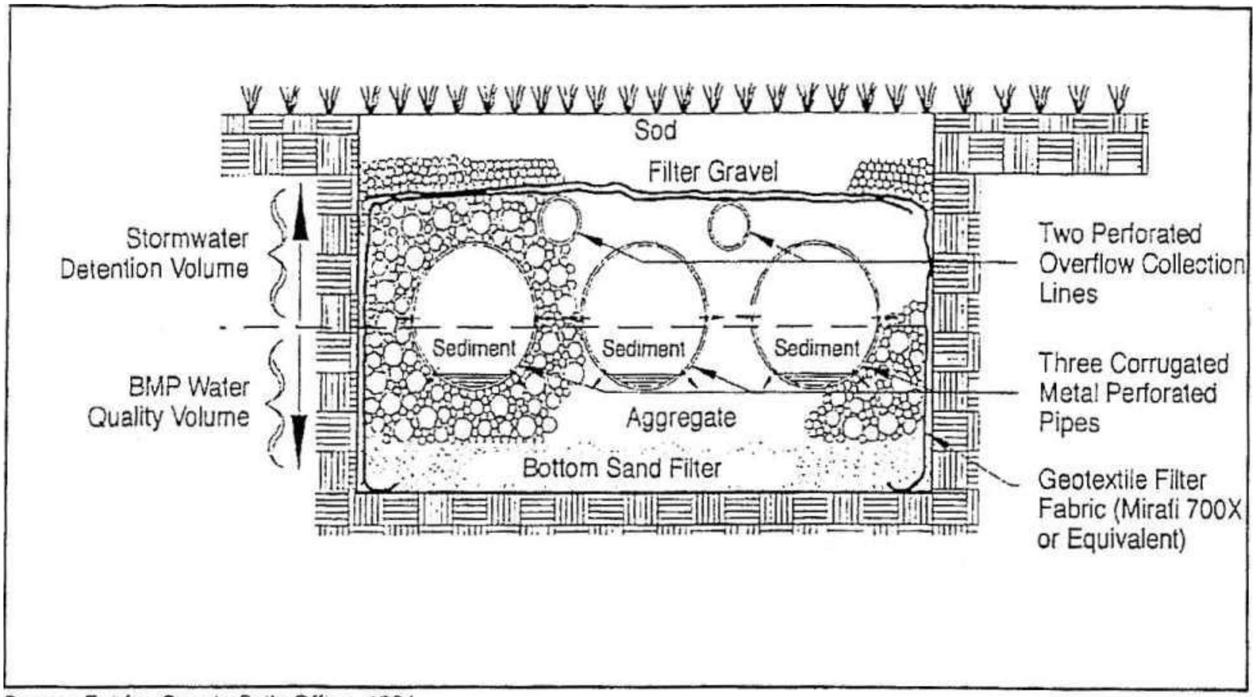
An additional limitation on use of infiltration trenches is the climate. In cold climates, the trench surface may freeze, thereby preventing the runoff from entering the trench and allowing the untreated runoff to enter surface water. The surrounding soils may also freeze, reducing infiltration into the soils and groundwater. However, recent studies indicate that if properly designed and maintained, infiltration trenches can operate effectively in colder climates. By keeping the trench surface free of compacted snow and ice, and by ensuring that part of the trench is constructed below the frost line, the performance of the infiltration trench during cold weather will be greatly improved.

Finally, there have been a number of concerns raised about the long term effectiveness of infiltration trench systems. In the past, infiltration trenches have demonstrated a relatively short life span, with over 50 percent of the systems checked having partially or completely failed after 5 years. A recent study of infiltration trenches in Maryland (Lindsey et ah, 1991) found that 53 percent were not operating as designed, 36 percent were partially or totally clogged, and another 22 percent exhibited slow filtration. Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

DESIGN CRITERIA

Prior to trench construction, a review of the design plans may be required by state and local governments. The design plans should include a geotechnical evaluation that determines the feasibility of using an infiltration trench at the site. Soils should have a low silt and clay content and have infiltration rates greater than 1.3 centimeters (0.5 inches) per hour. Acceptable soil texture classes include sand, loamy sand, sandy loam and loam. These soils are within the A or B hydrologic group. Soils in the C or D hydrologic groups should be avoided. Soil survey reports published by the Soil Conservation Sendee can be used to identify soil types and infiltration rates. However, sufficient soil borings should always be taken to verity site conditions. Feasible sites should have a minimum of 1.2 meters (4 feet) to bedrock in order to reduce excavation costs. There should also be at least 1.2 meters (4 feet) below the trench to the water table to prevent potential ground water problems. Trenches should also be located at least 30.5 meters (100 feet) upgradient from water supply wells and 30.5 meters (100 feet) from building foundations. Land availability, the depth to bedrock, and the depth to the water table will determine whether the infiltration trench is located underground or at grade. Underground trenches receive runoff through pipes or channels, whereas surface trenches collect sheet flow from the drainage area.

In general, infiltration trenches are suitable for drainage areas up to 4 hectares (10 acres) (SEWRPC, 1991, Harrington, 1989). However, when the drainage area exceeds 2 hectares (5 acres), other BMPs should be carefully considered. The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. Runoff from unstabilized areas should be diverted away from the trench into a construction BMP until vegetation is established.



Source: Fairfax County Soils Office, 1991.

FIGURE 2 INFILTRATION TRENCH WITH CONCENTRATED INPUT AND AUGMENTED PIPE STORAGE

The drainage area slope determines the velocity of the runoff and also influences the amount of pollutants entrained in the runoff. Infiltration trenches work best when the upgradient drainage area slope is less than 5 percent (SEWRPC, 1991). The downgradient slope should be no greater than 20 percent to minimize slope failure and seepage.

The trench surface may consist of stone or vegetation with inlets to evenly distribute the runoff entering the trench (SEWRPC, 1991, Harrington, 1989). Runoff can be captured by depressing the trench surface or by placing a berm at the down gradient side of the trench.

The basic infiltration trench design utilizes stone aggregate in the top of the trench to promote filtration; however, this design can be modified by substituting pea gravel for stone aggregate in the top 0.3 meter (1 foot) of the trench. The pea gravel improves sediment filtering and maximizes the pollutant removal in the top of the trench. When the modified trenches become clogged, they can generally be restored to full performance by removing and replacing only the pea gravel layer, without replacing the lower stone aggregate layers.

Infiltration trenches can also be modified by adding a layer of organic material (peat) or loam to the trench subsoil. This modification appears to enhance the removal of metals and nutrients through adsorption. The trenches are then covered with an impermeable geotextile membrane overlain with topsoil and grass (Figure 2).

A vegetated buffer strip (6.1 to 7.6 meters, or 20- 25 feet, wide) should be established adjacent to the infiltration trench to capture large sediment particles in the runoff. The buffer strip should be installed immediately after trench construction using sod instead of hydroseeding (Schueler, 1987). The buffer strip should be graded with a slope between 0.5 and 15 percent so that runoff enters the trench as sheet flow. If runoff is piped or channeled to the trench, a level spreader must be installed to create sheet flow (Harrington, 1989).

During excavation and trench construction, only light equipment such as backhoes or wheel and ladder type trenchers should be used to minimize compaction of the surrounding soils. Filter fabric should be placed around the walls and bottom of the trench and 0.3 meters (1 foot) below the trench surface. The filter fabric should overlap each side of the trench in order to cover the top of the stone aggregate layer (see Figure 1). The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate. Filter fabric that is placed 0.3 meters (1 foot) below the trench surface will maximize pollutant removal within the top layer of the trench and decrease the pollutant loading to the trench bottom, reducing frequency of maintenance.

The required trench volume can be determined by several methods. One method calculates the volume based on capture of the first flush, which is defined as the first 1.3 centimeters (0.5 inches) of runoff from the contributing drainage area (SEWRPC, 1991). The State of Maryland (MD., 1986) also recommends sizing the trench based on the first flush, but defines first flush as the first 1.3 centimeters (0.5 inches) from the contributing impervious area. The Metropolitan Washington Council of Governments (MWCOG) suggests that the trench volume be based on the first 1.3 centimeters (0.5 inches) per impervious acre or the runoff produced from a 6.4 centimeter (2.5 inch) storm. In Washington D.C., the capture of 1.3 centimeters (0.5 inches) per impervious acre accounts for 40 to 50 percent of the annual storm runoff volume. The runoff not captured by the infiltration trench should be bypassed to another BMP (Harrington, 1989) if treatment of the entire runoff from the site is desired.

Trench depths are usually between 0.9 and 3.7 meters (3 and 12 feet) (SEWRPC, 1991, Harrington, 1989). However, a depth of 2.4 meters (8 feet) is most commonly used (Schueler, 1987). A site specific trench depth can be calculated based on the soil infiltration rate, aggregate void space, and the trench storage time (Harrington, 1989). The stone aggregate used in the trench is normally 2.5 to 7.6 centimeters (1 to 3 inches) in diameter, which provides a void space of 40 percent (SEWRPC, 1991, Harrington, 1989, Schueler, 1987).

A minimum drainage time of 6 hours should be provided to ensure satisfactory pollutant removal in the infiltration trench (Schueler, 1987, SEWRPC, 1991). Although trenches may be designed to provide temporary storage of storm water, the trench should drain prior to the next storm event. The drainage time will vary by precipitation zone. In the Washington, D.C. area, infiltration trenches are designed to drain within 72 hours.

An observation well is recommended to monitor water levels in the trench. The well can be a 10.2 to 15.2 centimeter (4 to 6 inch) diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench as shown in Figure 1 above. Inadequate drainage may indicate the need for maintenance.

PERFORMANCE

Infiltration trenches function similarly to rapid infiltration systems that are used in wastewater treatment. Estimated pollutant removal efficiencies from wastewater treatment performance and modeling studies are shown in Table 1.

Based on this data, infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform-bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992).

TABLE 1 TYPICAL POLLUTANT REMOVAL EFFICIENCY

Pollutant	Typical Percent Removal Rates
Sediment	90%
Total Phosphorous	60%
Total Nitrogen	60%
Metals	90%
Bacteria	90%
Organics	90%
Biochemical Oxygen Demand	70-80%

Source: Schueler, 1992.

Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fmes before placement in the trench. The addition of organic material and loam to the trench subsoil will enhance metals and nutrient removal through adsorption.

OPERATION AND MAINTENANCE

Infiltration, as with all BMPs, must have routine inspection and maintenance designed into the life performance of the facility. Maintenance should be performed as indicated by these routine inspections. The principal maintenance objective is to prevent clogging, which may lead to trench failure. Infiltration trenches and any pretreatment BMPs should be inspected after large storm events and any accumulated debris or material removed. A more thorough inspection of the trench should be conducted at least annually. Annual inspection should include monitoring of the observation well to confirm that the trench is draining within the specified time. Trenches with filter fabric should be inspected for sediment deposits by removing a small section of the top layer. If inspection indicates that the trench is partially or completely clogged, it should be restored to its design condition.

When vegetated buffer strips are used, they should be inspected for erosion or other damage after each major storm event. The vegetated buffer strip should have healthy grass that is routinely mowed. Trash, grass clippings and other debris should be removed from the trench perimeter and should be disposed properly. Trees and other large vegetation adjacent to the trench should also be removed to prevent damage to the trench.

COSTS

Construction costs include clearing, excavation, placement of the filter fabric and stone, installation of the monitoring well, and establishment of a vegetated buffer stnp. Additional costs include planning, geotechnical evaluation, engineering and permitting. The Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991) has developed cost curves and tables for infiltration trenches based on 1989 dollars. The 1993 construction cost for a relatively large infiltration trench (i.e., 1.8 meters (6 feet) deep and 1.2 meters (4 feet) wide with a 68 cubic meter (2,400 cubic feet) volume) ranges from S8,000 to SI9,000. A smaller infiltration trench (i.e., 0.9 meters (3 feet) deep and 1.2 meters (4 feet) wide with a 34 cubic meter (1,200 cubic feet) volume) is estimated to cost from S3,000 to $8,500.

Maintenance costs include buffer strip maintenance and trench inspection and rehabilitation. SEWRPC (1991) has also developed maintenance costs for infiltration trenches. Based on the above examples, annual operation and maintenance costs would average S700 for the large trench and $325 for the small trench. Typically, annual maintenance costs are approximately 5 to 10 percent of the capital cost (Schueler, 1987). Trench rehabilitation, may be required every 5 to 15 years. Cost for rehabilitation will vary depending on site conditions and the degree of clogging. Estimated rehabilitation costs run from 15 to 20 percent of the original capital cost (SEWRPC, 1991).

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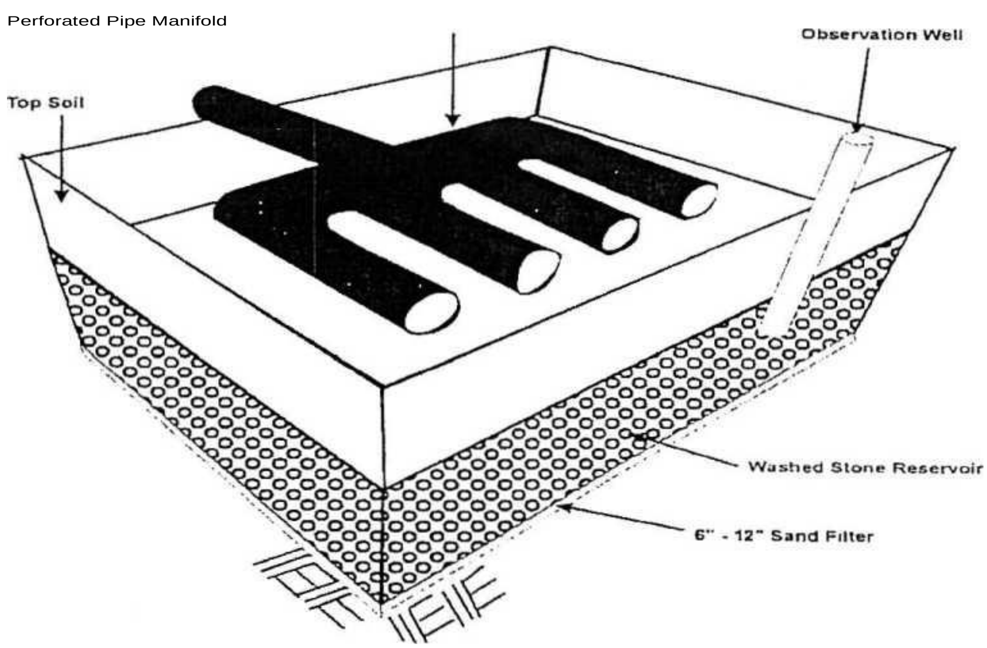
September 1S99

&EPA Storm Water
Technology Fact Sheet
Infiltration Drainfields

DESCRIPTION

Infiltration drainfields are innovative technologies that are specially designed to promote storm water infiltration into subsoils. These drainfields help to control runoff and prevent the contamination of local watersheds. The system is usually composed of a pretreatment structure, a manifold system, and a drainfield. Runoff is first diverted into a storm sewer system that passes through a pretreatment structure such as an oil and grit separator. The oil and grit chamber effectively removes coarse sediment, oils, and grease from the runoff. The storm water runoff then continues through a manifold system into the infiltration drainfield. The manifold system consists of a perforated pipe which distributes the runoff evenly throughout the infiltration drainfield. The runoff then percolates through an underlying aggregate sand filter and filter fabric into the subsoils. An example of this system is provided in Figure 1.



Source: Metropolitan Washington Council of Governments, 1987.

FIGURE 1 TYPICAL INFILTRATION DRAINFIELD SCHEMATIC

Common design modifications to the infiltration drainfieldbest management practice (BMP) include the installation of porous pavement surrounded by a grass filter strip over the infiltration drainfield or the insertion of an emergency overflow pipe in the oil and grit pretreatment chamber. The overflow pipe allows runoff volumes exceeding design capacities to discharge directly to a trunk storm sewer system.

APPLICABILITY

Infiltration drainfields are most applicable on sites with a relatively small drainage area (less than 15 acres.) They can be used to control runoff from parking lots, rooftops, impervious storage areas, or other land uses. Infiltration drainfields should not be used in locations that receive a large sediment load that could clog the pretreatment system, which in turn would plug the infiltration drainfield and reduce its effectiveness.

Soils in areas where the installation of an infiltration drainfield is being considered should have field-verified permeability rates of greater than 0.5 inches per hour and should include a 4-foot minimum clearance between the bottom of the system and the bedrock or the water table.

ADVANTAGES AND DISADVANTAGES

The use of infiltration drainfields may be restricted in regions with colder climates, arid regions, regions with high wind erosion rates (because of increased windblown sediment loads), and areas of sole source aquifers. Some specific limitations of infiltration drainfields include:

- High maintenance when sediment loads to the drainfield are heavy.

» High costs of engineering design, excavation, fill material, and pretreatment systems.

Short life span if not well maintained.

Not suitable for use in regions with clay or silty soils.

- Not suitable for use in regions where groundwater is used locally for human consumption.

- Anaerobic conditions that could clog the soil and reduce the capacity and performance of the system may develop in underlying soils if there is not sufficient time between storm events to allow the soil to dry out.

One potential negative impact of infiltration drainfields is the risk of groundwater contamination. Studies to date do not indicate that this is a major risk if site suitability guidelines are observed. However, migration of nitrates and chlorides from the drainfield has been documented.

Additional questions regarding infiltration drainfields remain to be answered:

- Is the oil and grit separator the most effective pretreatment system to protect infiltration capacity'?

- What are the pollutant removal capacities of infiltration drainfields with various pretreatment systems?

- Is the performance of infiltration drainfields better than the performance of infiltration basins and trenches during subfreezing weather and snow melt runoff conditions?

- What level of maintenance is required to ensure proper performance?

DESIGN CRITERIA

Infiltration drainfields, along with most other infiltration BMP structures (infiltration trenches, basins, etc.) have proved to have short life spans in the past. Failure of the systems has been attributed to poor design, inadequate construction techniques, low permeability' soils, and a lack of pretreatment. Some design factors which could significantly increase the longevity of infiltration drainfields and other infiltration processes are shown in Table 1.

TABLE 1 INFILTRATION DRAINFIELD DESIGN CRITERIA

Design Criteria	Guidelines
Sile Evaluation	Take soil borings to a depth of at least 4 feet below bottom of stone reservoir to check for soil permeability, porosity, depth to seasonally high water table, and depth to bedrock. Not recommended on slopes greater than 5 percent and best when slopes are as flat as possible. Minimum infiltration rate 3 feel below bottom of stone reservoir. 0.5 inches per hour. Minimum depth to bedrock and seasonally high water table: 4 feet. Minimum setback from building foundations: 10 feet downgradient, 100 feet upgradient. Drainage area should be less than 15 acres.
Design Storm Storage Volume	Literature values suggest this parameter is highly variable and dependent upon regulatory requirements. One typically recommended storage volume is the stormwater runoff volume produced in the tributary watershed by the 6- month, 24-hour duration storm event.
Drainage Time for Design Storm	Minimum: 12 hours. Maximum: 72 hours. Recommended: 24 hours.
Construction	Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction. As needed, divert stormwater runoff away from site before and during construction. A typical infiltration cross-section consists of the following : 1) a stone reservoir consisting of coarse 1.5 to 3-inch diameter stone (washed): 2) 6 to 12-inch sand filter at the bottom of the drainfield; and 3) filter fabric.
Pretrealment	Prelreatment is recommended to treat runoff from all contributing areas.
Dispersion Manifold	A dispersion manifold should be placed in the upper portions of the infiltration drainfield. The purpose of this manifold is to evenly distribute storm water runoff over the largest possible area. Two to four manifold extension pipes are recommended for most typical infiltration drainfield applications.

Source: Minnesota Pollution Control Agency, 1989.

PERFORMANCE

The effectiveness of infiltration drainfields depends upon their design. When runoff enters the drainfield, 100 percent of the pollutants are prevented from entering surface water. Any water that bypasses the pretreatment system and drainfield will not be treated. Pollutant removal mechanisms include absorption and adsorption, straining, microbial decomposition in the soil below the drainfield, and trapping of sediment, grit, and oil in the pretreatment chamber.

Currently there is little monitoring data on the performance of infiltration drainfields. However, some monitoring data is available on porous pavements. The design criteria for porous pavements is very similar to the design criteria of infiltration drainfields. An estimate of porous pavement pollutant removal efficiencies ranges between 82 and 95 percent for sediment, 65 percent for total phosphorus, and 80 to 85 percent for total nitrogen. Porous pavement works most effectively for about 6 months.

Some key factors to increase pollutant removal efficiencies include:

- Properly maintaining the system.
- Implementing good housekeeping practices in the tributary drainage area.
- Allowing sufficient drying time (approximately 24 hours) between storm events.
- Choosing a site with highly permeable soils and subsoils.
- Incorporating a pretreatment system.

- Ensuring that there is sufficient organic matter in subsoils.

- Using a sand layer on top of a filter fabric at the bottom of the drainfield.

OPERATION AND MAINTENANCE

Routine maintenance of infiltration drainfields is extremely important. The pretreatment grit chamber should be checked at least four times per year and after major storm events. Sediment should be cleaned out when the sediment depletes more than 10 percent ofthe available infiltration capacity. This can be done manually or by vacuum pump. Inlet and outlet pipes should also be inspected at this time.

The infiltration drainfield should contain an observation well that can provide information on how well the system is operating. It is recommended that the observation well be monitored daily after runoff-producing storm events. If the infiltration drainfield does not drain after three days, it usually means that the drainfield is clogged. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to a monthly or quarterly basis.

COSTS

There is little information on the cost of infiltration drainfields. However, the construction costs for installing an infiltration drainfield that is 30.5 meters (100 feet) long, 15 meters (50 feet) wide, 2.4 meters (8 feet) deep and with 1.2 meters (4 feet) of cover can be estimated using the general information in Table 2.

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TABLE 2 ESTIMATED COST FOR INSTALLING AN INFILTRATION DRA1NFIELD

Excavation Costs: 2,220 yd^3 @ \$5.00/yd^2	\$11,100
Stone Fill: (1,296 yd^3)(\$20.00/yd^3)	\$25,920
Sand Fill: (185 yd^3)(\$10.00/yd^3)	S1.850
Filter Fabric: Top and Bottom= 10,000 ft^2 Sides= 1.600 + 800= 2,400 ft^2 +10%= 13.640 ft^2 (13.640 ft^2)(1 yd^2 /9 fl^2)(\$3.00/yd^2)	\$4,550
Perforated Manifold and Inlet Pipe: 75 ft + (4){40ft)= 235 ft + 40 ft = 275 ft (275)(\$10.00/ft)	\$2,750
Observation Well: 1 at \$500 each	\$500
Pretreatmenl Chamber: 1 at \$10,000	\$10,000
Miscellaneous (back filling, overflow pipe, sodding, etc.):	\$1000
Subtotal:	\$57,670
Contingencies (engineering, administration, permits, etc.)= 25%	\$14,420
Total:	\$72,090

Note: Unit price will vary greatly depending upon local market conditions

Source: SWRPC, 1992.

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MUNICIPAL TECHNOLOGY BRANCH

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&EPA Storm Water Technology Fact Sheet Porous Pavement

DESCRIPTION

Porous pavement is a special type of pavement that allows rain and snowmelt to pass through it, thereby reducing the runoff from a site and surrounding areas. In addition, porous pavement filters some pollutants from the runoff if maintained.

There are two types of porous pavement: porous asphalt and pervious concrete. Porous asphalt pavement consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected voids to make it highly permeable to water. Pervious concrete consists of specially formulated mixtures of Portland cement, uniform, open-graded coarse aggregate, and water. Pervious concrete has enough void space to allow rapid percolation of liquids through the pavement.

The porous pavement surface is typically placed over a highly permeable layer of open-graded gravel and crushed stone. The void spaces in the aggregate layers act as a storage reservoir for runoff. A filter fabric is placed beneath the gravel and stone layers to screen out fine soil particles. Figure 3 illustrates a common porous asphalt pavement installation.

Two common modifications made in designing porous pavement systems are (1) varying the amount of storage in the stone reservoir beneath the pavement and (2) adding perforated pipes near the top of the reservoir to discharge excess storm water after the reservoir has been filled.

Some municipalities have also added storm water reservoirs (in addition to stone reservoirs) beneath the pavement. These reservoirs should be designed to accommodate runoff from a design storm and should provide for infiltration through the underlying subsoil.

APPLICABILITY

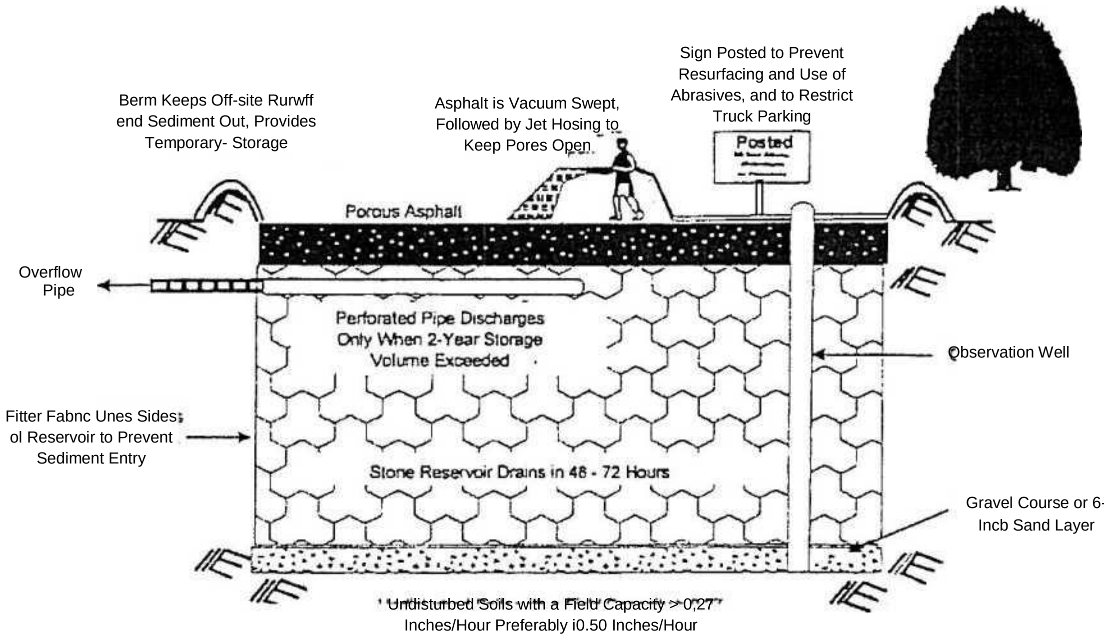
Porous pavement may substitute for conventional pavement on parking areas, areas with light traffic, and the shoulders of airport taxiways a runways, provided that the grades, subsoils, drainage characteristics, and groundwater conditions are suitable. Slopes should be flat or very gentle. Soils should have field-verified permeability rates of greater than 1.3 centimeters (0.5 inches) per hour, and there should be a 1.2 meter (4-foot) minimum clearance from the bottom of the system to bedrock or the water table.

ADVANTAGES AND DISADVANTAGES The

advantages of using porous pavement include:

- Water treatment by pollutant removal.
- Less need for curbing and storm sewers.
- Improved road safety because of better skid resistance.
- Recharge to local aquifers.

The use of porous pavement may be restricted in cold regions, arid regions or regions with high wind erosion rates, and areas of sole-source aquifers. The use of porous pavement is highly constrained, requiring deep permeable soils, restricted traffic, and adjacent land uses. Some specific



Source: Modified from MWCOG, 1987,

FIGURE 1 TYPICAL POROUS PAVEMENT INSTALLATION

disadvantages of porous pavement include the following:

- Many pavement engineers and contractors lack expertise with this technology.
- Porous pavement has a tendency to become clogged if improperly installed or maintained.
- Porous pavement has a high rate of failure.
- There is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility.
- Fuel may leak from vehicles and toxic chemicals may leach from asphalt and/or binder surface. Porous pavement systems are not designed to treat these pollutants.
- Some building codes may not allow for its installation.
- Anaerobic conditions may develop in underlying soils if the soils are unable to dry out between storm events. This may impede microbiological decomposition.

As noted above, the use of porous pavement does create risk of groundwater contamination. Pollutants that are not easily trapped, adsorbed, or reduced, such as nitrates and chlorides, may continue to move through the soil profile and into the groundwater, possibly contaminating drinking water supplies. Therefore, until more scientific data is available, it is not advisable to construct porous pavement near groundwater drinking supplies.

In addition to these documented pros and cons of porous pavements, several questions remain regarding their use. These include:

- Whether porous pavement can maintain its porosity over a long period of time, particularly with resurfacing needs and snow removal.
- Whether porous pavement remains capable of removing pollutants after subfreezing weather and snow removal.
- The cost of maintenance and rehabilitation options for restoration of porosity.'

DESIGN CRITERIA

Porous pavement - along with other infiltration technologies like infiltration basins and trenches - have demonstrated a short life span. Failures generally have been attributed to poor design, poor construction techniques, subsoils with low permeability, and lack of adequate preventive maintenance. Key design factors that can increase the performance and reduce the risk of failure of porous pavements (and other infiltration technologies) include:

- Site conditions;
- Construction materials; and
- Installation methods.

These factors are discussed further in Table 1.

PERFORMANCE

Porous pavement pollutant removal mechanisms include absorption, straining, and microbiological decomposition in the soil. An estimate of porous pavement pollutant removal efficiency is provided by two long-term monitoring studies conducted in Rockville, MD, and Prince William. VA. These studies indicate removal efficiencies of between 82 and 95 percent for sediment, 65 percent for total phosphorus, and between 80 and 85 percent of total nitrogen. The Rockville, MD, site also indicated high removal rates for zinc, lead, and chemical oxygen demand. Some key factors to increase pollutant removal include:

- Routine vacuum sweeping and high pressure washing (with proper disposal of removed material).
- Drainage time of at least 24 hours.
- Highly permeable soils.
- Pretreatment of runoff from site.
- Organic matter in subsoils.
- Clean-washed aggregate.

Traditionally, porous pavement sites have had a high failure rate - approximately 75 percent. Failure has been attributed to poor design, inadequate construction techniques, soils with low permeability, heavy vehicular traffic, and resurfacing with nonporous pavement materials. Factors enhancing longevity include:

- Vacuum sweeping and high-pressure washing.
- Use in low-intensity parking areas.
- Restrictions on use by heavy vehicles.
- Limited use of de-icing chemicals and sand.
- - Resurfacing.
- Inspection and enforcement of specifications during construction.
- Pretreatment of runoff from offsite.
- Implementation of a stringent sediment control plan.

OPERATION AND MAINTENANCE

Porous pavements need to be maintained. Maintenance should include vacuum sweeping at least four times a year (with proper disposal of

TABLE 1 DESIGN CRITERIA FOR POROUS PAVEMENTS

Design **Criterion**	**Guidelines**
Site Evaluation	• Take soil boring to a depth of at least 1.2 meters (4 feet) below bottom of stone reservoir to check tor soil permeability, porosity, depth of seasonally high water table, and depth to bedrock. • Not recommended on slopes greater than 5 percent and best with slopes as flat as possible. • Minimum infiltration rate 0.9 meters (3 feet) below bottom of stone reservoir: 1.3 centimeters (0.5 inches) per hour. • Minimum depth to bedrock and seasonally high water table: 1.2 meters (4 feet). • Minimum setback from water supply wells: 30 meters (100 feet). • Minimum setback from building foundations: 3 meters (10 feet) downgradient, 30 meters (100 feel) upgradient. • Not recommended in areas where wind erosion supplies significant amounts of windblown sediment. • Drainage area should be less than 6.1 hectares (15 acres).
Traffic conditions	• Use for low-volume automobile parking areas and lightly used access roads. • Avoid moderate to high traffic areas and significant truck traffic. • Avoid snow removal operations; post with signs to restrict the use of sand, salt, and other deicing chemicals typically associated with snow cleaning activities.
Design Storm Storage Volume	- Highly variable; depends upon regulatory requirements, Typically design for storm water runoff volume produced in the tributary watershed by the 6-month, 24-hour duration storm event.
Drainage Time for Design Storm	• Minimum: 12 hours. • Maximum: 72 hours. • Recommended: 24 hours.
Construction	• Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction. • As needed, divert storm water runoff away from planned pavement area before and during construction. • A typical porous pavement cross-section consists of the following layers: 1) porous asphalt course, 5-10 centimeters (2-4 inches) thick; 2) filter aggregate course; 3) reservoir course of 4-8 centimeters (1.5-3-inch) diameter stone; and 4) filter fabric.
Porous Pavement Placement	• Paving temperature: 240° - 260° F. • Minimum air temperature: 50° F. • Compact with one or two passes of a 10,000-kilogram (10-ton) roller. • Prevent any vehicular traffic on pavement for at least two days.
Pretreatment	• • Pretreatment recommended to treat runoff from off-site areas. For example, place a 7.6-meter (25-foot) wide vegetative filter strip around the perimeter of the porous pavement where drainage flows onto the pavement surface.

Source: Field, 1982.

removed material), followed by high-pressure hosing to free pores in the top layer from clogging, Potholes and cracks can be filled with patching mixes unless more than 10 percent of the surface area needs repair. Spot-clogging may be fixed by drilling 1.3 centimeter (half-inch) holes through the porous pavement layer every few feet.

The pavement should be inspected several times during the first few months following installation and annually thereafter. Annual inspections should take place after large storms, when puddles will make any clogging obvious. The condition of adjacent pretreatment devices should also be inspected.

COSTS

The costs associated with developing a porous pavement system are illustrated in Table 2,

Estimated costs for an average annual maintenance program of a porous pavement parking lot are approximately $4,942 per hectare per year ($200 per acre per year). This cost assumes four inspections each year with appropriate jet hosing and vacuum sweeping treatments.

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IV. CASE STUDY #1: THE FIELDS AT COLD HARBOR, A RURAL RESIDENTIAL CASE STUDY

The Fields at Cold Harbor is a proposed 19-unit, rural residential development in Hanover County, Virginia near the Richmond National Battlefield Park. While approximately two- thirds of the existing parcel is forested, this I20.3~acre parcel also houses an existing farm and features a farmhouse and cropland along with historic military earthworks (man-made earthen hills usually marked by wooden posts dating back to the Civil War). There is no existing stormwater management of the site, but there is a pond and two wetlands within the parcel (Figure 4.1). The entire parcel is located within a Chesapeake Bay Resource Management Area (RMA) and was recently rezoned as a Rural Conservation District (RCD).

The purpose of the RCD zone is to presen/e the rural characteristics of an area while permitting the development of these areas into low-density, single-family residential subdivisions. This consists of both residential lots and conservation areas in which existing buildings and agricultural uses are permitted. Not less than 70% of the "net acreage" must be devoted to conservation areas, which may include both preservation lots and common open space with restricted allowable uses. Preservation lots permit existing homes, stables, and agricultural uses that are not likely to generate noxious odors; natural or landscaped buffers; forests; passive/active recreational areas; facilities for utility service; and/or golf courses. Common open space may include natural or land-scaped buffers, active and passive recreation areas, common wells, forests, wildlife reservations, and agricultural uses that do not generate noxious odors or sewage sludge. "Net acreage" is defined as the total area of the site minus the total of RPAs and areas of slopes

Table 4.1: Model Development Principles Incorporated into the Design of.

Model Development Principle	IVinimizes Land Disturbance	Preserves Indigenous Vegetation	Minimizes Impervious Surface
1. Native Plant and Tree Conservation	✓	✓	
2. Minimized Clearing and Grading	✓	✓	
3. Open Space Design	✓	✓	
4. Shorter Setbacks & Frontages	✓		✓
5. Common Walkways			✓
6. Shared Driveways			✓
7. Narrower Streets	✓	✓	✓
8. Shorter Streets			✓
11. Vegetated Open Channels			✓

greater than 25%. The RCD designation aiso requires that the parcel of land be no less than 25 contiguous acres.

The RCD zoning ordinance, as well as the Virginia Department of Transportation's residential street width requirements, codify some of the design features incorporated into the proposed site. The proposed development consists of lots that range from
1,0 to 1.4 acres. Approximately 96.7 of the 120.3 acres are provided as conservation area, with 22.2 of these acres in the form of common open space. Innovative features include the use of 18-foot roads, the preservation of existing trees and historic structures, and the inclusion of a walking trail.

At the time of publication, the design of The Fields at Cold Harbor was still in its early planning stages. While it is clear that the existing and proposed sites utilize on-site sewage disposal systems with wells as the water supply source, exact specifications on house sizes, prices, or placement on the lots were not available. Several assumptions were made based on available information, including house placement and driveway layout.

The Model Development Principles in The Fields at Cold Harbor

Nine of the Model Development Principles have been incorporated in the design of The Fields at Cold Harbor (Table 4.1), While rural areas are often zoned for larger lots, The Fields at Cold Harbor illustrates the application of Model Development Principles to minimize land disturbance, reduce impervious cover, and preserve indigenous vegetation in an area that wouid typically be designated for large-iot zoning. A detailed evaluation of each principle applied in the design of The Fields at Cold Harbor follows, including a discussion of the design characteristics, an outline of local codes and ordinances that allowed or required the design characteristics, and a comparison to the status quo site design techniques.

Principle 1, Native Plant and Tree Conservation
Much of the existing forest was preserved as contiguous open area. In addition, the preservation of trees of a five-inch caliper or greater in the side and rear yards was proffered by the developer in the rezoning of the property, Tree preservation can have a substantial influence on the marketability of the site, particularly if preserved as a greenway or buffer. A few of the numerous economic benefits include increased property values, lower air conditioning costs, retention of carbon dioxide and ozone, and reduced stormwater flows and management costs (CWP, 1998).

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
Regulations under the RCD require that no less than 70% of the net acreage be devoted to conservation areas with no less than 25 contiguous acres. While indigenous plants and trees are not specifically protected by local ordinances, preserving large tracts of land allows existing vegetation to be kept intact.

A Comparison to the Status Quo Unlike the proposed development at The Fields at Cold Harbor, with many status quo subdivisions, complete clearing and grading of the site is common. In the status quo site design, none of the individual trees on lots were preserved and much more land was cleared and graded to aiiow for larger individual lots. This increased clearing and grading resulted in more impervious cover and increased infrastructure costs.

Principle 2. Minimized Clearing and Grading
Preservation of 80% of the site, along with retention of larger trees on the side and rear yards, significantly minimizes clearing and grading at The Fields at Cold Harbor. By keeping clearing and grading to a minimum, the area is aiso protected against possible increases in impervious cover and drastic changes in the rural character of the site. It also reduces the need for erosion and sediment control (ESC) measures, while increasing property values through tree and plant preservation.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
Regulations under the RCD allow only 30% of the net acreage to be cleared and graded for development, keeping most of the site preserved in its existing state. Net acreage is calculated after the steep slopes and RPAs have been deducted from the gross acreage of the site.

Table 4.3: The Influence of Walkways on Impervious Area .		
Scenario	**Total Impervious Area (square feet)**	**% of Total Site Area**
Status Quo Site Design	28,942	.6%
As-Built	24,960	.5%
Difference	3,982	**.1%**

or

strian

open

walk

required are 15 feet for the front yard, 20 feet aggregate for side yards, and 25 feet for the rear yard.

A Comparison to the Status Quo With the status quo site design, front yard setbacks were increased to 100 feet or more, requiring extended driveways to service the homes. The resulting 30% increase in driveway impervious cover in the status quo site design was primarily due to the increased front setback (see Principle 6). The houses were also placed far away from lot lines or other possible structures, which incrementally increased the street length required to service the houses.

Principle 5. Common Walkways

The proposed design of The Fields at Cold Harbor utilizes a walking trail that travels along the preserved forest, farmland, and other historic features. This trail, designed using a crushed brick material, helps divert pedestrians away from automobile traffic, provides access to recreational areas, and is much less expensive than concrete.

A Comparison to the Status Quo In the status quo design, safety concerns often lead to placement of sidewalks on both sides of the street. While safety is an important consideration, mobility, access, and service to common areas should also be considered. Tne crushed brick material used for the trail is slightly more pervious than concrete and costs about 3.5 times less than concrete. Despite the increased square footage of the longer trail path as compared to sidewalks on both sides of the street, the cost was still three times less for the crushed brick trail than for concrete sidewalks along both sides of the entire street length. Table 4.3 summarizes the influence of walkways on impervious area between the case study and the status quo site design.

Principle 6, Shared Driveways

Based on the layout of the proposed septic fields, the use of two common driveways serving two houses each was assumed. This reduced the amount of potential impervious cover by about a third for these four lots. While the final design could incorporate more shared driveways, only the two were assumed.

Table 4.4: The Influence of Shared Driveways and Reduced Front Setbacks onImpervious Area		
Scenario	**Total Impervious Area (square feet)**	**% of Total Site Area**
Status Quo Site Design	35,524	0.7%
As-Buiil	25,164	0.5%
Difference	10,360	0.2%

\ Table 46: The Influence of Vegetated Open Channels on Inpenrious Area*

Scenario	Street Width (feet)	Total Impervious Area (square feet)	% of Total Site Area
Status Quo Site Ctesign	28	93,000	1.9%
As-Built	18	34,200	0.7%
Difference	10	64,800	1*2%*

* \Mrile VDOT regulations allcwvthe use of open vegetated channels with narrower streets, the biggest benefits of vegetated open channels are reduced stormwater runoff and decreased nutrient loads

c

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
While stormwater management is not required for The Fields at Cold Harbor, it is recognized as a design alternative. According to VDOT, they will be responsible for maintenance of drainage systems that fall within the dedicated right-of-way, but the system must be a "natural watercourse/' as opposed to a swale. In addition, for an area with up to 250 ADT, pavement width for open section roads can be a minimum of 18 feet, but with curb and gutter, residential road width must be a minimum of 28 feet.

A Comparison to the Status Quo With the status quo site design of The Fields at Cold Harbor, the use of curb and gutters was assumed. Curb and gutters can increase construction costs and do not allow for the infiltration of stormwater runoff that vegetated open channels can provide. In addition, according to VDOT, curb and gutters require a minimum street width of 28 feet, which increases the amount of impervious cover. Table 4.6 compares the influence of vegetated open channels on impervious areas. It is important to note that while re-duced impervious cover is a benefit of vegetated open channels in Virginia, reduced stormwater runoff and decreased nutrient loads are two of the biggest benefits of vegetated open channels.

Conclusion

The Fields at Cold Harbor sharply contrasts with the typical rural residential development seen throughout Virginia and elsewhere. New rural residential development is often characterized by large-lot sub-divisions with wide roads, large cul-de-sacs, and ample setbacks and frontages. Table 4.7 summa

pre-developed site, the status quo site design, and the case study site.

Due to the existing structures, the parcel was 3.3% impervious prior to development. The case study design has an impervious level of 7.4%, whereas the status quo site design resulted in slightly more imperviousness at 8.3%, primarily due to the increased width and length of streets and the inclusion of paved sidewalks.

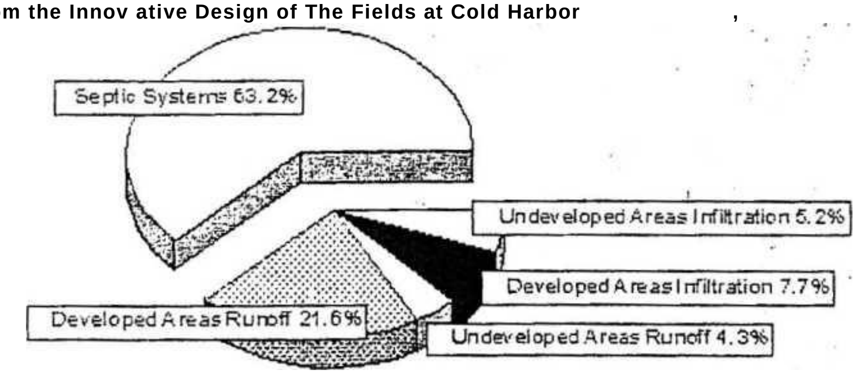
The increased imperviousness in the status quo site (design results in more annual stormwater runoff and nutrient loading from the site than in the case study design scenario. The status quo site design also results in a 6.4% higher infiltration rate. The difference was not as significant as in the other case studies, primarily due to preservation of a cultivated field. Cultivated fields have a lower infiltration factor than forest and wetlands, meadows, and lawn and landscaped areas.

Nitrogen and phosphorous loads increase dramatically with development, and The Fields at Cold Harbor was no exception. With the status quo site design, nitrogen loads more than doubled and phosphorous loads increased by about 81% as compared to pre-developed conditions. While the increase in nutrient ioads for the innovative site were not quite as high as the status quo site design, nitrogen loads were still 77% higher and phosphorous loads were 55% higher than pre-development rates. These calculations were computed without septic loads, which can further increase nutrient loading significantly. The impacts of septic loads are discussed in Box 4.1 on page 23, which details the influence of septic systems on nutrient loading on residential sites.

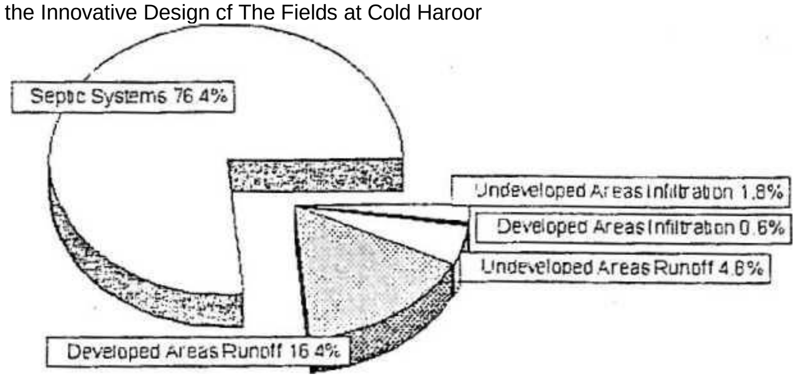
Box 4.1: Nutrient Loading from Residential Septic Systems

Septic systems are often the single largest source of nitrogen and phosphorous output on rural residential sites where better site design techniques can only reduce the relatively small stormwater load. While failing septic systems can be a significant source of pollution to a stream, even properly functioning septic systems still remain the largest source of nutrient loading. The pie charts below show the sources of nitrogen and phosphorous loads for The Fields at Cold Harbor and the percentage that septic systems would contribute if they had been included in the site's nutrient loading calculations, £

Nitrogen Output from the Innov ative Design of The Fields at Cold Harbor



Phosphorous Output from the Innovative Design cf The Fields at Cold Haroor



Tnere are several alternatives to the conventional septic system capable of reducing pollutants that are | not effectively treated by conventional systems and rely less on ideal site conditions to function. Most ’ of these alternatives follow the basic design with certain modifications. One example is the recirculat- ■ ing sand filter which pumps waste water through a PVC pipe into a sand filter. The flow percolates | through the soil where 75% of the effluent recirculates back to mix with anaerobic wastewater, result- j ing in increased denitrification, where maximum nutrient removal is a goal for rural development,] careful selection of septic systems alternatives should be considered. |

V. CASE STUDY #2: WHITTAKER ISLAND AT GOVERNOR'S LAND, A MEDIUM-DENSITY RESIDENTIAL CASE STUDY

Figure 5.1: Whittaker Island is bordered by conserved forest and wetland areas and the James River to the south.

Whittaker Island is a 122.6 acre section within the medium-density residential subdivision of Governor's Land, a planned residential development in James City County, Virginia. Governor's Land covers 1,482 acres on a peninsula bordered by the James and Chickahominy Psivers, just a few miles from Jamestown and Williamsburg. Designed and developed through the 1980s and early 1990s, the site includes 734 homes, conservation areas, a golf course, a marina, and community recreational facilities. Homes border water, tidal marshlands, golf course fairways, meadowland, or mature forests. Approximately 70% of Governor's Land consists of permanent open space and conservation areas. Much of the design and development of Governor's Land predates the Chesapeake Bay Preservation Act. However, lots recorded after September 30, 1989 are subject to the requirements of the *Chesapeake Bay Preservation Area Designation and Management Regulations.*

Development within Governor's Land consists of several smaller residential "pods," including Whittaker Island (Figure 5.2). Whittaker Island, bordering the James River, employs several of the Model Development Principles typical of a well-designed open space subdivision (Table 5.1). Whittaker Island features 82 one- third to one and three-quarter acre lots on public water and sewer, bordered by conserved forest and wetland areas to the east and south (Figure 5.1), and a golf course fairway to the west. Instead of sidewalks, trails run through the common open space areas. In one location, a 10-foot wide paved bike trail connects Whittaker Island to the adjacent residential pod (Figure 5.3). The project incorporates relatively

Table 5.1: Model Development Principles Incorporated Into the Design of Whittaker Island

Model Development Principle		Minimizes Land Disturbance	Preserves Indigenous Vegetation	Minimizes Impervious Surface
1.	Native Plant & Tree Conservation	✓	✓	
2.	Minimized Clearing & Grading	✓	✓	
3.	Open Space Design	✓		
4.	Shorter Setbacks & Frontages	✓	✓	✓
5.	Com mon Walkways			✓
7.	Narrower Streets	✓	✓	✓
10.	Smaller & Landscaped Culnde-Sacs			✓

Figure 5.3: A 10-foot paved bike trail connects Whittaker Island to the adjacent residential pod.

narrow streets and alternatives to the conventional cul-de sac. A 100-foot wetland buffer [which would now be designated as a Resource Protection Area (RPA)] runs along the back of several lots bordering the wetland preservation area. Clearing and grading by individual lot owners is prohibited within this zone.

When examining the unique design characteristics of Whittaker Island, it is important to do so in the context of the rules under which it was developed. The parcel was rezoned within James City County's Residential Planned Community District (R-4) zone in 1989. As part of the rezoning, wetland protection and trail and bikepath amenities were proffered by the developer. The R-4 zone provides the design flexibility for this type of planned residential community, which utilizes small lot sizes in exchange for larger open space areas. These communities are dominated by residential land uses and open space, but can also contain active recreation centers, fire stations, schools, and retail establishments that help make the community somewhat self-sufficient. An important feature of the development plan is the emphasis on site planning and the retention of large, open areas.

While Whittaker Island demonstrates several of the Model Development Principles, applying additional design techniques may have further reduced impervious cover along with the resultant stormwater runoff and nutrient loading. For instance, the average lot size is just over half an acre. Reducing this area may have allowed for greater preservation of contiguous open space in the uplands as well as in the forested wetland areas. The incorporation of shared driveways may have also contributed to a decrease in impervious coverage. More advanced stormwater management implementation would have certainly contributed to additional nutrient reduction.

The Model Development Principles in Whittaker Island

Whittaker Island employs seven of the Model Development Principles, even though it was planned in large part in the late eighties (Table 5.1). As a medium-density project, the application of open space design techniques, coupled with good planning and reduced street width and setback requirements, afforded many opportunities to minimize clearing and grading, preserve natural vegetation, and minimize impervious cover.

Principle 1. Native Plant and Tree Conservation

The design of Whittaker Island preserved 60.5 acres, or approximately 49% of the site, as conserved forest and wetlands areas consisting of large contiguous land adjacent to the James River plus some common open spaces throughout the residential lots (the golf course fairway was excluded from these computations). This area is covered by a permanent conservation easement managed by a local land conservation trust. For lots that border on wetlands, the 100-foot buffer (again, what would now be considered an RPA) also serves as the clearing limit, thereby preserving some vegetation on private lots.

The conservation of native plants and trees goes hand-in-hand with an overall open space design objective. The individual smaller lots allow for more common open space and consequently less pressure on existing natural features. Conserving trees also makes economic sense by reducing clearing and grading costs while increasing market values. In fact, a study of 14 variables that might influence the price of suburban homes in Manchester, Connecticut and Greece, New York found that trees ranked sixth in influencing the selling price. Trees on individual lots increased sales prices by 5 to 15% (National Arbor Day Foundation, 1996). Other documented economic benefits of trees include reduced air conditioning costs, increased retention of carbon diox-

to approximately 62% for the status quo site design.

Principle 3, Open Space Design
The success of applying the previous two principles to Whittaker Island, or any other subdivision for that matter, is largely contingent on the planner's ability to leave large portions of the site as dedicated open space. The key to providing open space in developments are the provisions that allow smaller lots, narrower streets and rights-of way, smaller cul-de-sacs, and to a lesser extent, smaller setback requirements. All of these provisions were incorporated into the design at Whittaker Island.

As stated previously, the as-built lots in Whittaker Island range in size from a third of an acre to nearly one and three-quarters of an acre. The average lot size is affproximately 0.63 acres. Houses are close to the street and each other, allowing for more preservation of community open space.

Some worry that the smaller lots of open space designs are not marketable, or that property values are less for these types of projects. However, the reality is that many independent studies have found that open space designs are highly desirable and have economic advantages that include cost savings and higher market appreciation (Arendt, *etal.,* 1994; Ewing, 1996; NAHB, 1997; ULI, 1992; Porter, *etal.,* 1988). In fact, a recent survey of new home buyers conducted by American Lives, Inc. noted that 77% of the respondents rated natural open space as extremely important (Fletcher, 1997). Whittaker Island is dearly a desirable place to live and there is no evidence that the smaller lot sizes limited initial sales, property value appreciation, or resale value.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
As stated previously, Whittaker Island was developed under the Planned Residential Community District (R-4) zone. One key provision of the R-4 zone allows for the establishment of minimum lot sizes and setbacks with the design and approval of the development plan. This is a common provision of many planned development zones that go by different names such as "planned neighborhood developments" (PNDs) or "planned unit developments" (PUDs).

A Comparison to the Status Quo Again, many jurisdictions have strict zoning provisions that dictate minimum lot size, the size of setbacks and frontage distances, and the width of street rights-of-way, all of which contribute to the overall size of the net imprint of the developed portion of the site. In comparing Whittaker Island to its status quo site design counterpart it is assumed that the minimum lot size is half an acre, the number of lots maintained is 82, and setbacks are increased to 40 feet for the front yard and 12 feet for side yards. The Whittaker Island site design as-built provides approximately 51% of the site as open space, whereas the status quo site design option retains only 42% of the project in dedicated open space.

Table 5.3: Influence of Front Setback Requirements on Total Site Area and Total Impervious Cover

Scenario	Setback ,	Total Site Area Consumed		Total Impervious Area (acres)
		Area (acres)	% of Total Site	
Status Quo Site Design	40'	11.12	9.1%	1.27
As-Built	25‘	6.29	5.1%	0.96
Difference	15'	4.83	11.8%	0.31

Table 5.4: Influence of Common Walkways on Total Impervious Cover

Scenario	Total Sidewalk Area (acres)	% of Total Site
Status Quo Site Design	1.66	1.4%
As-Built	0	0%
Difference	1.66	1.4%

hides per day, and on one side of all roads expected to serve more than 1,000 vehicles per day. The planning commission may modify this requirement if equivalent facilities have been provided that adequately provide for pedestrian-access within the development and to abutting property, as is the case in Whittaker Island.

A Comparison to the Status Quo Sidewalks contribute to a small but measurable fraction of a site's total impervious cover. In Whittaker Island, while there is impervious cover associated with the 10-foot wide bikepath leading to the neighboring section of Governor's Land, it is not considered to be within the limits of the site. In contrast, the status quo site design with five-foot wide sidewalks on both sides of the street adds over 70,000 square feet of impervious cover (Table 5.4).

Principle 7. Narrower Streets

Whittaker Island employs closed-section roads ranging from 12-foot wide private drives (Figure 5.4) to a 32-foot wide collector road. The main entrance road into the section, Whittaker Island Road, consists of two 16-foot travel ways separated by a 30- foot landscaped island (Figure 5.5). As stated previously, narrower streets serve at least two environmental design objectives. First, narrower streets produce less impervious cover and less stormwater runoff than their wider counterparts. Secondly, the smaller the street width, the less area required for the right-of-way. This translates into more flexibility to provide more open space.

Narrow streets also cost less than wide streets. Assuming that asphalt paving costs about $15 per square yard, developers can easily save as much as $3 per running foot for a paving width reduction of five feet. Moreover, this doesn't include the potential additional economic benefits of reduced clearing and grading costs; reduced water, sewer and storm drainage costs; reduced stormwater management costs; and equally important, reduced municipal

Figure 5.6: Instead of a traditional cul-de-sac, West Whittaker Close is a loop-de-lane —a road with a 16-foot one-way travel lane and a 90-foot central landscaped area.

maintenance costs for snow removal, street sweeping, or paving repair.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

The Virginia Department of Transportation's standard for a closed-section road less than half a mile long and with under 250 average daily trips is 28 feet. In addition, VDOT approved street width reductions for some streets in Whittaker Island.

A Comparison to the Status Quo Many communities require residential streets to be up to 36 feet wide, even when they serve developments that produce small volumes of traffic. In Whittaker Island as-built, street widths are considerably narrower than this value and make up approximately 4.9 acres of impervious area. In contrast, the status quo site design is assumed to have 34-foot wide streets covering over 5.8 acres of the site. This increased imperviousness translates into increased stormwater runoff and, consequently, increased nutrient loading (see Table 5.6).

Principle 10. Smaller & Landscaped Cul-de-Sacs

Instead of traditional cul-de-sacs, Whittaker island

Table 5.5: Influence of Cul-de-Sac Size on Total Impervious Cover

Scenario	Total Cul-de-Sac Area (acres)	% ofTotal Site
Status Quo Site Design	0.44	0.4%
As-Buili	0.27	0.2%
Difference	0.17	0.2%

Incorporates three non-traditional looping roads. West Whittaker Close.is a looping 16-foot-wide one-way travel lane with a 90-foot-wide central landscaped area (Figure 5.6). The three cul-de-sacs also have radii of 35 feet, which are smaller than average. Providing landscaped central areas in cul-de-sacs affords the opportunity to provide additional stormwater retention areas to help reduce stormwater runoff and nutrient loading. J] .
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Again, less asphalt means less cost. While the savings in paving will probably be offset by increased costs for stormwater management in the cul-de-sac, the net result, however, is still a savings over the traditional pipe-to-pond stormwater approach.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

Cul-de-sacs at Whittaker Island exactly meet the minimum requirements of VDOT at a 35-foot radius.

A Comparison to the Status Quo Many communities require the cul-de-sac "bulb" to be 50 to 60 feet in radius. In Whittaker Island as- built, cul-de-sacs are significantly smaller and comprise only 0.27 acres of the site (Table 5.5). In the status quo site design, cul-de-sacs having a radius of 45 feet comprise 0.44 acres . While this seems to be a modest increase, this value represents only three cul-de-sacs. The real implication is that communities containing a large number of these cul-de-sacs can expect to see significantly less impervious cover with smaller turn-arounds.

Conclusion

■In general, the use of smaller lots, smaller setbacks and narrower streets reduces the actual land disturbance area and allows for increased open space and consequently larger preservation of natural vegetation. The actual case study of Whittaker Island preserves over 62% of the original vegetation on-site, and much of this area is sensitive natural wetland and forested areas that is protected by a permanent conservation easement. In addition, common walkways, narrower streets, shorter front setbacks leading to shorter driveways, and smaller cul-de-sacs help to minimize total site impervious cover. These impervious surfaces consume about 4.8% of the total area of the actual site, but may have been as high as 7.1% had the status quo site design techniques been used instead. The remaining impervious coverage for both the as-built and status quo sites consisted of rooftops, which consumed roughly 3% of the total site area for both scenarios.

As a result of the reduced impervious cover and the increased open space, the case study design results in a lower volume of annual runoff and a higher volume of annual infiltration than the status quo site design. Reduced runoff and increased infiltration translate into decreased nutrient loading (Table 5.6). In fact, the nutrient load from Whittaker Island is reduced by approximately 17% without even considering the benefits of potential stormwater best management practices (BMPs). Other studies have shown that with the application of BMPs and better site design, nutrients can be reduced by as much as 45% for medium-density residential sites on public sewer (CWP, 1998). In addition, infrastructure costs for Whittaker Island as-built decrease from the status quo site design by nearly $260,000, or roughly 14%. Cost savings are greatest from the decreased street, driveway, and sidewalk areas. As discussed previously, while development costs are typically less for open space subdivisions, home sales prices, sales rates, and appreciation values tend to be the same or higher then those for status quo subdivisions,

On a final note, it is worth mentioning that both nitrogen and phosphorus loading increase over predevelopment loadings by a substantia! percentage for the Whittaker Island case study, even with the employment of the Mode! Development Principles described in this document. Employing' the most effective best management practices, coupled with the principles of better site design, can minimize this increase substantially. Watershed managers and plan reviewers need to ensure that both effective BMPs and the better site design principles discussed here are employed at new development sites if nutrient loading is to be kept in check.

VI. CASE STUDY #3: RIVERGATE, A REDEVELOPMENT CASE STUDY


Figure 6.1: Three-story brick townhouses line narrow, privately-owned streets.

Rivergate is a 58-unit townhouse urban "infill" development in Alexandria that applies the Model Development Principles in a high-density, open space design. In densely developed communities such as Alexandria, infill and redevelopment projects like Rivergate are much more common than "greenfield" development. There are many benefits associated with this type of development. For example, from a watershed management standpoint, development that occurs within a previously developed watershed is more desirable than in an undeveloped or lightly developed one. Redevelopment tends to concentrate density and impervious cover in. developed watersheds where infrastructure, such as sewer, water, and transportation facilities, is already in place. This helps to prevent new growth from encroaching on more distant and lightly developed watersheds. Although the Model Development Principles tend to focus on better site design for greenfield development, many of the principles are applicable to infill and redevelopment as well, and were incorporated into the design of Rivergate (Table 6.1).

Located on the banks of the Potomac River, the 4.2 acre parcel historically housed industrial facilities and was formerly the site of the Norton Rendering Plant. Prior to redevelopment, the site was vacant for several years, and site conditions consisted of the remnants of the rendering plant, a concrete slab, and gravel, with impervious cover estimated at about 95%. The soils on the site consist of fill material deposited within the last 10 years. The flag-shaped parcel is adjacent to a 0.4 acre piece of property owned by the City of Alexandria.

Developed in the early 1990s, Rivergate is an open space, high-density residential development clustered at one end of the site that retained a large portion of the parcel next to the Potomac River as parkland (Figure 6.2).

Table 6.1: Model Development PrinciplesIncorporateid Into the Design of Rivergate -				
Model Development Principle		Minimizes Land Disturbance	Preserves Indigenous Vegetation	Minimizes Impervious Surface
3.	Open Space Design	√	√	
4.	Shorter Setbacks & Frontages	√	√	√
5.	Com m on Walkways			√
7.	Narrower Streets	√	√	√
9.	Narrower Right-of-Way Widths	√	V	
12.	Reduced Parking Ratios	√	√	√
16.	Treated Parking Lot Runoff	√		

Figure 6.3: The townhouses are garage units that accommodate one or two cars.

Within the 2.2 cre residential portion of the development, three-story brick townhouses line narrow, privately-owned streets. The townhouses are garage units that accommodate one or two cars with stacked parking spaces in front of some units (Figure 6.3). There is a common walkway through the center of Rivergate leading to the river and park (Figure 6.4).

When examining the unique design characteristics of Rivergate, it is important to do so in the context of the rules under which it was developed. The parcel is within Alexandria's Waterfront Mixed Use Zone (W-l). The W-l zone is intended to promote mixed use development with suitable public amenities along appropriate portions of the City's waterfront by permitting a mixture of residential, commercial, cultural, and institutional uses and by allowing greater densities than would otherwise be permitted. In this zoning district, the maximum number of dwelling units allowed per acre is 30, and the minimum lot size is 1,452 square feet. The City encourages this higher density since property values are higher, and there is easy access to public transportation.

The Model Development Principles in Rivergate

In this case study, seven Model Development Principles are highlighted (Table 6.1). The design of Rivergate illustrates that even on infill and redevelopment projects, there are ways to limit impervious cover, reduce land disturbance, and still provide a marketable, cost-effective product. Following is a discussion, for each principle, of the design characteristics, iocal codes and ordinances that allowed or required the design characteristics, and a comparison of the case study to status quo design techniques.

Figure 6.4: A common walkway **through the center of Rivergate leads to the Potomac River and adjacent park.**

Principle 3. Open Space Design

The residential portion of Rivergate is clustered at one end of the site, retaining 47% of the parcel next to the Potomac River as common open space. The two-acre landscaped park is open to public access and includes stone-dust paths and benches (Figures 6.5 and 6.6). Although this redevelopment site had no existing indigenous vegetation prior to development, the open space design and landscaped park contribute to the enhancement of indigenous vegetation, as several native species are incorporated into the landscape plan. The Rivergate Owners'Association pays for maintenance of the parkland.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

Three design considerations are particularly noteworthy in the open space design of the Rivergate site. First, within the W-l zone, at least 300 square feet of open and usable space per dwelling unit must be provided. Next, the Alexandria Chesapeake Bay Preservation Ordinance has designated all land within the corporate limits of the City as a Chesapeake Bay Preservation Area. As such, the 100-foot buffer area along the Potomac River is a RPA and the rest of the parcel is a RMA. Finally, the Riverfront Agreement between the City of Alexandria and the U.S. Department of justice (US DOJ) requires that each use, development, or project adjacent to the Potomac River provide a public access, open space walkway, and bikeway adjacent to the high tide watermark of the Potomac River. Tne US DOJ negotiates this public access with the property owners when development is proposed.

A Comparison to the Status Quo A townhouse development, by its

very nature, has open space. However, townhouse developments throughout Virginia often feature characteristics that conflict with the Model Development Principles, such as bigger streets, more on-site parking, and bigger setbacks, resulting in more land consumption. The basic features of the status quo site design include wider interior residential streets, increased front and rear setbacks, increased parking ratios and on-site surface parking, and wider sidewalks along interior residential streets. Assumptions made for this case study during the redesign analysis included a reduction in the parkland along the Potomac River and an increase in utilities in proportion to the increase in road length. The required 100-foot RPA buffer is maintained along the Potomac River.

Common open space covers a significant portion of Rivergate as-built, with 47% of the site preserved as parkland. In the status quo site design, however, more land is consumed by increased setbacks, frontages, and parking, and wider streets and easements, reducing the parkland to only 11% of the site.

Principle 4. Shorter Setbacks & Frontages

The short setbacks and frontages in Rivergate are one of the major elements allowing for the open space design described above. The frontages range from 18 feet to 36 feet; the front yard setbacks range from 16 feet to 20.5 feet; the side yard setbacks range from 0 feet to 18 feet; and the rear yard setbacks range from 8.5 feet to 18 feet. Since the interior streets are privately owned, each residential lot includes a portion of a street. All setbacks are from the edge of the lots, which equals the centerline of the road in some cases, This results in townhouses set only a few feet from the edge of the street.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

Frontage and setback requirements in the W-l zone are as follows:

* Minimum frontage = lot width at building line = 18 feet for interior lots; 26 feet for end lots.
* Minimum front yard setback = none.
* Minimum side yard setback = 8 feet for end units only; 0 feet for interior units.
■ Minimum rear yard setback = 8 feet.

A Comparison to the Status Quo 5maller setback distances are t/picalfy not permitted, or require a zoning variance. For the purposes of the status quo site redesign analysis, all front yard setbacks were increased to 20 feet and all rear yard setbacks were increased to 18 feet.

In general, the use of shorter setbacks and frontages helps minimize land disturbance at Rivergate as-buiit. These features consume only about 14% of the total site area on the as-built project, as compared to 27% of the site in the status quo.

Principle 5. Common Walkways

Rivergate incorporates common walkways throughout the site instead of sidewalks adjacent to the streets. There are five-foot brick walkways down the center of the residential area leading to the parkland and along the perimeter of the site on Madison Street and Montgomery Street. In addition, there is an eight-foot stone dust, public access path in the parkland along the Potomac River.

Table 6.2: The Influence of Walkways on Impervious Area

Scenario	Total Impervious Area (square feet)	% of Total Site Area
Status Quo Site Design	14,630	7.3%
• As-Built	6,990	3.5%
Difference	7,640	3.8%

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
As mentioned earlier, the City of Alexandria did not have standards for private streets at the time Rivergate was developed. For public, local residential streets, the City requires a 60-foot right-of-way.

A Comparison to the Status Quo A public right-of-way is rare in townhouse developments, and many communities require private streets. In many communities that do require a right-of-way, a single width is applied to all residential street categories. For Rivergate, a 40-foot easement or right- of-way area is used for the status quo redesign analysis.

Like setbacks, the reduced easement widths in Rivergate as-built help to minimize land disturbance (Table 6.4). These features consume only about 9% of the total site area on the actual project, as compared to 28% of the site had the status quo site design techniques been used.

Principle 12. Reduced Parking Ratios The developers of Rivergate provided two parking spaces per townhouse. Forty-two of the 58 units have a two-car garage, and the remaining 16 have a one-car garage with Space for a second vehicle in front of the unit. Parallel parking is available for visitors on Montgomery Street and Madison Street adjacent to the property.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics
The City of Alexandria requires two parking spaces per dwelling unit, and each space must be individually accessible. The 16 stacked parking spaces in Rivergate required a Special Use Permit. The developer requested a reduction in required parking equivalent to 16 individually accessible parking spaces in exchange for 16 stacked parking spaces.

A Comparison to the Status Quo To account for visitor parking, many communities require up to 2.5 parking spaces per dwelling unit for townhouse developments. Another common requirement is one space per dwelling unit plus another half of a space per bedroom. Often, this is provided as surface parking in the form of driveways or parking lots, since many communities do not allow garage parking to satisfy residential parking requirements.

For the status quo site redesign analysis, the number of parking spaces is maintained at two spaces per townhouse. Howevep the increased front set-

Table 6.5: The Influence of Parking Ratios on Site impervious Area

Scenario	Parking Spaces Provided in Driveways	Total Impervious Area (square feet)*	% of T otal Site Area
Status Quo Site Design	116	23,200	12.7%
As-Built '	16	6,400	3.5%
Difference	10?)	16,800	9.2%

* Assumes driveway width is 20 feet.

Table 6.6: The Influence of Site Design on Nutrient Loading .

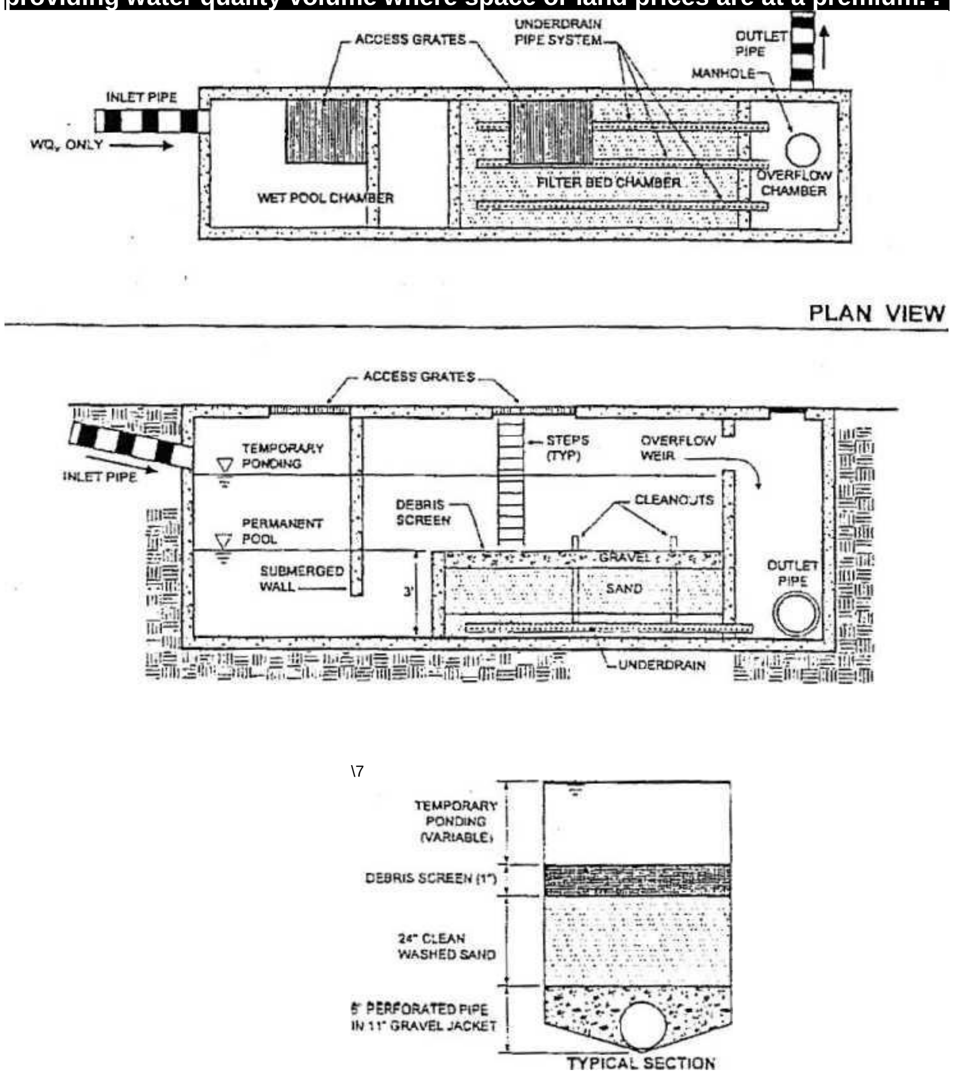
Scenario	Nitrogen (ibs/year)		Phosphorus (lbs/year)	
	without BMP	with BMP[1]	without BMP	with BMP[2]
Status Quo Site Design	49.4	37.8	6.0	4.3
As-Built	37.0	29.6	4.3	3.3
Difference	12.4	8.2	1.7	1.0

1. Underground sand filter removal efficiency of nitrogen = 44%
2. Underground sand filter removal efficiency of phosphorus = 51%

system. The first chamber is used for pretreatment and relies on a wet pool as well as temporary runoff storage. It is connected to the second sand filter chamber by an inverted elbow, which keeps the filter surface free from-trash and oil. The filter bed is typically 18 inches in depth, and may have a protective screen of gravel or permeable geotextile to limit clogging. During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir. Filtered runoff is collected using perforated underdrains that extend into the third overflow chamber.

To demonstrate the influence of site design on nutrient loading, an underground sand filter was used for the status quo site design as well as for the case study. Table 6.5 displays the annual nutrient loading from the site under four scenarios: the status quo site design with and without a BMP, and the case study with and without a BMP, The influence of the previously discussed Model Development Principles becomes evident here. The phosphorus and nitrogen loads from the status quo site design with an underground sand filter are comparable to the loads from the case study design before the reductions of the BMP are even factored into analysis. This is due in large part to the reduction of impervious cover in the case study as compared to the status quo site design.

Figure 6.9: The underground sand filter used at Rivergate is an option for providing water quality volume where space or land prices are at a premium. .



Conclusion

In general, the use of shorter setbacks and frontages, as well as narrower easement widths, helps minimize land disturbance at Rivergate, These features consume only about 23% of the total site area on the. actual project, as opposed to as much as 55% of the site had the status quo site design techniques been used. Although this redevelopment site had no existing indigenous vegetation prior to development, the open space design and landscaped park contribute to the enhancement of indigenous vegetation, as several native species are incorporated into the landscape plan. Finally, common walkways, narrower streets, and reduced surface parking help to minimize impervious cover. These impervious surfaces consume about 21% of the total site area of the actual site, but may have been as high as 44% had the status quo site design techniques been used instead.

Table 6.6 compares the land cover associated with the site under three scenarios; pre-development, the status quo site design, and the actual Rivergate design. This information is used to compute the annual hydrologic budget, annual nutrient export, and infrastructure cost for each scenario.
As a result of the reduced impervious cover and the increased parkland, the case study design results in the lowest volume of runoff and the highest volume of infiltration per year over both the pre-development conditions and the status quo site design scenario. These site characteristics also result in reduced nutrient loading. As previously stated, the annual nutrient loads from.the status quo site design with a BMP (an underground sand filter) are comparable to the loads from the case study design even when the BMP is eliminated from the analysis.

The Model Development Principles were developed to promote design techniques that are both environmentally friendly and economically sound, In Rivergate as-built, the larger parkland results in a higher landscaping cost. However, the increase in asphalt and utility lengths in the status quo site design results in a higher infrastructure cost than for the case study design. Also, the increased imperviousness of the status quo site design results in a higher volume of stormwater runoff to be treated, which in turn increases the BMP construction cost by 35%. Overall, the status quo site design is estimated to have total infrastructure construction costs that are about 50% higher than Rivergate as-built.

VII. CASE STUDY #4: THE ARBORETUM, A COMMERCIAL CASE STUDY

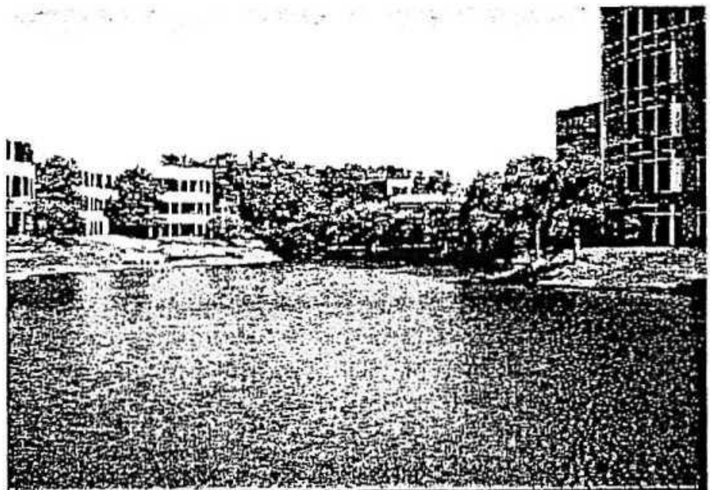


Figure 7.1: Regional stormwater management facility with Arboretum I on the left, Arboretum III on the right, and the Arboretum III parking structure in the background.

The Arboretum is a commercial/office development complex located in Chesterfield County, Virginia. The development project, constructed in the late 1980s, consists of two buildings, Arboretum I and Arboretum III, and the associated infrastructure (Figure 7.1). Arboretum I is a three-story office building comprising

63.0 square feet of office space. Surface parking for this building is provided on the 4.81 acre site. Arboretum III is a six-story office building comprising

223.0 square feet of office space. Parking for this building is provided on the 7.96 acre site in a four-story, 272,000-square- foot parking structure and through additional surface parking, Stormwater management for the office complex and upstream development is provided by a regional stormwater management facility constructed between the two building sites. Figures 7.1 through 7.5 depict the layout and site features of the Arboretum complex. Prior to construction, the development site was predominately forested, with a small headwater stream flowing across it.

The Model Development Principles in the Arboretum

In this case study, five of the sixteen Model Development Principles are highlighted (Table 7.1). The principles highlighted on the Arboretum site include the conservation of native plants and trees, minimized clearing and grading, the use of mass transit and shared parking, reduced parking lot imperviousness, and the use of structured parking.

Table 7.1: Model Development Principles UtiGzed on the Aboretum Site

Model Development Principle	Minimizes Land Disturbance	Preserves Indigenous Vegetation	Minimizes Impervious Surfaces
1. Native Plant & Tree Conservation	/	/	
2. Minimize Clearing and Grading	/		
13. Mass Transit and Shared Parking	/		/
14. Less Parking Lot Imperviousness	/	S	/
15. Structured Parking	/	/	/

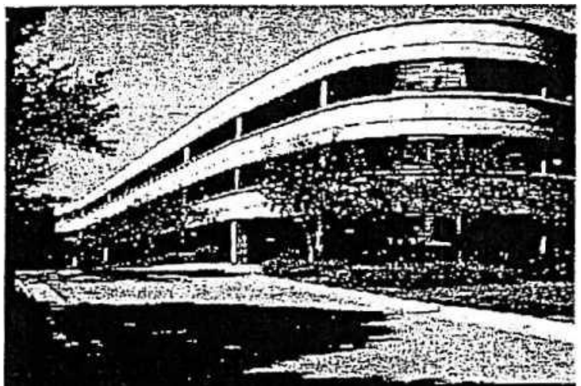


Figure 7.3: The Arboretum III on-site parking structure.

In this case study, the status quo site design consists of two redesign scenarios for the Arboretum III site. The redesign scenarios were limited to the Arboretum III site because the project incorporates a greater number of the Model Development Principles than does the Arboretum I project site.

There are two principal components in the design of a commercial office development: the size of the building, and the amount of parking required to serve the building. The as-buiit design of the Arboretum III building consists of a six-story 223,000 square foot office building with a four-story parking structure that provides 964 parking spaces. The status quo site design examines how the Arboretum III site would be developed without using structured parking.

The acreage of a building site controls the amount of area available for parking, and the amount of parking dictates the size of the building. When the Arboretum III site is redesigned to utilize only surface parking, there is not enough area on the site necessary to provide all of the parking required for the existing 223,000 square foot building. The first design scenario looks at constructing a smaller 124,200 square foot building that can be served by surface parking on the existing site. The second scenario looks at constructing the same size building as exists now, but increases the acreage of the site to allow enough surface parking to provide the required number of spaces.

Principle 1. Native Plant and Tree Conservation

Of the two building sites in the project, The Arboretum I site is significant in that 24% of the site is maintained in existing native tree cover. While the Arboretum III site preserved much less existing forest cover, (only 6% of the site), the development provides more than three times the office space and more than four and a halftimes the number of parking spaces on a site that is a little more than twice as large as the Arboretum I site.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

The Chesterfield County Code requires that "Preservation of existing trees and shrubs shall be maximized to provide continuity and improved buffering. Except when necessary to provide access, any trees that are eight inches or greater in caliper, located within the setback from a public right-of-way, shall be retained unless removal is approved through site, subdivision, or schematic plan review..." While this code does not stipulate a minimum amount of native plant and tree preservation, it does require that tree and shrub removal be justified on each site by the developer.

A Comparison to the Status Quo

Many communities throughout Virginia do not re-

Table 7.2: The Influence of Tree Save Requirements on Native Plant andTree Conservation Forthe Arboretum 111 Site

Scenario		Area Conserved (square feet)	% of Total Site Area
Status Quo Site Design	Redesign 1	0	0%
	Redesign Z	0	0%
As-Built		20,804	6%
Difference		20,804	6%

building square footage),

A Comparison to the Status Quo

Although shared parking arrangements can significantly reduce the area needed for parking, only a few communities have actively encouraged such arrangements. The status quo site design assumes that there would be no shared parking allowed and that any overflow parking would have to be accommodated on the individual sites.

• BETTER SITE DESIGN

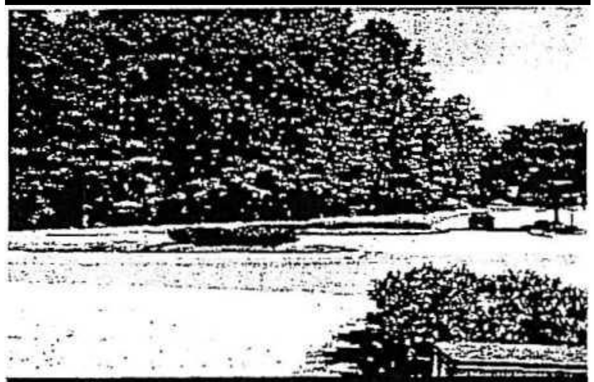


Figure 7.5: Tree save area at entrance to Arboretum III.

Principle 14. Less Parking Lot Imperviousness

Parking is the largest component of impervious cover in most commercial and industrial zones, but conventional design practices do little to reduce the impervious area associated with parking lots. For example, many communities require parking dimensions geared toward larger vehicles, despite the fact that smaller cars make up almost half of all cars on the road (ITE, 1994). The use of design practices such as compact spaces, efficient parking space layout and one-way traffic aisles can significantly reduce the impervious cover in parking lots.

Both the Arboretum I and the Arboretum III buildings incorporate means of minimizing parking lot impervious, but in different ways. The Arboretum I building utilizes a short entrance drive and an efficientparking space layout to maximize the numbers of spaces within the parking area. When examined in terms of the overall parking lot impervious area versus the number of parking spaces, the Arboretum I parking lot requires 364 square feet of impervious surface per parking space, In many instances impervious area per parking space exceeds 400 square feet (Schueler, 1995) making the Arboretum I parking efficient in terms of impervious surface utilization,

The Arboretum III building utilizes a four-story parking structure to minimize the amount of impervious surface attributed to parking. The advantages of utilizing parking structures will be discussed in the next section.

Applicable Codes/Ordinances Allowing or Requiring Design Characteristics

At the time the Arboretum Buildings were approved, The local code required the construction of six parking spaces for the first 1,000 square feet of building space and one parking space for each additional 300 square feet of office space. Soon after, the parking requirement was revised to progressively reduce the number of parking spaces needed as a building grew larger. Had the new code been in place at the time the Arboretum III was approved, it would have required the construction of 82 fewer parking spaces on the site.

The new code required the following:

• One parking space for each 200 square feet of office space for the first 10,000 square feet

Table 7.4: Advantages of Minimizing Parking Lot Imperviousness on the Arboretum U1

Scenario		Area Conserved (square feet)	% of Total Site Area
Status Quo Site Design	Redesign 1	139,391	40%
	Redesign 2	272,250	57%
As-Built		68,000	20%
Difference	Redesign 1	71,391	20%
	Redesign 2	204.250	43%

parking spaces. Had only surface parking been used to service the Arboretum III building, it would have required a parking iot of at least six acres in size. Not building a parking structure on the site would have required that either the building be downsized to accommodate the limited site area available for parking (Scenario 1), or that additional land be acquired to accommodate the existing building and provide sufficient surface parking (Scenario 2). Either one of these alternatives wouid result in an increase in impervious cover and pollutant loads. Table 7.6 depicts the impervious cover calculations and pollutant loads for the existing Arboretum III site.

Table 7.6: Impervious Cover Calculations and Pollutant Loads for the Existing Arboretum 111 Site

Arboretum III Project As-Built (7.96 ac. site, 223,000ft² office space)		
Land Use	Area (acres)	% of Site
Pavement and Rooftops (acres)	4.2	52%
Semi-Impervious Area (acres)	2.1	21%
Forest and Wetlands (acres)	0.4	5%
Meadow (acres)	0.0	0%
SWM Pond (acres)	1.3	16%
Imperviousness 69%		
Hydrology		
Runoff (inches/yr.)	24.1	
Infiltration (inches/yr.)	3.1	
Nutrient Loads		
	Without BMPs	With BMPs
Nitrogen (Ibs./yr.)	90.6	63.7
Phosphorous (Ibs2yr.)	11.0	8.9

Status Quo Scenario 1

Assuming that 1) no structured parking was provided, 2) the existing site could not be expanded, and 3) a building with the same footprint was constructed, there is available land to create approximately 3.4? acres of surface parking on the Arboretum III site. The Arboretum I building utilizes a 1.78 acre parking lot to provide 213 parking spaces, for a parking lot area to parking space ratio of 364 square feet of total impervious area per parking space. Using this same parking space to parking lot area ratio, approximately 417 parking spaces could be created on the Arboretum III site. Based upon Chesterfield County parking requirements, this amount of parking would accommodate only 124,200 square feet of office space. This amount of surface parking would also result in the loss of the modest amount of tree save areas on the Arboretum III site (0.41 acres). The resulting development would be approximately 74% impervious, as opposed to the existing site's impervious cover of 69% (Table 7.9). Table 7.7 details the impervious cover and pollutant load increases of Scenario 1.

While this approach is feasible and would not significantly increase the pollutant load associated with this site, it would ultimately lead to the development of another site, of about the same size as the Arboretum I, in order to create the equivalent amount of office space that the current Arboretum III building provides. This wouid require additional road infrastructure to access a new site, an increase in sediment loss as an additional site was graded and constructed, and a doubling of impervious surfaces attributed to buildings and parking, all to create the same amount of office space. This would also result in a significant increase in the pollutant load that ultimately reaches local waterways.

Status Quo Scenario 2

The second scenario would be to build the Arboretum III building as it stands now and-service it with surface parking only. This scenario would require the site area to be increased to approximately 11 acres. Using the parking space to parking lot area ratio discussed earlier, 6.25 acres of the 11 acre parcel would be dedicated to parking. The resulting site would be approximately 81% impervious as opposed to the existing Arboretum III impervious cover of 69%. In terms of pollutant loads, this scenario would result in a 50% increase in the nitrogen load and a 60% increase in the phosphorus load leaving the site, when compared to the as-built condition. Table 7.8 details the impervious cover and pollutant load increases of Scenario 2.

Summary of the Redesign Scenarios The Arboretum III development site follows the philosophy of "build up, not out." There is no guarantee

Table 7.9: A Conparison of The Arboretum ID As-Built tothe Status Quo Ste Design Scenarios

		Pre-De vel cpm ent	Status Quo Scenario 1	Status Quo Scenario 2	As-Built
Site Characteristics					
Ste Area		7.95 acres	7.95 acres	11.00 acres |	7.95 acres
Office Space (sqft)		0	124,200	223.003	223,003
Site impervi ousness					
Access Drive Area (sq ft)		N/A	12,632	12632	12632
Parking Aea (sq ft)		*N/A*	139,391	272,250	121,532
SideAdk *Area* (sq ft)		N/A	8,276	8.276	8,276
Rooftop Area (sq ft) .		*N/A*	39,204	39,204	39,204
Lawn Area[1] (sqft)		*N/A*	91,040	91,040	91,040
Fcrest Area[1] (sq ft)		346,737	0	0	17,860
SV\M Porri Area[2] (sq ft)		*N/A*	56,192	56,192	56,192
Tetri Impervious Area (sq ft)		*3,468*	*256,605*	*389,564*	*238,925*
Percent Impervious		*1%*	*74%*	*81%*	*69%*
Stormwater Impacts					
Runoff (inches/yr)		2,1	25.8	30	24.1
Infiltration (inches/yr)		120	2.5	1.3	3.1
Nitrogen Load (Ibs/yr)	without EMP	7.4	96.5[3]	141.6	90.6
	with EMP	NA	67.7°	98.4	63.7
Phosphorous Load (lbs/yr)	without EMP	0.7	11.8[3]	17.5	11.0
	with EMP	NA	9.5[s]	14.2	8.9

1. Turf and forest areas are assumed to be 1% impervious.
2. Pond area is considered 103% impervious.
3. Does net account for the pollutant load from additional development site required to make up for reduction in office space.

utilizing only surface parking. Table 7,9 lists the improvements gained from utilizing the Model Development Principles in the as-buiit design.

Appendix D - Advisory Maps for Neuse Riparian Buffer Rule and Soils

Table 4-1

BMP Ability for Stormwater Quantity Control

	Quantity Control	TSS Removal Efficiency	TN Removal Efficiency	TP Removal Efficiency	Fecal Removal Ability	High Temperature Concern
Bioretention without IWS	Possible	85%	35%	45%	High	Med
Bioretention with IWS *Coastal Counties*	Possible	85%	60%	60%	High	Med
Bioretention with IWS *Non-Coastal Counties*	Possible	85%	40%	45%	High	Med
Stormwater wetlands	Yes	85%	40%	40%	Med	High
Wet detention basin	Yes	85%	25%	40%	Med	High
Sand filter	Possible	85%	35%	45%	High	Med
Filter strip	No	25-40%	20%	35%	Med	Low
Grassed swale	No	35%	20%	20%	Low	Low
Restored riparian buffer	No	60%	30%	35%	Med	Low
Infiltration devices	Possible	85%	30%	35%	High	Low
Dry extended detention basin	Yes	50%	10%	10%	Med	Med
Permeable pavement system	Possible	0%	0%	0%	Low	Med
Rooftop runoff management	Possible	0%	0%	0%	Low	Med

4.5. Comparison of BMP Site Constraints

The basic nature of stormwater BMPs often places them in low-lying areas and next to existing waterways,, which can put them at odds with other regulations. The designer must always be aware of other regulations when siting BMPs. A non-exhaustive list of possible environmental regulatory issues is provided below:

- **Jurisdictional wetlands**
- **Stream channels**
- **100-year floodplains**
- **Stream buffers**
- **Forest conservation areas**

SECTION .1000 - STORMWATER MANAGEMENT

15A NCAC 02H .1001 STORMWATER MANAGEMENT POLICY

The rules in this Section set forth the requirements for application and issuance of permits for stormwater management systems in accordance with G,S. 143-215.1(d) and 15A NCAC 2H .0200. These requirements to control pollutants associated with stormwater runoff apply to development of land for residential, commercial, industrial, or institutional use but do not apply to land management activities associated with agriculture or silviculture unless specifically addressed in special supplemental classifications and management strategies adopted by the Commission.

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.3(a)(1);
Eff. January 1, 1988;
Amended Eff. September 1, 1995.

15A NCAC 02H .1002 DEFINITIONS

The definition of any word or phrase in this Section shall be the same as given in Article 21, Chapter 143 of the General Statutes of North Carolina, as amended. Other words and phrases used in this Section are defined as follows:

(1) "Built-upon Area" means that portion of a development project that is covered by impervious or partially impervious cover including buildings, pavement, gravel roads and parking areas, recreation facilities (e.g., tennis courts), etc. (Note: Wooden slatted decks and the water area of a swimming pool are considered pervious).

(2) "CAMA Major Development Permits" mean those permits or revised permits required by the Coastal Resources Commission according to 15A NCAC 7J Sections .0100 and **.**0200**.**

(3) "Certificate of Stormwater Compliance" means the approval for activities that meet the requirements for coverage under a stormwater general permit for development activities that are regulated by this Section.

(4) "Coastal Counties" include Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Gates, Hertford, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Tyrrell, and Washington.

(5) "Curb Outlet System" means curb and gutter installed in a development which meets low density criteria [Rule .1003(d)(1) of this Section] with breaks in the curb or other outlets used to convey stormwater runoff to grassed swales or vegetated or natural areas and designed in accordance with Rule .1008(g) of this Section,

(6) "Development" means any land disturbing activity which increases the amount of built-upon area or which otherwise decreases the infiltration of precipitation into the soil.

(7) "Drainage Area or Watershed" means the entire area contributing surface runoff to a single point.

(8) "Forebay" means a device located at the head of a wet detention pond to capture incoming sediment before it reaches the main portion of the pond. The forebay is typically an excavated settling basin or a section separated by a low weir.

(9) "General Permit" means a "permit" issued under G.S. 143-215.1(b)(3) and (4) authorizing a category of similar activities or discharges.

(10) "Infiltration Systems" mean stormwater control systems designed to allow runoff to pass or move (infiltrate/exfiltrate) into the soil.

(11) "Notice of Intent" means a written notification to the Division that an activity or discharge is intended to be covered by a general permit and takes the place of "application" used with individual permits.

(12) "Off-site Stormwater Systems" mean stormwater management systems that are located outside the boundaries of the specific project in question, but designed to control stormwater drainage from that project and other potential development sites. These systems shall designate responsible parties for operation and maintenance and may be owned and operated as a duly licensed utility or by a local government.

(13) "On-site Stormwater Systems" mean the systems necessary to control stormwater within an individual development project and located within the project boundaries.
(14) "Redevelopment" means any rebuilding activity which has no net increase in built-upon area or which provides equal or greater stormwater control than the previous development (stormwater controls shall not be allowed where otherwise prohibited).
(15) "Seasonal High Water Table" means the highest level that groundwater, at atmospheric pressure, reaches in the soil in most years. The seasonal high water table is usually detected by the mottling of the soil that results from mineral leaching.
(16) "Sedimentation/Erosion Control Plan" means any plan, amended plan or revision to an approved plan submitted to the Division of Land Resources or delegated authority in accordance with G.S. 113A-57.
(17) "Stormwater" is defined in G.S. 143, Article 21.
(18) "Stormwater Collection System" means any conduit, pipe, channel, curb or gutter for the primary purpose of transporting (not treating) runoff. A stormwater collection system does not include vegetated swales, swales stabilized with armoring or alternative methods where natural topography or other physical constraints prevents the use of vegetated swales (subject to case-by-case review), curb outlet systems, or pipes used to carry drainage underneath built-upon surfaces that are associated with development controlled by the provisions of Rule .1003(d)(1) in this Section.
(19) "10 Year Storm" means the surface runoff resulting from a rainfall of an intensity expected to be equaled or exceeded, on the average, once in 10 years, and of a duration which will produce the maximum peak rate of runoff, for the watershed of interest under average antecedent wetness conditions.
(20) "Water Dependent Structures" means a structure for which the use requires access or proximity to or siting within surface waters to fulfill its basic purpose, such as boat ramps, boat houses, docks, and bulkheads. Ancillary facilities such as restaurants, outlets for boat supplies, parking lots and boat storage areas are not water dependent uses.
(21) "Wet Detention Pond" means a structure that provides for the storage and control of runoff and includes a designed and maintained permanent pool volume.
(22) "Vegetative Buffer" means an area of natural or established vegetation directly adjacent to surface waters through which stormwater runoff flows in a diffuse manner to protect surface waters from degradation due to development activities. The width of the buffer is measured horizontally from the normal pool elevation of impounded structures, from the bank of each side of streams or rivers, and from the mean high water line of tidal waters, perpendicular to the shoreline.
(23) "Vegetative Filter" means an area of natural or planted vegetation through which stormwater runoff flows in a diffuse manner so that runoff does not become channelized and which provides for control of stormwater runoff through infiltration of runoff and filtering of pollutants. The defined length of the filter shall be provided for in the direction of stormwater flow.

History Note: Authority G.S 143-213; 143-214.1; 143-214.7; 143-215.3 (a)(1); Eff. January 1, 1988;
Amended Eff. December 1, 1995; September 1, 1995.

15A NCAC 02H .1003 STORMWATER MANAGEMENT: COVERAGE: APPLICATION: FEES

(a) The intent of the Commission is to achieve the water quality protection which low density development near sensitive waters provides. To that end, the Director, by applying the standards in this Section shall cause development to comply with the antidegradation requirements specified in 15A NCAC 2B .0201 by protecting surface waters and highly productive aquatic resources from the adverse impacts of uncontrolled high density development or the potential failure of stormwater control measures.

(b) To ensure the protection of surface waters of the State in accordance with G.S. 143-214.7, a permit is required in accordance with the provisions of this Section for any development activities which require a CAMA major development permit or a Sedimentation/Erosion Control Plan and which meet any of the following criteria:

(1) development activities located in the 20 coastal counties as defined in Rule .1002(4) of

this Section;

(2) development activities draining to Outstanding Resource Waters (ORW) as defined in 15A NCAC 2B .0225; or

(3) development activities within one mile of and draining to High Quality Waters (HQW) as defined in 15A NCAC 2B .0101(e)(5).

Projects under a common plan of development shall be considered as a single project and shall require stormwater management in accordance with this Section. Local governments with delegated Sedimentation/Erosion Control Programs often implement more stringent standards in the form of lower thresholds for land area disturbed. In these situations, the requirements of this Rule apply only to those projects that exceed the state's minimum area of disturbance as outlined in G.S. 113A-57. Specific permitting options, including general permits for some activities, are outlined in Paragraph (d) of this Rule.

(c) Development activity with a CAMA major development permit or a Sedimentation/Erosion Control Plan approved prior to January 1, 1988 are not required to meet the provisions of these Rules unless changes are made to the project which require modifications to these approvals after January 1, 1988.

(d) Projects subject to the permitting requirements of this Section may be permitted under the following stormwater management options:

(1) Low Density Projects: Projects permitted as low density projects must be designed to meet and maintain the applicable low density requirements specified in Rules .1005 through .1007 of this Section. The Division shall review project plans and assure that density levels meet the applicable low density requirements. The permit shall require recorded deed restrictions and protective covenants to ensure development activities maintain the development consistent with the plans and specifications approved by the Division.

(2) High Density Projects: Projects permitted as high density projects must be designed to meet the applicable high density requirements specified in Rules .1005 through .1007 of this Section with stormwater control measures designed, operated and maintained in accordance with the provisions of this Section. The permit shall require recorded deed restrictions and protective covenants to ensure development activities maintain the development consistent with the plans and specifications approved by the Division. Stormwater control measures and operation and maintenance plans developed in accordance with Rule .1008 of this Section must be approved by the Division. In addition, NPDES permits for stormwater point sources may be required according to the provisions of 15A NCAC 2H .0126.

(3) Other Projects: Development may also be permitted on a case-by-case basis if the project:

(A) controls runoff through an off-site stormwater system meeting provisions of this Section;

(B) is redevelopment which meets the requirements of this Section to the maximum extent practicable;

(C) otherwise meets the provisions of this Section and has water dependent structures, public roads and public bridges which minimize built-upon surfaces, divert stormwater away from surface waters as much as possible and employ other best management practices to minimize water quality impacts.

(4) Director's Certification: Projects may be approved on a case-by-case basis if the project is certified by the Director that the site is situated such that water quality standards and uses are not threatened and the developer demonstrates that:

(A) the development plans and specifications indicate stormwater control measures which shall be installed in lieu of the requirements of this Rule; or

(B) the development is located such a distance from surface waters that impacts from pollutants present in stormwater from the site shall be effectively mitigated.

(5) General Permits: Projects may apply for permit coverage under general permits for specific types of activities. The Division shall develop general permits for these activities in accordance with Rule .1013 of this Section. General Permit coverage shall be available to activities including, but not limited to:

(A) construction of bulkheads and boat ramps;

(B) installation of sewer lines with no proposed built-upon areas;

(C) construction of an individual single family residence; and
(D) other activities that, in the opinion of the Director, meet the criteria in Rule .1013 of this Section.

Development designed to meet the requirements in Subparagraphs (d)(1) and (d)(3) of this Paragraph must demonstrate that no areas within the project site are of such high density that stormwater runoff threatens water quality.

(e) Applications: Any person with development activity meeting the criteria of Paragraph (b) of this Rule shall apply for permit coverage through the Division. Previously issued Stormwater Certifications (issued in accordance with stormwater management rules effective prior to September 1, 1995) revoked due to certification violations must apply for permit coverage. Stormwater management permit applications, project plans, supporting information and processing fees shall be submitted to the appropriate Division of Environmental Management regional office. A processing fee, as described in Paragraph (f) of this Rule, must be submitted with each application. Processing fees submitted in the form of a check or money order shall be made payable to N.C. Department of Environment, Health, and Natural Resources. Applications which are incomplete or not accompanied by the processing fee may be returned. Permit applications shall be signed as follows:

(1) in the case of corporations, by a principal executive officer of at least the level of vice-president, or his authorized representative;
(2) in the case of a partnership, by a general partner and in the case of a limited partnership, by a general partner;
(3) in the case of a sole proprietorship, by the proprietor;
(4) in the case of a municipal, state or other public entity by either a principal executive officer, ranking official or other duly authorized employee.

The signature of the consulting engineer or other agent shall be accepted on the application only if accompanied by a letter of authorization.

(f) Permit Fees:

(1) For every application for a new or revised permit under this Section, a nonrefundable application processing fee in the amount stated in Subparagraph (f)(2) of this Paragraph shall be submitted at the time of application.
(A) Each permit application is incomplete until the application processing fee is received;
(B) No processing fee shall be charged for modifications of permits when initiated by the Director;
(C) A processing fee of forty dollars ($40.00) shall be charged for name changes;
(D) No processing fee shall be required for name changes associated with the initial transfer of property from the developer to property owner or responsible party. Any subsequent changes in ownership shall be subject to the name change processing fee in Part (C) of this Paragraph.

(2) Schedule of Fees

Permit Application Processing Fee

	New Applications/ Modifications/ Rate Renewal	Timely Renewals Without Modifications
Low Density	$225	N/A
High Density	385	225
Other	225	N/A
Director's Certification	350	N/A
General Permits	50	N/A

(g) Supporting Documents and Information, This Paragraph outlines those supporting documents and information that must be submitted with stormwater applications. Additional information may also be applicable or required. The applicant shall attempt to submit all necessary information to describe the site, development and stormwater management practices proposed. The following documents and information shall be submitted with stormwater applications:

fl) two sets of detailed plans and specifications for the project;

(2) plans and specifications must be dated and sealed as outlined in Rule .1008(j) of this Section and show the revision number and date;

(3) general location map showing orientation of the project with relation to at least two references (numbered roads, named streams/rivers, etc.) and showing the receiving water (a USGS map preferable);

(4) topographic map(s) of the project area showing original and proposed contours and drainage patterns;

(5) delineation of relevant boundaries including drainage areas, seasonal high water table, wetlands, property/project boundaries and drainage easements;

|6) existing and proposed built-upon area including roads, parking areas, buildings, etc.;

|{7) technical information showing all final numbers, calculations, assumptions, and drawing procedures associated with the stormwater management measures including but not limited to: built-upon area, runoff coefficients, runoff volume, runoff depth, flow routing, inlet and outlet configuration (where applicable), other applicable information as specified;

{8) operation and maintenance plan signed by responsible party;

{9) recorded deed restriction and protective covenants. As an alternative proposeddeed restriction and protective covenants and a signed agreement to provide final recorded articles shall be accepted when final documents are not available at the time of submittal.

(h) Permit Issuance and Compliance: Stormwater management permits shall be issued in a manner consistent with the following:

(1) Stormwater management permits issued for low density projects shall not require permit renewal.

(2) Stormwater management permits issued for projects that require the construction of engineered stormwater control measures shall be issued for a period of time not to exceed 10 years. Applications for permit renewals shall be submitted 180 days prior to the expiration of a permit and must be accompanied by the processing fee described in Paragraph (f) of this Rule.

(3) Stormwater management permits shall be issued to the developer or owner and shall cover the entire master plan of the project ("stormwater master plan permit"). The master plan permit shall include specifications for stormwater management measures associated with each individual lot or property within the project.

(4) Any individual or entity found to be in noncompliance with the provisions of a stormwater management permit or the requirements of this Section is subject to enforcement procedures as set forth in G.S. 143, Article 21.

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.1(d); 143-215.3 (a)(1); Eff. January 1, 1988;
Amended Eff. December 1, 1995; September 1, 1995.

15A NCAC 02H .1004 STATEWIDE STORMWATER GUIDELINES

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.3(a)(1); 143-215.8A; Eff. January 1, 1988;
Repealed Eff. September 1, 1995.

15A NCAC 02H .1005 STORMWATER REQUIREMENTS: COASTAL COUNTIES

All development activities within the coastal counties which require a stormwater management permit in accordance with Rule .1003 of this Section shall manage stormwater runoff as follows:

(1) development activities within the coastal counties draining to Outstanding Resource Waters (ORW) shall meet requirements contained in Rule .1007 of this Section;

(2) development activities within one-half mile of and draining to SA waters or unnamed tributaries to S A waters:'

(a) Low Density Option: Development shall be permitted pursuant to Rule .1003(d)(1) of this Section if the development has:

(i) built-upon area of 25 percent or less; or proposes development of single family residences on lots with one-third of an acre or greater with a built-upon area of 25 percent or less;

(ii) stormwater runoff transported primarily by vegetated conveyances; conveyance system shall not include a discrete stormwater collection system as defined in Rule .1002 of this Section;

(iii) a 30 foot wide vegetative buffer.

(b) High Density Option: Higher density developments shall be permitted pursuant to Rule .1003(d)(2) of this Section if stormwater control systems meet the following criteria:

(i) no direct outlet channels or pipes to SA waters unless permitted in accordance with 15 A NCAC 2H .0126;

(ii) control systems must be infiltration systems designed in accordance with Rule .1008 of this Section to control the runoff from all surfaces generated by one and one-half inches of rainfall. Alternatives as described in Rule .1008(h) of this Section may also be approved if they do not discharge to surface waters in response to the design storm;

(iii) runoff in excess of the design volume must flow overland through a vegetative filter designed in accordance with Rule .1008 of this Section with a minimum length of 50 feet measured from mean high water of SA waters;

(3) development activities within the coastal counties except those areas defined in Items (1) and (2) of this Paragraph:

(a) Low Density Option: Development shall be permitted pursuant to Rule .1003(dXl) of this Section if the development has:

(i) built-upon area of 30 percent or less; or proposes development of single family residences on lots with one-third of an acre or greater with a built-upon area of 30 percent or less;

(ii) stormwater runoff transported primarily by vegetated conveyances; conveyance system shall not include a discrete stormwater collection system as defined in Rule .1002 of this Section;

(iii) a 3 0 foot wide vegetative buffer.

(b) High Density Option: Higher density developments shall be permitted pursuant to Rule .1003(dX2) of this Section if stormwater control systems meet the following criteria:

(i) control systems must be infiltration systems, wet detention ponds or alternative stormwater management systems designed in accordance with Rule .1008 of this Section;

(ii) control systems must be designed to control runoff from all surfaces generated by one inch of rainfall.

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.1; 143-215.3(a); Ejf. September 1, 1995.

15A NCAC 02H .1006 STORMWATER REQUIREMENTS: HIGH QUALITY WATERS

All development activities which require a stormwater management permit under Rule .1003 of this Section

and are within one mile of and draining to waters classified as High Quality Waters (HQW) shall manage
stormwater runoff in accordance with the provisions outlined in this Rule. More stringent stormwater management measures may be required on a case-by-case basis where it is determined that additional measures are required to protect water quality and maintain existing and anticipated uses of these waters.

(1) All waters classified as WS-I or WS-II (15A NCAC 2B .0212 and .0214) and all waters located in the coastal counties (Rule .1005 of this Section) are excluded from the requirements of this Rule since they already have requirements for stormwater management.

(2) Low Density Option: Development shall be permitted pursuant to Rule .1003(c)(1) of this Section if the development has:
   (a) built-upon area of 12 percent or less or proposes single family residential development on lots of one acre or greater;
   (b) stormwater runoff transported primarily by vegetated conveyances; conveyance system shall not include a discrete stormwater collection system as defined in Rule .1002 of this Section;
   (c) a 30 foot wide vegetative buffer.

(3) High Density Option: Higher density developments shall be permitted pursuant to Rule .1003(c)(2) of this Section if stormwater control systems meet the following criteria:
   (a) control systems must be wet detention ponds or alternative stormwater management systems designed in accordance with Rule .1008 of this Section;
   (b) control systems must be designed to control runoff from all surfaces generated by one inch of rainfall.

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.1; 143-215.3(a); Ejf.
September 1, 1995;
Amended Eff. December 1, 1995.

15A NCAC 02H .1007 STORMWATER REQUIREMENTS: OUTSTANDING RESOURCE WATERS

All development activities which require a stormwater management permit under Rule .1003 of this Section and which drain to waters classified as Outstanding Resource Waters (ORW) shall manage stormwater runoff in accordance with the provisions of this Rule. Water quality conditions shall clearly maintain and protect the outstanding resource values of waters classified as Outstanding Resource Waters (ORW). Stormwater management strategies to protect resource values of waters classified as ORW shall be developed on a site specific basis during the proceedings to classify these waters as ORW. The requirements of this Rule serve as the minimum conditions that must be met by development activities. More stringent stormwater management measures may be required on a case-by-case basis where it is determined that additional measures are required to protect water quality and maintain existing and anticipated uses of these waters.

(1) Freshwater ORWs: Development activities which require a stormwater management permit under Rule .1003 of this Section and which drain to freshwaters classified as ORW shall manage stormwater runoff as follows:
   (a) Low Density Option: Development shall be permitted pursuant to Rule .1003(d)(1) of this Section if the development has:
      (i) built-upon area of 12 percent or less or proposes single family residential development on lots of one acre or greater;
      (ii) stormwater runoff transported primarily by vegetated conveyances; conveyance system shall not include a discrete stormwater collection system as defined in Rule .1002 of this Section; and
      (iii) a 30 foot wide vegetative buffer.
   (b) High Density Option: Higher density developments shall be permitted pursuant to Rule .1003(d)(2) of this Section if stormwater control systems meet the following criteria:

(i) control systems must be wet detention ponds or alternative stormwater management systems designed in accordance with Rule .1008 of this Section; and

(ii) control systems must be designed to control runoff from all surfaces generated by one inch of rainfall.

(2) Saltwater ORWs: Development activities which require a stormwater management permit under Rule .1003 of this Section and which drain to saltwaters classified as ORW shall manage stormwater runoff as follows:

(a) Within 575 feet of the mean high water line of designated ORW areas, development activities shall comply with the low density option as specified in Rule .1005(2)(a) of this Section.

(b) Projects draining to saltwaters classified as ORW that impact the Areas of Environmental Concern (AEC), determined pursuant to G.S. 113A-113, shall delineate the ORW AEC on the project plans and conform to low density requirements as specified in Rule .1005(2)(a) of this Section within the ORW AEC.

(c) After the Commission has received a request to classify Class SA waters as ORW and given permission to the Director to schedule a public hearing to consider reclassification and until such time as specific stormwater design criteria become effective, only development which meets the requirements of Rule .1003(d)(3)(A), (B) and (C) and Rule .1005(2)(a) of this Section shall be approved within 575 feet of the mean high water line of these waters.

History Note: Authority G.S. 143-214.1; 143-214.7; 143-215.1; 143-215.3(a);
Eff. September 1, 1995.

15A NCAC 02H .1008 DESIGN OF STORMWATER MANAGEMENT MEASURES

(a) Structural Stormwater Control Options. Stormwater control measures which may be approved pursuant to this Rule and which shall not be considered innovative include:

(1) Stormwater infiltration systems including infiltration basins/ponds, swales, and vegetative filters;

(2) Wet detention ponds; and -

(3) Devices approved in accordance with Paragraph (h) of this Rule.

All stormwater management structures are subject to the requirements of Paragraph (c) of this Rule.

(b) Innovative Systems. Innovative measures for controlling stormwater which are not well established through actual experience may be approved on a demonstration basis under the following conditions:

(1) There is a reasonable expectation that the control measures will be successful;

(2) The projects are not located near High Quality Waters (HQW);

(3) Monitoring requirements are included to verify the performance of the control measures; and

(4) Alternatives are available if the control measures fail and shall be required when the Director determines that the system has failed.

(c) (General Engineering Design Criteria For All Projects.'

(1) The size of the system must take into account the runoff at the ultimate built-out potential from all surfaces draining to the system, including any off-site drainage. The storage volume of the system shall be calculated to provide for the most conservative protection using runoff calculation methods described on pages A.l and A.2 in "Controlling Urban Runoff: A Practical Manual For Planning And Designing Urban BMPs" which is hereby incorporated by reference not including amendments. This document is available through the Metropolitan Washington (D.C.) Council of Governments at a cost of forty dollars ($40.00). This method is also described in the Division's document "An Overview of Wet Detention Basin Design." Other engineering methods may be approved if these methods are shown to provide for equivalent protection;

(2) All side slopes being stabilized with vegetative cover shall be no steeper than 3:1 (horizontal to vertical);

(3) All stormwater management structures shall be located in recorded drainage

easements for the purposes of operation and maintenance and shall have recorded access easements to the nearest public right-of-way. These easements shall be granted in favor of the party responsible for operating and maintaining the stormwater management structures;

(4) Vegetative filters designed in accordance with Paragraph (f) of this Rule are required from the overflow of all infiltration systems and discharge of all stormwater wet detention ponds. These filters shall be at least 30 feet in length, except where a minimum length of 50 feet is required in accordance with Rule .1005(2)(b)(iii) of this Section;

(5) Stormwater controls shall be designed in accordance with the provisions of this Section. Other designs may be acceptable if these designs are shown by the applicant, to the satisfaction of the Director, to provide equivalent protection;

(6) In accordance with the Antidegradation Policy as defined in 15A NCAC 2B .0201, additional control measures may be required on a case-by-case basis to maintain and protect, for existing and anticipated uses, waters with quality higher than the standards; and

(7) Stormwater control measures used for sedimentation and erosion control during the construction phase must be cleaned out and returned to their designed state.

(d) Infiltration System Requirements. Infiltration systems may be designed to provide infiltration of the entire design rainfall volume required for a site or a series of successive systems may be utilized. Infiltration may also be used to pretreat runoff prior to disposal in a wet detention ponds. The following are general requirements:

(1) Infiltration systems shall be a minimum of 30 feet from surface waters and 50 feet from Class SA waters;

(2) Infiltration systems shall be a minimum distance of 100 feet from water supply wells;

(3) The bottom of infiltration systems shall be a minimum of two feet above the seasonal high water table;

(4) Infiltration systems must be designed such that runoff in excess of the design volume by-passes the system and does not flush pollutants through the system;

(5) Infiltration systems must be designed to completely draw down the design storage volume to the seasonal high water table under seasonal high water conditions within five days and a hydrogeologic evaluation may be required to determine whether the system can draw down in five days;

(6) Soils must have a minimum hydraulic conductivity of 0.52 inches per hour to be suitable for infiltration;

(7) Infiltration systems must not be sited on or in fill material, unless approved on a case-by-case basis under Paragraph (h) of this Rule;

(8) Infiltration systems may be required on a case-by-case basis to have an observation well to provide ready inspection of the system;

(9) If runoff is directed to infiltration systems during construction of the project, the system must be restored to design specifications after the project is complete and the entire drainage area is stabilized.

(e) Wet Detention Pond Requirements. These practices may be used as a primary treatment device or as a secondary device following an infiltration system. Wet detention ponds shall be designed for a specific pollutant removal. Specific requirements for these systems are as follows:

(1) The design storage volume shall be above the permanent pool;

(2) The discharge rate from these systems following the one inch rainfall design storm shall be such that the draw down to the permanent pool level occurs within five days, but not in less than two days;

(3) The design permanent pool level mean depth shall be a minimum of three feet and shall be designed with a surface area sufficient to remove 85 percent of total suspended solids. The design for 85 percent total suspended solids removal shall be based on "Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality" which is hereby incorporated by reference not including subsequent amendments. This document is available from the U.S. Environmental Protection Agency (Document number EPA440/5-87-001) at no cost;

(4) The inlet structure must be designed to minimize turbulence using baffles or other appropriate design features and shall be located in a manner that avoids short circuiting in the pond;
(5) Pretreatment of the runoff by the use of vegetative filters may be used to minimize sedimentation and eutrophication of the detention pond;
(6) Wet detention ponds shall be designed with a forebay to enhance sedimentation at the inlet to the pond;
(7) The basin side slopes for the storage volume above the permanent pool shall be stabilized with vegetation down to the permanent pool level and shall be designed in accordance with Subparagraph (c)(2) of this Rule;
(8) The pond shall be designed with side slopes no steeper than 3:1 (horizontal to vertical);
(9) The pond shall be designed to provide for a vegetative shelf around the perimeter of the basin. This shelf shall be gently sloped (6:1 or flatter) and shall consist of native vegetation;
(10) The pond shall be designed to account for sufficient sediment storage to allow for the proper operation of the facility between scheduled cleanout periods.

(f) Vegetative Filter Requirements.' Vegetative filters shall be used as a non-structural method for providing additional infiltration, filtering of pollutants and minimizing stormwater impacts. Requirements for these filters are as follows:

(1) A distribution device such as a swale shall be used to provide even distribution of runoff across the width of the vegetative filter;
(2) The slope and length of the vegetative filter shall be designed, constructed and maintained so as to provide a non-erosive velocity of flow through the filter for the 10 year storm and shall have a slope of five percent or less, where practicable; and
(3) Vegetation in the filter may be natural vegetation, grasses or artificially planted wetland vegetation appropriate for the site characteristics.

(g) Curb Outlet Systems.'/Projects that meet the low density provisions of Rules .1005 through .1007 of this Section may use curb and gutter with outlets to convey the stormwater to grassed swales or vegetated areas prior to the runoff discharging to vegetative filters or wetlands. Requirements for these curb outlet systems are as follows:

(1) The curb outlets shall be located such that the swale or vegetated area can carry the peak flow from the 10 year storm and the velocity of the flow shall be non-erosive;
(2) The longitudinal slope of the swale or vegetated area shall not exceed five percent, where practicable;
(3) The side slopes of the swale or vegetated area shall be no steeper than 5:1 (horizontal to vertical). Where this is not practical due to physical constraints, devices to slow the rate of runoff and encourage infiltration to reduce pollutant delivery shall be provided;
(4) The minimum length of the swale or vegetated area shall be 100 feet; and
(5) In sensitive areas, practices such as check dams, rock or wooden, may be required to increase detention time within the swale or vegetated area.

(h) Alternative Design Criteria. In addition to the control measures outlined in Paragraphs (b), (d), (e), (f) and (g) of this Rule, stormwater management systems consisting of other control options or series of control options may be approved by the Director on a case-by-case basis. This approval shall only be given in cases where the applicant can demonstrate that the Alternative Design Criteria shall provide equal or better stormwater control, equal or better protection of waters of the state, and result in no increased potential for nuisance conditions. The criteria for approval shall be that the stormwater management system shall provide for 85 percent average annual removal of Total Suspended Solids and that the discharge rate from the system meets one of the following:

(1) the discharge rate following the one-inch design storm shall be such that the runoff volume draws down to the pre-storm design stage within five days, but not less than two days; or
(2) the post development discharge rate shall be no larger than predevelopment discharge rate for the one year 24 hour storm.

(i) Operation and maintenance plans/ Prior to approval of the development by the Division an operation and maintenance plan or manual shall be provided by the developer for stormwater systems, indicating the operation and maintenance actions that shall be taken, specific quantitative criteria used for determining when those actions shall be taken, and who is responsible for those actions. The plan must clearly indicate the steps that shall be taken and who shall be responsible for restoring a stormwater system to design specifications if a failure occurs and must include an acknowledgment by the responsible party.

Development must be maintained consistent with the requirements in these plans and the original plans and any modifications to these plans must be approved by the Division.
(j) System Design. Stormwater systems must be designed by an individual who meets any North Carolina occupational licensing requirements for the type of system proposed. Upon completion of construction, the designer for the type of stormwater system installed must certify that the system was inspected during construction, was constructed in substantial conformity with plans and specifications approved by the Division and complies with the requirements of this Section prior to issuance of the certificate of occupancy.

History Note: Authority G.S. J43-214.1; 143-214.7; 143-215.1; 143-215.3(a);
Eff. September 1, 1995.

15A NCAC 02H .1009 STAFF REVIEW AND PERMIT PREPARATION
(a) The staff of the permitting agency shall conduct a review of plans, specifications and other project data accompanying the application and shall determine if the application and required information are complete. The staff shall acknowledge receipt of a complete application.
(b) If the application is not complete with all required information, the application may be returned to the applicant. The staff shall advise the applicant by mail:
(1) how the application or accompanying supporting information may be modified to make them acceptable or complete; and
(2) that the 90 day processing period required in G.S. 143-215.1 begins upon receipt of corrected or complete application with required supporting information.
(c) If an application is accepted and later found to be incomplete, the applicant shall be advised how the application or accompanying supporting information may be modified to make them acceptable or complete, and that if all required information is not submitted within 30 days that the project shall be returned as incomplete.

History Note: Authority G.S. 143-215.1; 143-215.3(a);
Eff. September 1, 1995.

15A NCAC 02H .1010 FINAL ACTION ON PERMIT APPLICATIONS TO THE DIVISION
(a) The Director shall take final action on all applications not later than 90 days following receipt of a complete application and with required information. All permits or renewals of permits and decisions denying permits or renewals shall be in writing.
(b) The Director is authorized to:
(1) issue a permit containing such conditions as are necessary to effectuate the purposes of G.S. 143, Article 21;
(2) issue permit containing time schedules for achieving compliance with applicable water quality standards and other legally applicable requirements;
(3) deny a permit application where necessary to effectuate:
(A) the purposes of G.S. 143, Article 21;
(B) the purposes of G.S. 143-215.67(a);
(C) rules on coastal waste treatment, disposal, found in Section .0400 of this Subchapter;
(D) rules on "subsurface disposal systems," found in 15A NCAC 18A .1900. Copies of these Rules are available from the Division of Environmental Health, P.O. Box 29535, Raleigh, North Carolina 27626-0535; and
(E) rules on groundwater quality standards found in Subchapter 2L of this Chapter.
(4) hold public meetings when necessary to obtain additional information needed to complete the review of the application. The application will be considered as incomplete until the close of the meeting record.
(c) If a permit is denied, the letter of denial shall state the reason(s) for denial and any reasonable measures which the applicant may take to make the application approvable.
(d) Permits shall be issued or renewed for a period of time deemed reasonable by the Director.

History Note: Authority G.S. 143-215.1; 143-215.3(a);
Ejf. September 1,1995.

15A NCAC 02H .1011 MODIFICATION AND REVOCATION OF PERMITS

Any permit issued by the Division pursuant to these Rules is subject to revocation, or modification upon 60 days notice by the Director in whole or part for good cause including but not limited to:

(1) violation of any terms or conditions of the permit;
(2) obtaining a permit by misrepresentation or failure to disclose folly all relevant facts;
(3) refusal of the permittee to allow authorized employees of the Department of Environment, Health, and Natural Resources upon presentation of credentials:
 (a) to enter upon permittee's premises on which a system is located in which any records are required to be kept under terms and conditions of the permit;
 (b) to have access to any copy and records required to be kept under terms and conditions of the permit;
 (c) to inspect any monitoring equipment or method required in the permit; or
 (d) to sample any discharge of pollutants;
(4) failure to pay the annual fee for administering and compliance monitoring.

History Note: Authority G.S. 143-215.1; 143-215.3(a);
Ejf. September 1, 1995.

15A NCAC 02H .1012 DELEGATION OF AUTHORITY

For permits issued by the Division, the Director is authorized to delegate any or all of the functions contained in these Rules except the following:

(1) denial of a permit application;
(2) revocation of a permit not requested by the permittee; or
(3) modification of a permit not requested by the permittee.

History Note: Authority G.S. 143-215.3(a);
Eff. September 1, 1995.

15A NCAC 02H .1013 GENERAL PERMITS

(a) In accordance with the provisions of G.S. 143.215.1(b)(3) and (4), general permits may be developed by the Division and issued by the Director for categories of activities covered in this Section. All activities in the State that received a "Certificate of Coverage" for that category from the Division shall be deemed covered under that general permit. Each of the general permits shall be issued individually under G.S. 143-215.1, using all procedural requirements specified for state permits including application and public notice. Activities covered under general permits, developed in accordance with this Rule, shall be subject to the same standards and limits, management practices, enforcement authorities, and rights and privileges as specified in the general permit. Procedural requirements for application and permit approval, unless specifically designated as applicable to individuals proposed to be covered under the general permits, apply only to the issuance of the general permits. After issuance of the general permit by the Director, activities in the applicable categories may request coverage under the general permit, and the Director or his designee shall grant appropriate certification. General permits may be written to regulate categories of other activities that all: involve the same or substantially similar operations; have similar characteristics; require the same limitations or operating conditions; require the same or similar monitoring; and in the opinion of the Director are more appropriately controlled by a general permit.
(b) No provision in any general permit issued under this Rule shall be interpreted to allow the permittee to violate state water quality standards or other applicable environmental standards.
(c) For a general permit to apply to an activity, a Notice of Intent to be covered by the general permit must be submitted to the Division using forms provided by the Division and, as appropriate, following the application procedures specified in this Section. If all requirements are met, coverage

under the general permit may be granted. If all requirements are not met, a long form application and full application review procedure shall be required.

(d) General permits may be modified and reissued by the Division as necessary. Activities covered by general permits need not submit new Notices of Intent or renewal requests unless so directed by the Division. If the Division chooses not to renew a general permit, all facilities covered under that general permit shall be notified to submit applications for individual permits.

(e) All previous state water quality permits issued to a facility which can be covered by a general permit, whether for construction or operation, are revoked upon request of the permittee, termination of the individual permit and issuance of the Certification of Coverage.

(f) Anyone engaged in activities covered by the general permit rules but not permitted in accordance with this Section shall be considered in violation in G.S. 143-215.1.

(g) Any individual covered or considering coverage under a general permit may choose to pursue an individual permit for any activity covered by this Section.

(h) The Director may require any person, otherwise eligible for coverage under a general permit, to apply for an individual permit by notifying that person that an application is required. Notification shall consist of a written description of the reason(s) for the decision, appropriate permit application forms and application instructions, a statement establishing the required date for submission of the application, and a statement informing the person that coverage by the general permit shall automatically terminate upon issuance of the individual permit. Reasons for requiring application for an individual permit may be:

(1) the activity is a significant contributor of pollutants;
(2) conditions at the permitted site change, altering the constituents or characteristics of the site such that the activity no longer qualifies for coverage under a general permit;
(3) noncompliance with the general permit;
(4) noncompliance with Commission Rules;
(5) a change has occurred in the availability of demonstrated technology or practices for the control or abatement of pollutants applicable to the activity; or
(6) a determination that the water of the stream receiving stormwater runoff from the site is not meeting applicable water quality standards.

(i) Any interested person may petition the Director to take an action under Paragraph (h) of this Rule to require an individual permit.

(j) General permits may be modified, terminated, or revoked and reissued in accordance with the authority and requirements of Rules .1010 and .1011 of this Section.

History Note: Authority G.S. 143-215.1; 143-215.3(a);
Ejf. September 1, 1995.

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GENERAL ASSEMBLY OF NORTH CAROLINA
SESSION 2007

SESSION LAW 2008-211
SENATE BILL 1967

AN ACT TO PROVIDE FOR IMPROVEMENTS IN THE MANAGEMENT OF STORMWATER IN THE COASTAL COUNTIES IN ORDER TO PROTECT WATER QUALITY.

The General Assembly of North Carolina enacts:

SECTION l.(a) Disapprove Rule. - Pursuant to G.S. 150B-21.3(bl), 15A NCAC 02H .1005 (Stormwater Requirements: Coastal Counties), as adopted by the Environmental Management Commission on 10 January 2008 and approved by the Rules Review Commission on 20 March 2008, is disapproved.

SECTION l.(b) Supersede Rule. - 15A NCAC 02H .1005 (Stormwater Requirements: Coastal Counties), effective 1 September 1995, is superseded by this act. References in the North Carolina Administrative Code to 15A NCAC 02H .1005 shall be deemed to refer to the equivalent provisions of this act.

SECTION 2.(a) Definitions. - The following definitions apply to this act and its implementation:

(1) The definitions set out in 15A NCAC 02H .1002 (Definitions).

(2) The definitions set out in G.S. 143-212 and G.S. 143-213.

(3) ’’Built upon area" has the same meaning as in Session Law 2006-246 and means that portion of a project that is covered by impervious or partially impervious surface including, but not limited to, buildings; pavement and gravel areas such as roads, parking lots, and paths; and recreation facilities such as tennis courts. "Built upon area" does not include a wooden slatted deck, the water area of a swimming pool, or pervious or partially pervious paving material to the extent that the paving material absorbs water or allows water to infiltrate through the paving material.

(4) "Permeable pavement" means paving material that absorbs water or allows water to infiltrate through the paving material.^ Permeable pavement materials include porous concrete, permeable interlocking concrete pavers, concrete grid pavers, porous asphalt, and any other material with similar characteristics. Compacted gravel shall not be considered permeable pavement.

(5) "Residential development activities" has the same meaning as in 15A NCAC 02B .0202(54).

(6) "Vegetative buffer" has the same meaning as in 15A NCAC 02H .1002(22) and means an area of natural or established vegetation directly adjacent to surface waters through which stormwater runoff flows in a diffuse manner to protect surface waters from degradation due to development activities.

(7) "Vegetative conveyance" means a permanent, designed waterway lined with vegetation that is used to convey stormwater runoff at a non-erosive velocity within or away from a developed area.

SECTION 2.(b) Requirements for Certain Nonresidential and Residential Development in the Coastal Counties. - All nonresidential development activities that occur within the Coastal Counties that will add more than 10,000 square feet of built

upon area or that require a Sedimentation and Erosion Control Plan, pursuant to G.S. 113A-57 or a Coastal Area Management Act (CAMA) Major Development Permit, pursuant to G.S. 113A-118 and all residential development activities within the Coastal Counties that require a Sedimentation and Erosion Control Plan, pursuant to G.S. 113 A-57 or a Coastal Area Management Act (CAMA) Major Development Permit, pursuant to G.S. 113A-118 shall manage stormwater runoff as provided in this subsection. A development activity or project requires a Sedimentation and Erosion Control Plan if the activity or project disturbs one acre or more of land, including an activity or project that disturbs less than one acre of land that is part of a larger common plan of development. Whether an activity or project that disturbs less than one acre of land is part of a larger common plan of development shall be determined in a manner consistent with the memorandum referenced as "Guidance Interpreting Phase 2 Stormwater Requirements" from the Director of the Division of Water Quality of the Department of Environment and Natural Resources to Interested Parties dated 24 July 2006.

(1) Development Near Outstanding Resource Waters (ORW). - Development activities within the Coastal Counties and located within 575 feet of the mean high waterline of areas designated by the Commission as Outstanding Resource Waters (ORW) shall meet the requirements of 15A NCAC 02H .1007 (Stormwater Requirements: Outstanding Resource Waters) and shall be permitted as follows:

a. Low-Density Option. - Development shall be permitted pursuant to 15A NCAC 02H .1003(d)(1) if the development meets all of the following requirements:

1. The development has a built upon area of twelve percent (12%) or less. A development project with an overall density at or below the low-density threshold, but containing areas with a density greater than the overall project density, shall be considered low-density as long as the project meets or exceeds the requirements for low- density development and locates the higher density development in upland areas and away from surface waters and drainageways to the maximum extent practicable.

2. Stormwater runoff from the development is transported primarily by vegetated conveyances. As used in this sub-sub-subdivision, "conveyance system" shall not include a stormwater collection system. Stormwater runoff from built upon areas that is directed to flow through any wetlands shall flow into and through these wetlands at a non-erosive velocity.

3. The development contains a 5 0-foot-wide vegetative buffer for new development activities and a 30-foot-wide vegetative buffer for redevelopment activities. The width of a buffer is measured horizontally from the normal pool elevation of impounded structures, from the bank of each side of streams or rivers, and from the mean high waterline of tidal waters, perpendicular to the shoreline. The vegetative buffer may be cleared or graded, but must be planted with and maintained in grass or any other vegetative or plant material. The Division of Water Quality may, on a case-by-case basis, grant a minor variance from the vegetative buffer requirements of this section pursuant to the procedures set out in 15A NCAC 02B .0233(9)(b). Vegetative buffers and filters required by this section and any other buffers or filters required by State water quality or coastal management rules or local government requirements

may be met concurrently and may contain, in whole or in part, coastal, isolated, or 404 jurisdictional wetlands that are located landward of the normal waterline.

b. High-Density Option. - Development shall be permitted pursuant to 15A NCAC 02H .1003(d)(2) if the development meets all of the following requirements:

1. The development has a built upon area of greater than twelve percent (12%).
2. The development has no direct outlet channels or pipes to Class SA waters unless permitted in accordance with 15A NCAC 02H .0126. Stormwater runoff from built upon areas that is directed to flow through any wetlands shall flow into and through these wetlands at a non-erosive velocity.
3. The development utilizes control systems that are any combination of infiltration systems, bioretention systems, constructed stormwater wetlands, sand filters, rain barrels, cisterns, rain gardens or alternative low impact development stormwater management systems designed in accordance with 15A NCAC 02H .1008 to control and treat the runoff from all surfaces generated by one and one-half inches of rainfall, or the difference in the stormwater runoff from all surfaces from the predevelopment and postdevelopment conditions for a one-year, 24-hour storm, whichever is greater. Wet detention ponds may be used as a stormwater control system to _ meet the_ requirements of this sub-sub-subdivision, provided that the stormwater control system fully complies with the requirements of this sub-subdivision. If a wet detention pond is used within one-half mile of Class SA waters, installation of a stormwater best management practice in series with the wet detention pond shall be required to treat the discharge from the wet detention pond. Secondaty stormwater best management practices that are used in series with another stormwater best management practice do not require any minimum separation from the seasonal high water table. Alternatives as described in 15A NCAC 02H .1008(h) may also be approved if they meet the requirements of this sub-subdivision.
4. Stormwater runoff from the development that is in excess of the design volume must flow overland through a vegetative filter designed in accordance with 15A NCAC 02H .1008 with a minimum length of 50 feet measured from mean high water of Class SA waters.
5. The development contains a 50-foot-wide vegetative buffer for new development activities and a 30-foot-wide vegetative buffer for redevelopment activities. The width of a buffer is measured horizontally from the normal pool elevation of impounded structures, from the bank of each side of streams or rivers, and from the mean high waterline of tidal waters, perpendicular to the shoreline.

   The vegetative buffer may be cleared or graded, but must be planted with, and maintained in, grass or any other vegetative or plant material. Furthermore, stormwater control best management practices (BMPs), or stormwater control structures, with the exception of wet detention ponds, may be located within this vegetative buffer. The

Division of Water Quality may, on a case by case basis, grant a minor variance from the vegetative buffer requirements of this section pursuant to the procedures set out in 15A NCAC 02B .0233(9)(b). Vegetative buffers and filters required by this section and any other buffers or filters required by State water quality or coastal management rules or local government requirements may be met concurrently and may contain, in whole or in part, coastal, isolated, or 404 jurisdictional wetlands that are located landward of the normal waterline.

c. Stormwater Discharges Prohibited. - All development activities, including both low- and high-density projects, shall prohibit new points of stormwater discharge to Class SA waters or an increase in the volume of stormwater flow through conveyances or increase in capacity of conveyances of existing stormwater conveyance systems that drain to Class SA waters. Any modification or redesign of a stormwater conveyance system within the contributing drainage basin must not increase the net amount or rate of stormwater discharge through existing outfalls to Class SA waters. The following shall not be considered a direct point of stormwater discharge:

1. Infiltration of the stormwater runoff from the design storm as described in sub-sub-subdivision 3. of sub-subdivision b. of subdivision (1) of this subsection.
2. Diffuse flow of stormwater at a non-erosive velocity to a vegetated buffer or other natural area, that is capable of providing effective infiltration of the runoff from the design storm as described in sub-sub-subdivision 3. of sub-subdivision b. of subdivision (1) of this subsection. Notwithstanding the other requirements of this section, the infiltration mandated in this sub-sub-subdivision does not require a minimum separation from the seasonal high-water table.
3. The discharge from a wet detention pond that is treated by a secondary stormwater best management practice, provided that both the wet detention pond and the secondary stormwater best management practice meet the requirements of this sub-subdivision.

d. Limitation on the Density of Development. - Development shall be limited to a built upon area of twenty-five percent (25%) or less.

(2) Development Near Class SA Waters. - Development activities within one-half mile of and draining to those waters classified by the Commission as Class SA waters or within one-half mile of waters classified by the Commission as Class SA waters and draining to unnamed freshwater tributaries to Class SA waters shall meet the requirements of sub-subdivisions a., b., and c. of subdivision (1) of this subsection. The extent of Class SA waters is limited to those waters

that are determined to be at least an intermittent stream based on a site stream determination made in accordance with the procedures that are delineated in the Division of Water Quality's "Identification Methods for the Origin of Intermittent and Perennial Streams" prepared pursuant to Session Law 2001-404.

(3) Other Coastal Development. - Development activities within the Coastal Counties except those areas described in subdivisions (1) and (2) of this subsection shall meet all of the following requirements:

a. Low-Density Option: Development shall be permitted pursuant to 15A NCAC 02H .1003(d)(1) if the development meets all of the following requirements:

1. The development has a built upon area of twenty-four percent (24%) or less. A development project with an overall density at or below the low-density threshold, but containing areas with a density greater than the overall project density, shall be considered low density as long as the project meets or exceeds the requirements for low- density development and locates the higher density in upland areas and away from surface waters and drainageways to the maximum extent practicable.

2. Stormwater runoff from the development is transported primarily by vegetated conveyances. As used in this sub-sub-subdivision, "conveyance system" shall not include a stormwater collection system. Stormwater runoff from built upon areas that is directed to flow through any wetlands shall flow into and through these wetlands at a non-erosive velocity.

3. The development contains a 50-foot-wide vegetative buffer for new development activities and a 3 0-foot-wide vegetative buffer for redevelopment activities. The width of a buffer is measured horizontally from the normal pool elevation of impounded structures, from the bank of each side of streams or rivers, and from the mean high waterline of tidal waters, perpendicular to the shoreline. The vegetative buffer may be cleared or graded, but must be planted with, and maintained in, grass or any other vegetative or plant material. The Division of Water Quality may, on a case-by-case basis, grant a minor variance from the vegetative buffer requirements of this section pursuant to the procedures set out in 15A NCAC 02B .0233(9)(b). Vegetative buffers and filters required by this section and any other buffers or filters required by State water quality or coastal management rules or local government requirements may be met concurrently and may contain, in whole or in part, coastal, isolated, or 404 jurisdictional wetlands that are located landward of the normal waterline.

b. High-Density Option: Higher density developments shall be permitted pursuant to 15A NCAC 02H .1003(d)(2) if the development meets all of the following requirements:

1. The development has a built upon area of greater than twenty-four percent (24%).

2. The development uses control systems that are any combination of infiltration systems, wet detention ponds, bioretention systems, constructed stormwater wetlands, sand filters, rain barrels, cisterns, rain gardens or alternative

stormwater management systems designed in accordance with 15ANCAC 02H .1008.

3. Control systems must be designed to store, control, and treat the stormwater runoff from all surfaces generated by one and one-half inch of rainfall.
4. Stormwater runoff from built upon areas that is directed to flow through any wetlands shall flow into and through these wetlands at a non-erosive velocity.
5. A 5 0-foot-wide vegetative buffer for new development activities and a 30-foot-wide vegetative buffer for redevelopment activities. The width of a buffer is measured horizontally from the normal pool elevation of impounded structures, from the bank of each side of streams or rivers, and from the mean high waterline of tidal waters, perpendicular to the shoreline. The vegetative buffer may be cleared or graded, but must be planted with, and maintained in, grass or any other vegetative or plant material. Furthermore, stormwater control best management practices (BMPs), or stormwater control structures, with the exception of wet detention ponds, may be located within this vegetative buffer. The Division of Water Quality may, on a case by case basis, grant a minor variance from the vegetative buffer requirements of this section pursuant to the procedures set out in 15A NCAC 02B .0233(9)(b). Vegetative buffers and filters required by this section and any other buffers or filters required by State water quality or coastal management rules or local government requirements may be met concurrently and may contain, in whole or in part, coastal, isolated, or 404 jurisdictional wetlands that are located landward of the normal waterline.

(4) Requirements for Structural Stormwater Controls. - Structural stormwater controls required under this section shall meet all of the following requirements:

a. Remove an eighty-five percent (85%) average annual amount of Total Suspended Solids.
b. For detention ponds, draw down the treatment volume no faster than 48 hours, but no slower than 120 hours.
c. Discharge the storage volume at a rate equal to or less than the predevelopment discharge rate for the one-year, 24-hour storm.
d. Meet the General Engineering Design Criteria set forth in 15A NCAC 02H.1008(c).
e. For structural stormwater controls that are required under this section and that require separation from the seasonal high-water table, a minimum separation of two feet is required. Where a separation of two feet from the seasonal highwater table is not practicable, the Division of Water Quality may grant relief from the separation requirement pursuant to the Alternative Design Criteria set out in 15A NCAC 02H .1008(h). No minimum separation from the seasonal highwater table is required for a secondary stormwater best management practice that is used in a series with another stormwater best management practice.

(5) Certain Wetlands Excluded From Density Calculation. - For the purposes of this section, areas defined as Coastal Wetlands under 15A NCAC 07H .0205, as measured landward from the normal high waterline, shall not be included in the overall project area to calculate impervious surface density.

Wetlands that are not regulated as coastal wetlands pursuant to 15A NCAC 07H .0205 and that are located landward of the normal high waterline may be included in the overall project area to calculate impervious surface density.

SECTION 2.(c) Requirements for Limited Residential Development in Coastal Counties. - For residential development activities within the 20 Coastal Counties that are located within one-half mile and draining to Class SA waters, that have a built upon area greater than twelve percent (12%), that do not require a stormwater management permit under subsection (b) of this section, and that will add more than 10,000 square feet of built upon area, a one-time, nonrenewable stormwater management permit shall be obtained. The permit shall require recorded deed restrictions or protective covenants to ensure that the plans and specifications approved in the permit are maintained. Under this permit, stormwater runoff shall be managed using any one or combination of the following practices:

(1) Install rain cisterns or rain barrels designed to collect all rooftop runoff from the first one and one-half inches of rain. Rain barrels and cisterns shall be installed in such a manner as to facilitate the reuse of the collected rain water on site and shall be installed in such a manner that any overflow from these devices is directed to a vegetated area in a diffuse flow. Construct all uncovered driveways, uncovered parking areas, uncovered walkways, and uncovered patios out of permeable

E avement or other pervious materials, lirect rooftop runoff from the first one and one-half inches of rain to an appropriately sized and designed rain garden. Construct all uncovered driveways, uncovered parking areas, uncovered walkways, and uncovered patios out of permeable pavement or other pervious materials.

(3) Install any other stormwater best management practice that meets the requirements of 15A NCAC 02H .1008 to control and treat the stormwater runoff from all built upon areas of the site from the first one and one-half inches of rain.

SECTION 2.(d) Exclusions. - The requirements of this section shall not apply to any of the following:

(1) Activities of the North Carolina Department of Transportation that are regulated in accordance with the provisions of the Department's National Pollutant Discharge Elimination System (NPDES) Stormwater Permit.

(2) Development activities that are conducted pursuant to and consistent with one of the following authorizations, or any timely renewal thereof, shall be regulated by those provisions and requirements of 15A NCAC 02H .1005 that were effective at the time of the original issuance of the following authorizations:

a. State Stormwater Permit issued under the provisions of 15A NCAC 02H.1005.

b. Stormwater Certification issued pursuant to 15A NCAC 02H .1000 prior to 1 December 1995.

c. A Coastal Area Management Act Major Permit,

d. 401 Certification that contains an approved Stormwater Management Plan.

e. A building permit pursuant to G.S. 153A-357 or G.S. 160A-417.

f. A site-specific development plan as defined by G.S. 153A-344.1(b)(5) and G.S. 160A-385.1(b)(5).

g. A phased development plan approved pursuant to G.S. 153A-344.1 or G.S. 160A-385.1 that shows:

1. For the initial or first phase of development, the type and intensity of use for a specific parcel or parcels, including at a minimum, the boundaries of the project and a subdivision plan that has been approved pursuant to G.S. 153A-330 through G.S. 153A-335 or G.S. 160A-371 through G.S. 160A-376.

2. For any subsequent phase of development, sufficient detail so that implementation of the requirements of this section to that phase of development would require a material change in that phase of the plan.

h. A vested right to the development pursuant to common law.

(3) Redevelopment activities that result in no net increase in built upon area and provide stormwater control equal to the previous development.

(4) Development activities for which a complete Stormwater Permit Application has been accepted by the Division of Water Quality prior to the effective date of this act, shall be regulated by the provisions and requirements of 15A NCAC 02H .1005 that were effective at the time that this application was accepted as complete by the Division of Water Quality. For purposes of this subsection, a Stormwater Permit Application is deemed accepted as complete by the Division of Water Quality when the application is assigned a permit number in the Division's Basinwide Information Management System.

(5) Development activities for which only a minor modification of a State Stormwater Permit is required shall be regulated by the provisions and requirements of 15A NCAC 02H .1005 that were effective at the time of the original issuance of the State Stormwater Permit. For purposes of this subsection, a minor modification of a State Stormwater Permit is defined as a modification that does not increase the net area of built upon area within the project site or does not increase the overall size of the stormwater controls that have been previously approved for that development activity.

(6) Municipalities designated as a National Pollutant Discharge Elimination System (NPDES) Phase 2 municipality located within the 20 Coastal Counties until such time as the NPDES Phase 2 Stormwater Permit expires and is subject to renewal. Upon renewal of the NPDES Phase 2 Stormwater Permits for municipalities located within the 20 Coastal Counties, the Department shall review the permits to determine whether the permits should be amended to include the provisions of this section.

SECTION 2.(e) Exemptions From Vegetative Buffer Requirements. - The following activities are exempt from the vegetative buffer requirements of this section:

(1) Development in urban waterfronts that meets the requirements of 15A NCAC 07H .0209(g),

(2) Development in a new urban waterfront area that meets the requirements of Session Law 2004-117,

(3) Those activities listed in 15A NCAC 07H .0209(d)(10)(A) through 15ANCAC 07H .0209(d)(10)(H),

(4) Development of upland marinas that have received or are required to secure a Coastal Area Management Act Major Permit.

SECTION 2.(f) Compliance with Other Rules. - In addition to the requirements specified in this section, activities regulated under this section must also comply with any requirements of any other applicable law or rule.

SECTION 3. Rescission of Phase 2 Designations. - All designations of local governments within the 20 Coastal Counties as Phase 2 municipalities by the Environmental Management Commission under Section 5 of Session Law 2006-246 that occurred after 16 August 2006 are rescinded. The provisions of this section do not preclude any future designations of these areas as Phase 2 municipalities by the Environmental Management Commission under Section 5 of Session Law 2006-246.

SECTION 4. Additional Rule Making. - The Commission may adopt rules to replace the rules that are disapproved or superseded as provided in Section 1 of this act. If the Commission adopts rules pursuant to this section, notwithstanding G.S. 150B-19(4), the rules shall be substantively identical to the provisions of Section 2 of this act. The Commission may reorganize or renumber any of the rules to which this section applies at its discretion. Rules adopted pursuant to this section are not subject to G.S. 150B-21.9 through G.S. 150B-21.14. Rules adopted pursuant to this section shall become effective as provided in G.S. 150B-21.3(bl) as though 10 or more written objections had been received as provided by G.S. 150B-21.3(b2).

SECTION 5. Construction of Act. -

(1) Except as specifically provided in Section 4 of this act, nothing in this act shall be construed to limit, expand, or otherwise alter the authority of the Environmental Management Commission or any unit of local government.

(2) This act shall not be construed to affect any delegation of any power or duty by the Commission to the Department or subunit of the Department.

(3) As used in subsection (b) of Section 2 of this act, the phrase "common plan of development" shall be interpreted and implemented in a manner consistent with the memorandum referenced as "Guidance Interpreting Phase 2 Stormwater Requirements" from the Director of the Division of Water Quality of the Department of Environment and Natural Resources to Interested Parties dated 24 July 2006, and for these purposes the memorandum shall be considered a part of this act and as such shall be printed as a part of the Session Laws.

SECTION 6. Application of Memorandum to Prior Session Law. - Subdivision (5) of Section 18 of S.L. 2006-246 reads as rewritten:

"(5) As used in Section 9 of this act, the phrase 'common plan of development or sale' shall be interpreted and implemented in a manner consistent with the memorandum referenced as 'Guidance Interpreting Phase II Stormwater Requirements' from the Director of the Division of Water Quality of the Department of Environment and Natural Resources to Interested Parties dated 24 July <u>2006. and for these </u>purposes the memorandum shall be considered a part of this act and as

such shall be printed as a part of the Session Laws."

SECTION 7. Provisions of Act Not Codified; Set Out As Note. - Notwithstanding G.S. 164-10, the Revisor of Statutes shall not codify any of the provisions of this act. The Revisor of Statutes shall set out the text of this act as a note to G.S. 143-214.7 and may make notes concerning this act to other sections of the General Statutes as the Revisor of Statutes deems appropriate.

SECTION 8. Effective Date. - Subsection (b) of Section 1 of this act and Sections 2 and 3 of this act become effective 1 October 2008. All other sections of this act are effective when this act becomes law.

In the General Assembly read three times and ratified this the 15th day of July, 2008.

s/ Beverly E. Perdue
President of the Senate

s/ Joe Hackney
Speaker of the House of Representatives

s/ Michael F. Easley
Governor

Approved 10:01 a.m. this 9th day of August, 2008