Chapter 9. WATER QUALITY

9.1. Water Quality Background and Calculations

The selection and design guidelines set forth in this chapter of the Design Manual for water quality controls are provided to aid the design professional in planning and designing appropriate water quality BMPs relative to target pollutants, function, ease of maintenance, aesthetics, and safety. The design professional is responsible for designing water quality BMPs to function properly for each specific site. It is important to understand the types of pollutants that are present in urban runoff as well as their potential impacts on receiving water bodies. It is equally important to locate the source of these pollutants so source controls can be applied to eliminate these pollutants from entering receiving water bodies. Table 9-1 lists typical urban storm water runoff pollutants and their sources, and the list is by no means exhaustive.

Table 9-1 Pollutants and Sources in the Urban Landscape

Pollutant Source	Pollutant of Concern
Erosion	Sediment and attached soil nutrients, organic matter, and other adsorbed pollutants.
Atmospheric Deposition	Hydrocarbons emitted from automobiles, dust, metals, and other chemicals released from industrial and commercial activities.
Construction Materials	Metals, paint, and wood preservatives.
Manufactured Products	Heavy metals, phenols and oils from automobiles, Zinc and Cadmium from tire wear.
Landscape Maintenance	Fertilizer and pesticides. Generally as impervious area increases, nutrients build up on surfaces and runoff transport capacities rise resulting in high loads.
Plants and Animals	Plant debris, animal excrement.
Septic Tanks	Coliform bacteria, nitrogen, NO_3.
Non-Storm Water Connections	Sanitary sewage, industrial wastewater, commercial discharge, and construction activities.
Accidental Spills	Pollutants of concern depend on the nature of the spill.
Animal Waste Management	Fecal coliform, nitrates and phosphorus.
Pesticide Applications	Pollutants of concern depend on the pesticide being used and the type of crop.
Land Disturbance Agriculture	Sediment and attached soil nutrients, organic matter, and other adsorbed pollutants.
Fertilizer Applications	Nitrogen and phosphorus.

Source: U.S. Environmental Protection Agency, June 1992.

9.1.1 Characterization of Urban Storm Water Runoff Quality

9.1.1.1 Suspended Solids

The most prevalent form of storm water pollution is the presence of suspended matter that is either eroded by storm water or washed off paved surfaces by storm water. Suspended solids increase the turbidity of the receiving water, thereby reducing the penetration of light, resulting in decreased activity and growth of photosynthetic organisms. Also, elevated concentrations of suspended sediment alters stream nutrient biogeochemistry which impacts nutrient adsorption and desorption, processes very important to control over primary production and overall ecosystem health (Lee, 1996; Dent and Henry, 1999). The increased turbidity also detracts from the aesthetics of natural waters. In addition, the clogging of fish gills has been attributed to the presence of suspended solids. Combined sewer overflows typically contain high suspended solids concentrations. The solids that settle in the receiving water pose long-term threats resulting from their oxygen demand and gradual accumulation of toxic substances (Moffa, 1990). Sedimentation and other forms of physical separation are often an effective means of removing suspended solids from storm water.

Sediment is derived from a variety of sources, including erosion from disturbed areas, washoff of sediment deposited on impervious areas, and detachment of sediment due to the increased stream power that comes from increased flow rates and flow durations with urbanization. A significant number of

models are available to predict total suspended solids (TSS) contributions from “clean” sediment, but few of the models have parameters specific to urbanized areas. Most of the models were developed to deal with agricultural soils, and their application to urban areas is limited.

Models that do have capabilities that have been used for predicting urban clean sediment include SWMM and the SEDIMOT models. For the models to be effectively utilized in sizing BMPs, predictions must be made of time varying quantities as well as the size distribution. Those distributions must be of the aggregated particles, not the primary particles.

9.1.1.2 Oxygen Demanding Matter and Bacteria

Sufficient levels of dissolved oxygen (DO) in the water column are necessary to maintain aquatic life, growth, and reproductive activity, as well as to maintain aerobic conditions. The introduction of storm water containing oxygen-demanding organic matter can impair the receiving water quality by reducing the DO levels such that it is unable to sustain certain forms of aquatic life and can further cause the water to become foul. Bacteria enter the storm water drainage system typically from the washoff of animal feces and organic matter from the catchment surface. Occasionally, bacteria may enter the drainage system through residential sanitary lateral connections and industrial or commercial drains, although such practices are typically illegal. Organic matter, usually in the form of vegetation and detritus, is carried through the conveyance system by the storm water. Pathogenic bacteria and viruses in storm water discharges pose human health threats. The removal of pathogenic bacteria is achieved primarily through the process of biological decay and physical-chemical disinfection where practiced.

9.1.1.3 Nutrients

Nitrogen and phosphorus are plant nutrients that promote the growth of plants and protista such as algae, and are the second leading stressor of impaired rivers and streams and the leading stressor of impaired lakes (US EPA, 1997). Such nutrients contribute to the eutrophication of water bodies resulting in the list of associated liabilities such as decreased oxygen supply, alteration of aquatic life, decreased recreational value (Novotny,1985).

Nutrients are typically derived from agricultural runoff as well as runoff from chemicals applied to lawns in urbanized areas, runoff from industrial sites, municipal wastewaters (of more concern for combined sewer overflows), or dry fall onto impervious surfaces that is later washed into storm water. Model studies indicate that the increase in nutrient loading due to increased imperviousness will be dramatic. For example, the increase in the Maryland Chesapeake Bay watershed due to increased urbanization is expected to range from 2 to 20 times the current load, depending on whether residential development is highly restricted or unrestricted (Houlahan, 1992). Nutrients can be removed from storm water prior to discharge through biological uptake such as by plantings in storm water quality control ponds.

Most models of nutrient loadings that have an extensive data base included have been based on agricultural and forest operations. These have applicability to washoff from fertilized lawns and forested areas but not to the impervious areas. Models of nutrient loading in urban runoff are typically based on washoff type calculations or user-defined loadings and concentrations, all of which require user-defined constants. Estimating the water quality loading for nutrients is difficult to accomplish without local data.

9.1.2 Pollutant Loading

Estimating the pollutant load for a particular development site is commonly calculated based on the general land use category of the site. Primary land use contributors are streets, roads, highways, residential areas, commercial areas, industrial areas, and sites under development.

The control of urban runoff can be classified in two categories:

- Runoff quantity control, and
- Runoff quality control.

Quantity control techniques are well established and are based on the physical laws of conservation and momentum. Such measures seek to attenuate peak runoff flow rates and to reduce hydrograph volumes to mitigate flooding and the potential for erosion downstream.

A much more difficult task is the water quality control of urban runoff. This problem is confounded by the intermittent nature of rainfall, the variability of rainfall characteristics, such as volume and intensity, and the variability of constituent concentrations.

Tables 9-2 through 9-6 list several published pollutants loads based on urban land use.

Table 9-2. Urban "C" Values For Use With the Simple Method (mg/l)

Pollutant	New Suburban NURP Sites (Wash DC)	Older Urban Areas (Baltimore)	Central Business District (Wash DC)	National NURP Study Average	Hardwood Forest (Virginia)	National Urban Highway Runoff
Phosphorus						
Total	0.26	1.08	---	0.46	0.15	---
Orhto	0.12	0.26	1.01	---	0.02	---
Soluble	0.16	---	---	0.16	0.04	0.59
Organic	0.10	0.82	---	0.13	0.11	---
Nitrogen						
Total	2.00	13.6	2.17	3.31	0.78	---
Nitrate	0.48	8.9	0.84	0.96	0.17	---
Ammonia	0.26	1.1	---	---	0.07	---
Organic	1.25	---	---	---	0.54	---
TKN	1.51	7.2	1.49	2.35	0.61	2.72
COD	35.6	163.0	---	90.8	> 40.0	124.0
BOD (5-day)	5.1	---	36.0	11.9	---	---
Zinc	0.037	0.397	0.250	0.176	---	0.380
Lead	0.018	0.386	0.370	0.180	---	0.550
Copper	---	0.105	---	0.047	---	---

Source: Schueler (1987)

Table 9-3. Concentrations For Use With the Simple Method (mg/l)

Pollutant	Residential	Mixed	Commercial	Open/Non-urban
BOD (5-day)	10.0	7.8	9.3	---
COD	73	65	57	40
TSS	101	67	69	70
Total P	0.383	0.263	0.201	0.121
Soluble P	0.143	0.560	0.800	0.250
TKN	1.900	1.288	1.179	0.965
Nitrate	0.736	0.558	0.572	0.543
Copper	0.144	0.114	0.104	0.030
Lead	0.033	0.027	0.029	---
Zinc	0.135	0.154	0.226	0.195

Source: NURP (U.S. Environmental Protection Agency, 1983)

Table 9-4. Event Mean Concentrations in mg/l for Simple Method for Greenville, S.C. Area

Pollutant	Open / Ag	Residential	Office	Woods	Industrial	Commercial
TSS	185	138	308	119	133	99
TDS	79	58	85	41	57	48
Total-P	0..22	0.41	0.24	0.15	0.11	0.19
Dissolved-P	0.04	0.10	0.06	0.01	0.02	0.08
Total-N	2.49	2.19	2.14	0.79	1.43	1.61

Source: Greenville County Annual Report for NPDES Phase I MS4 Permit Prepared by Woolpert Inc. (Woolpert 2007)

Table 9-5. Estimated Pollutant Loading for Various Land Uses (mg/l)

	Estimated Pollutant Loading (mg/l)											
Land Use	BOD	COD	TSS	TDS	TP	DP	TKN	NO2 / NO3	Pb	Cu	Zn	Cd
Forest/ Rural Open	3	27	51	415	0.11	0.03	0.94	0.80	0.000	0.000	0.000	0.000
Urban	3	27	51	415	0.11	0.03	0.94	0.80	0.014	0.000	0.040	0.001
Agricultural/ Pasture	3	53	145	415	0.37	0.09	1.92	4.06	0.000	0.000	0.000	0.000
Low Density Residential	38	124	70	144	0.52	0.27	3.32	1.83	0.057	0.026	0.161	0.004
Medium Density Residential	38	124	70	144	0.52	0.27	3.32	1.83	0.180	0.047	0.176	0.004
High Density Residential	14	79	97	189	0.24	0.08	1.17	2.12	0.041	0.033	0.218	0.003
Commercial	21	80	77	294	0.33	0.17	1.74	1.23	0.049	0.037	0.156	0.003
Industrial	24	85	149	202	0.32	0.11	2.08	1.89	0.072	0.058	0.671	0.005
Highways	24	103	141	294	0.43	0.22	1.82	0.83	0.049	0.037	0.156	0.003
Water/ Wetlands	4	6	6	12	0.08	0.04	0.79	0.59	0.011	0.007	0.003	0.001

Adapted from NURP (1983), Horner et. al (1994), and Cave at. Al. (1994)

Table 9-6. Estimated Pollutant Loading for Various Land Uses (lbs/ac-yr)

	Estimated Pollutant Loading (lbs/ac-yr)					
Land Use	TSS	Total Phosphorus	Total Nitrogen	Pb	Zn	Cu
Road	447	0.95	2.14	0.70	0.28	0.05
Commercial	717	0.71	4.63	2.79	2.94	1.90
Single-Family, Low Density	178	0.49	3.56	0.05	0.12	0.16
Single-Family, High-Density	287	0.58	4.57	0.09	0.20	0.27
Multi-Family Residential	395	0.62	5.01	0.62	0.30	0.30
Forest	77	0.10	1.75	0.02	0.02	0.02
Grass	301	0.12	3.71	0.06	0.09	0.03
Pasture	305	0.12	3.71	0.09	0.09	0.03

Source: Terrene Institute, 1994

BOD	=	Biochemical Oxygen Demand	TKN	=	Total Kjeldahl Nitrogen
COD	=	Chemical Oxygen Demand	NO_2/NO_3	=	Nitrates / Nitrites
TSS	=	Total Suspended Solids	Pb	=	Lead
TDS	=	Total Dissolved Solids	Cu	=	Copper
TP	=	Total Phosphorus	Zn	=	Zinc
DP	=	Dissolved Phosphorus	Cd	=	Cadmium

9.2. Calculating Pollutant Loads Using the Simple Method

Schueler (1987) presented a constant concentration method of determining pollutant loads commonly known as the Simple Method. This method multiplies flows by a constant pollutant concentration based on land use. This method is based on an extensive database obtained in Washington, D.C. for the National Urban Runoff Program (NURP). The Simple Method estimates pollutant loads from urban development by the following equation:

$$L = 0.227(P \ P_j \ R_v \ C \ A)$$

Where:

L = Pollutant load in pounds per desired time interval
P = Rainfall depth over the desired time interval in inches
$\mathbf{P_j}$ = Fraction of rainfall events over the time interval that produce runoff
$\mathbf{P_j}$ = 1 for a single event
$\mathbf{P_j}$ = 0.9 for larger time intervals (months, years)
$\mathbf{R_v}$ = Volumetric runoff coefficient expressing the fraction of rainfall converted to runoff
C = Event mean pollutant concentration in mg/l (taken from local field data or tables)
A = Total area of site in acres (areas < 640 acres are recommended)

The most important factor affecting the volumetric runoff coefficient ($\mathbf{R_v}$) is the imperviousness of the watershed, **I**, in percent. An empirical relationship was developed that relates $\mathbf{R_v}$ and I as:

$$R_v = 0.05 + 0.09(I)$$

Event mean pollutant concentrations, **C,** should be obtained from local data. For situations where they are not available, values of **C** can be approximated from Tables 9-2, 9-3, and 9-4.

9.3. Calculating Pollutant Loads Using the Greenville IDEAL Model

9.3.1 Background

The intent of legislation such as the South Carolina Storm Water Management and Sediment Reduction Act is that developments in South Carolina will not negatively impact water quality and downstream habitats. The potential for problems present challenges to engineers and developers to design and install best management practices that will not cause the state's waters to be impaired by pollutants such as nutrients, sediment, or bacteria. Simplified methods and the IDEAL (Integrated Design and Assessment for Environmental Loadings) Model for calculating pollutant removal efficiency of BMPs and treatment systems will assist designers and regulators in meeting state and federal requirements.

The IDEAL Model provides Greenville County specific design methods that give reasonable assurance that effluent meets desired performance without the lengthy design process typically associated with designs developed to meet a performance standard. The use of area specific design methods provides a means of achieving control without the steep learning curve associated with simulation techniques. For large-scale developments or in sensitive areas, it is still anticipated that site specific data and other procedures such as modeling be used for detailed evaluation of controls.

9.3.2 Approach

The IDEAL Model includes estimation of performance of detention/retention ponds, extended detention ponds, sand filters, and riparian buffers. The performance of each control is modeled using Greenville County specific conditions (including soils, topography, and climate) and compared with removal efficiency. For each structure, spreadsheet modeling was developed that is consistent with performance standards.

Effectiveness of control, or removal efficiency, is commonly determined by either a water quality design standard or a performance standard. A water quality performance standard dictates a maximum acceptable level (i.e., concentration) in the effluent. The control is designed such that this level is not exceeded. On the other hand, a water quality design standard establishes a standard specification based on a given drainage area or similar criterion. There are obvious benefits associated with each method. Performance standards offer site specific water quality control, but require considerable on-site collection of information for design purposes and are much more difficult to design and review. Structures designed for performance standards have a higher design cost than structures designed for water quality design standards. However construction costs tend to be considerably less, since design standards are inherently conservative. Design standards, on the other hand, are more easily employed and complied with but often entail risk that the structure is either grossly over designed, resulting in added installation costs, or grossly under designed so that the measure may not perform satisfactorily, particularly in sensitive areas. A preferable alternative to these methods is to provide a design procedure that can meet a desired performance without incurring excessive design costs. To achieve this, the design is typically expected to be slightly conservative, but considerably less conservative than if developed from a design standard.

The IDEAL Model is based on site visits at numerous construction locations throughout South Carolina in order to see innovative BMPs, as well as areas needing improvement. Cooperation with regulatory personnel included discussions as to what specific BMPs should/should not be considered for evaluation.

It is recognized that there are a large number of potential post construction BMPs that can potentially be used.

Evaluation of existing modeling capabilities led to the development of a new spreadsheet model known as IDEAL. The IDEAL Model, a model for hydrology, sedimentology, and water quality, contains much detail and ties water quality modeling together with physical, chemical, and biological relationships to provide a much more realistic description of reactions that are taking place in the real world.

It should be recognized that selection of an appropriate water quality model to allow evaluation of a wide range of pollutant control technologies in a seamless manner depends on the user's application. This process led to some modifications in the program to account for selected BMPs, treatment trains, topography, soil properties, and climate. Data bases of rainfall records for three Greenville County locations were analyzed to simplify user data requirements and simplify input for spreadsheets.

Since the method selected for accomplishing the simulation is critical, several items were considered.

- Combine hydrologic, and hydraulic routines with accepted pollutant removal routines.
- Impact on channels or ponds on adjacent wetlands.
- Consider each of the pollutants of interest (nutrients, sediment, and bacteria indicator).

Each of these tasks was accomplished, and the results analyzed to produce spreadsheets that can be used as an aid for designing BMPs based on pollutant removal. It should be recognized that aids such as these are developed for typical conditions. More detailed evaluation methods should be utilized if the situation is environmentally sensitive or hazardous. In all cases, good engineering judgment should be considered as an essential ingredient in design.

9.3.3 The IDEAL Model

The IDEAL Model assists in streamlining the storm water permitting application process for new development and provides consistent water quality protection from all storm water runoff, in addition to traditional storm water management and erosion control requirements. These design aids provide a reasoned and uniform approach to evaluating the effect on water quality of storm water runoff.

The IDEAL Model is not rules or regulations promulgated by the agency, but is guidance for evaluation and implementation of BMPs for storm water design. The IDEAL Model was developed by means of a comprehensive literature review and then use of best available science and valid scientific principles. State environmental agencies and the EPA have traditionally used guidance documents to provide preferred methodology to assist its staff with consistent application and to provide information and guidance to persons outside the agency to allow them to more effectively and efficiently implement program requirements. Because the IDEAL Model is not binding rules, alternative approaches, methodologies and solutions are allowed; however, it is incumbent on one proposing an alternative to adequately demonstrate both the effectiveness and equivalency of that alternative. IDEAL is available on the Greenville County website along with documentation.

9.4. Water Quality Regulations

Water quality control consists of post-development controls to help reduce the impacts of development on the water quality of the receiving downstream water bodies. The following minimum design criteria are established for water quality control unless a waiver is granted on a case-by-case basis.

State Rules

- Permanent water quality ponds and detention structures having a permanent pool elevation shall be designed to store and release the first ½-inch of runoff from the site over a minimum period of 24-hours. The water quality storage volume of these water quality structures shall be designed to accommodate at least ½-inch of runoff from the entire site.
- Permanent water quality structures **not** having a permanent pool elevation shall be designed to store and release the first 1-inch of runoff from the site over a minimum period of 24-hours.
- Permanent water quality infiltration practices shall be designed to accommodate at a minimum the first 1-inch of runoff from impervious areas located on the site.
- When existing wetlands are intended to be water quality structures, the Storm Water Management Permit shall not be implemented until all necessary Federal and State permits have been obtained.

Greenville County Ordinance – Minimum Water Quality Requirements

- All storm water runoff generated from a site shall be adequately treated before discharged. It will be presumed that a storm water management system complies with this requirement if:
    - Preferred method is to size water quality capture devices to trap 85% of total suspended solids (TSS) based on annual loading.

      (Note: The Greenville County IDEAL Model or another model such as the USEPA overflow model may be used to design BMPs to meet this criteria. The updated IDEAL Users Manual available on the Greenville County website describes how to use the model to design several BMPs to this standard)
    - An alternative as a default criteria, the devices may be sized to capture the first inch of runoff from the impervious area of the site and discharge it over a 24-hour period.
- Appropriate structural storm water controls or non-structural practices are selected, designed, constructed or preserved, and maintained according to the specific criteria in this manual;
- The Director has discretion to require more stringent controls for water quality where the Director determines the minimum standards are not adequate. Areas where more stringent controls may apply include outstanding resource waters, trout waters, wetlands, steep slopes, TMDLs, or other sensitive areas.
- All development and redevelopment projects and portions of redevelopment projects disturbing one acre or more that will result in more than one cubic foot per second increase in peak runoff rate shall meet the requirements of this section even though there is not a change in land use.

Water Quality control BMPs can be classified into two major classifications:

- Non-structural Controls, and
- Structural Controls

9.5. First Flush Water Quality Volume

The water quality volume is the storage needed within a water quality control BMP to control the "first flush" of runoff during a storm event. Studies have shown that the highest pollutant concentrations are found in the initial runoff period known as the "first flush." For Greenville County, this "first flush" volume has been designated to be:

- The preferred method is to size the water quality capture device to trap 85% of TSS based on annual loading (The Greenville County IDEAL Model or another model such as the USEPA overflow model may be used to design BMPs to meet this criteria. The updated IDEAL User's Manual available on the Greenville County website describes how to use the model to design several BMPs to this standard).

- As an alternative as a default criteria, the device may be designed to capture the first inch of runoff from the impervious area of the site and discharge it over a twenty-four (24) hour period.

9.6. Water Quality Pollutant Removal Mechanics

The removal of pollutants from urban runoff by BMP facilities such as storm water management ponds and filter strips can occur in a number of ways which include:

- Sedimentation
- Decay and biological uptake
- Filtration
- Adsorption
- Nitrification/Denitrification
- Plant uptake, and
- Microbial degradation

Pollutant removal in storm water management ponds and detention facilities occurs primarily through the sedimentation of suspended solids. Pollutant removal by decay or biological uptake may also occur under long detention times and favorable environmental conditions.

9.6.1 Sedimentation

9.6.1.1 Quiescent Settling

Quiescent settling is associated with sedimentation in an ideal sedimentation basin which consists of four zones:

- Inlet zone, in which the pollutant concentration of the influent water is dispersed uniformly over the vertical cross section of the tank and the influent water is transformed into uniform horizontal flow;

- Sedimentation zone, where particles settle out of suspension by gravity;

- Sludge zone, where settled particles are removed from the water column; and

- Outlet zone.

Several simplifying assumptions are implicit in the formulation of sedimentation efficiency of an ideal basin. These assumptions are that quiescent settling of discrete particles is the only mechanism governing sedimentation, the concentration of suspended solids of each particle size entering the sedimentation zone is uniform over the vertical cross section, and a particle that strikes the sludge zone is permanently removed (Fair and Geyer, 1954).

It is clear that these assumptions may be violated. For urban runoff control systems, it is very difficult, if not impossible, to achieve completely quiescent conditions within a storage reservoir, due primarily to the intermittent and random nature of rainfall which results in fluctuations in storage level and variable inflow /outflow rates. For surface detention facilities, wind action and temperature-induced density currents may further affect the quiescent removal of suspended particles. As a result of these limitations, only the permanent pools of storm water management ponds are considered to approximate quiescent conditions in the inter event period.

Properly designed storage facilities, such as ponds with long, circuitous flow paths, enhance the sedimentation of suspended solids from the water column; however, it is difficult to ensure a completely mixed and uniformly dispersed concentration of pollutants in the influent runoff. In this regard, deep forebays in storm water management ponds may be used to reduce the potential for preferential flow paths and dead zones which are induced primarily by the momentum of the influent runoff. In reality, particles that settle out of suspension during one runoff event may be resuspended by a subsequent runoff event, especially for storage facilities which are able to drain completely between runoff events, such as extended detention dry ponds. This resuspension violates the assumption that particles that strike the bottom (or sludge zone) are removed permanently. Again, properly designed facilities with proper inlet protection should minimize such effects.

9.6.1.2 Dynamic Settling

Storage facilities for urban runoff control, which drain within and between storm events, operate in an unsteady mode with varying inflow and outflow rates, and therefore their removal efficiencies cannot be modeled assuming quiescent settling conditions. Since there is fluid turbulence in such storage facilities, the removal of total suspended solids (TSS) is assumed to occur by dynamic settling.

The pond settling performance factor or turbulence factor, n, is meant to reflect the degree of turbulence and short-circuiting in the flow through the pond (or basin), which is, in turn, affected by the pond geometry (e.g., length-to-width ratio, area-to-depth ratio, inlet and outlet configuration).

9.6.2 Decay and Biological Uptake

Some dissolved pollutants and pathogenic bacteria in urban runoff may be removed from the water column by decay or die-off. Other dissolved pollutants may be removed through biological uptake (e.g., nutrients such as organic nitrogen and orthophosphate ion), by means of vegetation in storm water management ponds and wetlands. The removal efficiencies of these pollutants are often approximated using first-order kinetics.

Most urban BMPs rely heavily on gravitational settling as a primary pollutant removal pathway. There are upper limits to the amount of pollutant removal that can be achieved in this pathway. Most removal occurs in the first six to twelve hours.

9.6.3 Filtration

Many particulate pollutants are physically strained out as they pass through the filter bed of sand, soil, or organic matter, and are trapped on the surface or among the pores of the filter media. The effect of filtration can be very strong. For example, Pitt et al. (1995) report that as much as 90 percent of small particles commonly found in urban runoff (6 to 41 microns) are trapped by an 18-inch layer of sand, and presumably an even greater percentage of larger particles.

The filtration pathway is not effective in removing soluble pollutants and the smallest particles upon which pollutants are often attached. In addition, the importance of the filtration pathway is a function of the media used in the filter. In relatively tight media, such as soil or sand, filtration is very important, whereas, in more porous media such as compost or peat, the filtration effect is comparatively weak.

9.6.4 Adsorption

The ability of a filtering system to remove soluble nutrients, metals, and organic pollutants is often due to the adsorption pathway, in which ions and other molecules attach to binding sites on filter media particles. In general, the adsorption potential of a filtering system increases when the filtering media has a high content of organic matter or clay, a high cation exchange capacity (CEC), and a neutral to alkaline pH.

Each of the media used for filtering systems exhibit sharply different adsorption potentials. Pure sand, for example, initially has little or no organic matter, clay or cation exchange capacity, and therefore, little potential for adsorption. Over time, most sand filters develop a thin layer of organic matter and fine particles at the surface layer of the filter media as a result of sediment deposition, thereby increasing the adsorption potential. Organic filter media such as soil, peat and compost, on the other hand, have a much greater potential for adsorption, if the pH of the media is in the optimum range.

9.6.5 Nitrification / Denitrification

Nitrification is an important nitrogen removal pathway as organic matter is gradually decomposed. Microbes break down organic nitrogen into ammonia, which is then transformed into soluble nitrate-nitrogen. The nitrification process generally requires an aerobic (oxygen-rich) environment which is characteristic of many filtering systems. As a result, nitrification occurs rapidly in many filtering systems, resulting in the export of low concentrations of ammonia.

Denitrification is the final step in the nitrogen cycle. It is the conversion of soluble nitrate into nitrogen gas that is returned to the atmosphere. To proceed, the denitrification process requires a moist, anaerobic environment, an abundant supply of both organic carbon and nitrate, and the presence of denitrifying bacteria. These conditions are not always met in most filtering systems. Consequently, most filtering systems actually export more soluble nitrate than they receive. In recent years, designers have attempted to create suitable conditions for denitrification within filtering systems, and have demonstrated a capability to remove nitrate.

9.6.6 Plant Uptake

Several filtering systems incorporate plants, such as algae, emergent wetlands or grass to improve removal rates. Examples included vegetated open channels (grass), sand or organic filters (that have a grass cover crop), bioretention, filter strips, and gravel wetland filters (algae, wetland plants). Plants can increase pollutant removal in several ways. During periods of stormflow, for example, grass and emergent wetland plants provide resistance to flow, thereby reducing runoff velocities. Slower runoff velocities translate into more time for other pollutant pathways to work (such as settling, filtering, infiltration and adsorption). In addition, the roots of grass and emergent plants help bind up the filter media, preventing loss of sediments and attached pollutants via erosion.

The growing plants also create a continual supply of thatch, or detritus, which provide the organic matter needed for greater adsorption. During periods of growth, the plants also take up nutrients and metals from the filter bed and incorporate it into their biomass. If plant biomass is harvested or mowed, pollutants are removed. Taken together, however, the use of plants in a filtering system is usually of secondary importance as a pollutant removal pathway in comparison to the other five pathways.

9.7. Non-Structural Water Quality Controls

9.7.1 Open Vegetated Conveyance Systems

Open vegetated conveyances can be designed and installed as an alternative to curb and gutter and hard piping storm water conveyance systems. Open vegetated conveyances improve water quality by providing partial pollutant removal as water is filtered by the vegetation and by the opportunity to infiltrate into the soil. Open vegetated conveyances also can be designed to reduce flow velocities when compared to hard piping systems.

Open vegetated conveyance systems can be incorporated into moderate to low density development sites where land is available and where the land surface is gently sloping (less than 5 percent). The soil must be able to withstand the design tractive forces and flow velocities of the open conveyance, or an applicable Turf Reinforcement Mat or Erosion Control Blanket shall be designed to protect the open conveyance. A dense cover of strong rooted vegetation, such as tall fescue, shall be called for on the plans.

For maximum water quality benefits, vegetated open conveyance shall be designed to promote shallow low velocity flow.

9.7.2 Water Quality Stream Buffers

A water quality stream buffer is an area along a shoreline, wetland or stream where development is restricted or prohibited. The primary function of the buffer is to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment.

9.7.3 Disconnected Rooftop Drainage to Pervious Areas

Disconnected rooftop drainage can reduce the runoff flow rates from developed areas. The disconnection involves directing storm water runoff from rooftops towards pervious areas where it is allowed to filter through vegetation and other landscaped material and infiltrate into the soil. This practice is applicable and most beneficial in low-density residential or commercial developments having less than 50 percent impervious area. Disconnection is not applicable to large buildings where the volume of runoff from the rooftops will cause erosion or degradation to receiving vegetated areas.

The disconnection of rooftop drainage has the following benefits:

- Increase the time of concentration by disconnecting runoff from any structural storm water drainage systems.
- Provide water quality benefits by allowing runoff to infiltrate into the soil. Downspouts from rooftops should discharge to gently sloping, well-vegetated areas, vegetated filter strips, or bio-retention areas. Erosion control devices such as splash blocks or level spreaders may be required at the downspout discharge point to transfer the flow from concentrated flow to sheet flow.

9.7.4 Cluster Development to Conserve Natural Areas

Cluster development practices concentrate development away from environmentally sensitive areas such as streams, wetlands, and mature wooded areas. The clustering of development in one area reduces the amount of roadways, sidewalks, and drives required when compared to development sprawled over the entire land area.

Clustering and conservation of natural area practices shall be installed at least to some extent on all development sites not only to reduce the impacts to natural resources by minimizing disturbance and impervious areas, but also to maintain some of the natural beauty of the site.

Reducing the amount of disturbed area and impervious area reduces the amount of runoff volume treated for water quantity and water quality control. Concentrating development away from environmentally sensitive areas will also reduce the amount of time and expenses to get federal and state permits for impacting jurisdictional waters.

Development should be concentrated on the flattest part of the development parcel away from environmentally sensitive areas such as steep slopes, streams, and wetlands. This will not only reduce the impacts to these areas, but may reduce the amount of earth moving necessary for the development.

9.7.5 Grass Paving or Alternative Paving Surfaces

Grass paving technology allows for the reduction of paved areas by implementing grass paving in areas that are infrequently used such as fire lanes and overflow parking where applicable. A variety of grass paving materials are available on the market. Grass paving units are designed to carry vehicular loading and may be composed of different types of materials. The pavers are typically covered with sod to make the areas indistinguishable from other grassed areas. Grass pavers allow water quality benefits by allowing storm water to infiltrate into the underlying soils and by the filtering of storm water as it flows through the grass.

Grass pavers provide a more aesthetically pleasing site and reduce the impact of complete asphalt surfaces. Grass pavers should not be used for frequently traveled or parked in areas.

Grass pavers can reduce the runoff volume and extend the time of concentration for a particular site. Some pavers may provide enough infiltration to be considered a pervious area.

9.7.6 Natural Infiltration

Natural infiltration is a method in which an undisturbed land area covered with natural vegetation accepts runoff from new development and infiltrates the runoff into the soil. Natural infiltration areas should only be used where the soils are suitable. The area should be in a forested condition with the land surface covered by leaves, pine needles, and other forest floor organic materials and should only be designated for passive recreation such as biking.

A natural infiltration area may be used as a storm water quality control if it meets the design criteria of this section.

The size of a natural infiltration area can be calculated using the following equation:

$$A = \frac{(K\ T\ I)}{[(cd) - K]}$$

Where:

A	=	Natural infiltration area required (acres)
K	=	Runoff volume to infiltrate (inches)
T	=	Total site area or total drainage area (acres)
I	=	Built upon area ratio (Built upon area / T)
c	=	Effective water capacity (in/in), shall be determined from site-specific soil samples.
d	=	Depth of soil A horizon (inches), shall be determined from site-specific soil samples.

The runoff from the areas to be treated by natural infiltration shall enter the infiltration area as sheet flow with a non-erosive velocity. The areas draining to the Natural Infiltration area shall be stabilized and vegetated a minimum of 20-feet in length.

The natural infiltration area shall have the following characteristics:

- Appropriate soils that have a minimum infiltration rate of 0.3-inches per hour, low erosion potential, and good drainage (not in a wetland or floodplain).
- Mature forest cover (if the natural infiltration area (A) is not located in a mature forest, then the area shall be double of that calculated by the equation above).
- Slopes less than 10 percent.
- The natural infiltration area shall remain permanently undisturbed.

The limitations of natural infiltration areas include:

- Not suitable for soils that have greater than 30 percent clay content or greater than 40 percent clay and silt content.
- Not suitable in areas with high water tables or shallow depth to highly impervious strata such as bedrock or clay layers.
- High sediment loadings or lack of maintenance clogs the surface layer therefore inhibiting any water infiltration into the soil.

9.8. Structural Controls

Structural water quality control structures are recommended for use with a wide variety of land uses and development types. These controls have demonstrated the ability to effectively treat runoff volume to reduce the amounts of pollutants discharged to the downstream system. Structural storm water quality controls are classified into the following categories:

- General Application Controls
  - WQ-01 Dry Storm Water Detention Ponds
  - WQ-02 Wet Storm Water Detention Ponds
  - WQ-03 Storm Water Wetlands

- WQ-04 Gravel Wetlands
- WQ-05 Bioretention Areas
- WQ-06 Sand Filtration Facilities
- WQ-07 Infiltration Trenches
- WQ-08 Enhanced Dry Swales
- WQ-09 Infiltration Basins
- WQ-10 Stormwater Manufactured Treatment Devices (MTDs)

- Limited Application Controls
  - WQ-11 Permanent Water Quality Stream Buffers
  - WQ-12 Vegetated Filter Strips
  - WQ-13 Level Spreaders

Greenville County technical specifications and details for these Post Construction Water Quality BMPs are located Appendix G.

9.8.1 General Application Controls

General application structural controls are recommended for use in a wide variety of application situations. These structural controls have demonstrated the ability to effectively treat water quality volumes and are presumed to be capable of removing 80 percent of the total suspended solids (TSS) load typically found in urban post development runoff. The general storm water controls can be classified into several categories as shown in Table 9-7.

Table 9-7. Structural Controls

General Structural Control	Description
Dry Ponds	A dry detention basin does not maintain a permanent pool and is intended to manage both the quantity and quality of stormwater runoff before discharging off-site.
Wet Ponds	Wet storm water ponds are constructed storm water basins that have a permanent pool or micropool of water. Runoff from each rain event is detained and treated in the pool, and released at a designed rate.
Storm Water Wetlands	Storm water wetlands are constructed wetland systems used for storm water management. Storm water wetlands consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent water surface.
Gravel Wetland Systems	Gravel wetlands use wetland plants in a submerged gravel or crushed rock media to remove storm water runoff pollutants. Use these in mid- to high- density environments where other structural controls will be utilized.
Bioretention Areas	Bioretention Areas are shallow storm water basins or landscaped area that utilize engineered soils and vegetation to capture and treat storm water runoff. Runoff may be returned to the conveyance system or partially exfiltrate into the soil.

General Structural Control	Description
Sand Filters	Sand filters are multi-chamber structures designed to treat storm water runoff through filtration, using a sand bed as its primary filter media. Filtered runoff may be returned to the conveyance system or partially exfiltrate into the soil.
Infiltration Trench	An infiltration trench is an excavated trench filled with stone aggregate used to capture and allow infiltration of storm water runoff into the surrounding soils from the bottom and sides of the trench.
Infiltration Basin	Infiltration Basins are shallow, impounded areas designed to temporarily store and infiltrate stormwater runoff. The size and shape can vary and designs can use one large basin, or multiple smaller basins throughout a site.
Enhanced Grassed Swales	Enhanced swales are vegetated open channels that are explicitly designed and constructed to capture and treat storm water runoff within dry or wet cells formed by check dams or other structures.
Stormwater Manufactured Treatment Devices (MTDs)	MTDs use the movement of storm water runoff through a specially designed structure to remove target pollutants. They are typically used on smaller commercial sites and urban hotspots. There are numerous commercial vendors of these structures, but there is limited data on the performance of these structures. These structures may require monitoring to verify specific pollutant removal efficiencies.

9.8.1.1 Comparative Pollutant Removal Capability

Several generalizations can be made about the overall performance of storm water filtering systems. In general, they exhibit a high capability to remove suspended sediments and a moderate ability to remove total phosphorus and nitrogen (although low or negative with respect to soluble nutrient forms). The storm water pollutant whose performance cannot easily be generalized is fecal coliform with some designs showing a high capability to remove bacteria, and others showing none.

Tables 9-9 and 9-10 provide a general comparison of expected pollutant removal rates based on monitoring data, theory and best professional judgement. As can be seen, most filtering designs have a high capability to remove sediment. Phosphorus removal rates range more widely with the highest rates reported for gravel fitters, dry swales and perimeter sand filters, and the lower rates for grass channels, wet swales and filter strips. Nitrogen removal typically ranges from 30 to 50 percent. Most filtering systems, however, have a zero or negative removal rate for soluble nitrate (with the exception of dry swales, wet swales and gravel fitters). Most filtering systems have a high capability to remove bacteria with the exception of open channel options such as drainage channels and grass channels.
Table 9-10 presents a very generalized comparison of the comparative pollutant removal capability four groups of BMPs (actual removal rates for a particular design within a BMP group, however, may be higher or lower than those shown in the Table, and are presented only for rough technology comparison).

When the four groups of BMP systems are compared, it is evident that there is not a great deal of difference in their capability to remove sediment or total phosphorus. Greater differences in pollutant removal are noted for nitrogen (especially nitrate). There are not enough data available to assess if there are any differences in bacteria removal among the four groups of BMPs. It should also be noted that the removal rates indicated for infiltration BMPs are projections only since very few of these systems have actually been monitored. In summary, it appears that the removal capability of most BMP systems is similar for most pollutants of concern when they are designed and maintained properly and incoming pollutant levels are higher than the irreducible concentration.

Table 9-8. Estimated Pollutant Removal Capability of General Storm Water Filter Systems

	Estimated Pollutant Removal Efficiency %					
BMP	**Monitoring**	**TSS**	**TP**	**TN**	**Nitrate Nitrogen**	**Other**
Surface Sand Filters	Yes	85	55	35	Neg	Bacteria 40-80 Metals 35-90
Dry Enhanced Swales	Yes	90	65	50	80	Metals 80-90
Wet Enhanced Swales	Yes	80	20	40	50	Metals 40-70
Vegetated Drainage Channel	Yes	65	25	15	Neg	Hydrocarbons 65 Metal 20-50 Bacteria Neg
Vegetated Filter Strip	Yes	70	10	30	0	Metals 40-50

Table 9-9. General Application Pollutant Removal Efficiencies

	Estimated Pollutant Removal Efficiency %							
BMP	**TSS**	**TP**	**TN**	**Nitrate Nitrogen**	**Metals**	**Bacteria**	**Cu**	**Pb**	**Zn**
Dry Ponds	61	19	31	9	26-54	---	---	---	---
Wet Ponds	67	51	33	43	24-73	70	57	73	66
Shallow Marsh Wetlands	51-83	40-43	26-49	49-73	36-85	76	---	---	---
Extended Detention Wetland	69	39	56	36	0-63	---	---	---	---
Pond / Wetland System	35-71	35-56	19-29	40-68	0-57	---	---	---	---

BMP	Estimated Pollutant Removal Efficiency %								
	TSS	TP	TN	Nitrate Nitrogen	Metals	Bacteria	Cu	Pb	Zn
Gravel Wetland	83	64	19	81	21-83	78	---	---	---
Bioretention Areas	---	65-87	49	15-16	---	---	43-97	70-95	64-95
Sand Filters	87	51	44	-13	34-80	55	---	---	---
Infiltration Basins	75	60-70	55-60	---	85-90	90	---	---	---
Infiltration Trenches	80	65-75	60-70	82	85-95	98	95	95	95
Enhanced Swales	81	28-83	40-92	31-90	14-55	---	11-70	67	33-86

Source: US EPA Post-Construction Storm Water Management BMP Manual, 2001.
Georgia Storm Water Manual, Volume 2: Policy Guidebook, First Edition, Atlanta Regional Commission, March 2001.

The removal rates shown are for comparison only. Actual removal rates can very widely based on the extent of the design

Table 9-10. Pollutant Removal Capability of Four Types of BMP Systems

BMP	Pollutant Removal Efficiency %								
	TSS	Organic Carbon	TN	Nitrate Nitrogen	TP	Cu	Pb	Zn	Hydrocarbons
Pond System	80	65	35	60	65	50	85	65	80
Wetland System	75	15	25	60	50	30	75	50	80
Infiltration System	90	90	50	50	60	60	90	90	---
Filtering System	85	50	35	Neg	60	45	85	75	85

Source: Current Assessment of Urban BMPs, Design of Storm Water Wetlands

Table 9-11. Pollutant Removal Capability of Storm Water Quality BMPs

	Estimated Pollutant Removal Efficiency %							
BMP	**TSS**	**TP**	**TN**	**Bacteria**	**Cu**	**Pb**	**Zn**	**COD**
Infiltration System	75	50	40	---	25	50	65	65
Dry Ponds	20-60	10-30	10-20	20-40	10-40	20-60	10-50	10-50
Extended Dry Pond	30-80	15-40	10-40	20-60	10-50	20-70	10-60	10-60
Wet Ponds	50-90	30-80	30-60	20-80	20-80	30-90	30-90	30-90
Bioretention Areas	50-85	20-40	0-40	10-60	30-60	40-80	30-80	30-80
Constructed Wetlands	60-90	30-85	30-80	20-80	20-80	50-90	30-90	30-90
Sand Filters	60-85	30-75	30-60	40-80	30-60	50-80	30-80	30-80

Source: Operation, Maintenance and Management of Storm Water Management, US EPA 1997

9.8.2 Limited Application Controls

Limited application structural controls are those that are recommended only for limited use for special site or design conditions. Generally, these practices cannot alone achieve 80 percent TSS removal goal and are intended for hotspots for specific land use constraints or conditions. Limited application controls may be used within a system of water quality controls and are very effective pre
treatment structures for the General Application Controls listed in Section 9.8.1. Limited application structural controls should be designed and used only in development situations where regular maintenance is guaranteed. The limited storm water controls can be classified into several categories as shown in Table 9-12.

Table 9-12. Limited Structural Control

Limited Structural Control	Description
Water Quality Stream Buffers	A stream buffer is an area along a shoreline, wetland or stream where development is restricted or prohibited with the primary function to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment.

Limited Structural Control	Description
Vegetated Filter Strips	Vegetated filter strips provide filtering of storm water runoff as it flows across the vegetation. However, by themselves these controls do not consistently obtain an 80% TSS removal. Vegetated filter strips are best used as pretreatment measures or part of a treatment system approach.
Grassed Channels and Swales	Grassed swales provide filtering of storm water runoff as it flows across vegetation. However, by themselves these controls do not consistently obtain an 80% TSS removal. Grassed swales are best used as pretreatment measures or part of a treatment system approach.
Porous Paver Systems	Porous paver systems consist of open void paver units laid on gravel subgrade to promote storm water infiltration. Porous pavers provide water quality and quantity benefits, but has high maintenance requirements.

9.8.2.1 Innovative Technologies

Innovative technologies are encouraged and shall be accepted providing there is sufficient documentation as to the effectiveness and reliability of the proposed structure. To justify the efficiency of innovated water quality control structures, the owner may be required to monitor the pollutant removal efficiency of the structure. If satisfactory results are obtained, the innovative water quality structure may be used and no other monitoring studies shall be required. If the control is not sufficient, other onsite and/or downstream controls shall be designed to trap the required pollutants.

9.9. Anti-degradation Rules for Impaired Waters

This section of the Design Manual provides information to ensure that Anti-degradation Rules are implemented for activities that contribute nonpoint source pollution to adjacent waterbodies. The Anti-degradation Rules are specifically formulated to ensure that no new activities will further degrade waterbodies that are not presently meeting water quality standards. The involvement in the Anti-degradation Rules shall occur though the Greenville County Storm Water Permitting, Section 401 Water quality Certificate, Critical Area Planning, and State Navigable Water Permitting. Greenville County shall implement the Anti-degradation Rules when issuing NPDES permits for point source and nonpoint source loadings into impaired waters. The activities of primary concern are land development projects that are immediately adjacent to and discharge runoff of storm water into impaired waters. These projects may also be required to obtain a Special Pollution Abatement Permit as discussed below in Section 9.10.

9.9.1 Impaired Waterbodies

Every two years SCDHEC is required by Section 303(d) of the Clean Water Act to identify waterbodies that are not meeting water quality standards despite the implementation of technology based controls. The listing of the impaired waters lists each waterbody by name monitoring station number hydrologic unit and basin. The impairment and cause shall also be identified for each waterbody.

9.9.2 Applicability

Large scale development projects with more than 25 acres of disturbed land which have storm water discharges directly into an impaired body via structures or ditches must have assurance that storm water runoff will not cause or contribute to degradation to the receiving waterbody. Also, there may be certain projects that are less than 25 acres adjacent to ecologically important or sensitive areas that shall require assurance that storm water runoff will not cause or contribute to degradation to the receiving waterbody. The concern of water quality pertains to runoff during construction and runoff after the project is finished and stabilized.

9.9.3 Water Quality Impairment

Design professionals shall determine whether runoff from the proposed land disturbance contains pollutants that are already causing impairment of the adjacent waterbody. These pollutant discharges will vary from site to site. If storm water runoff from the proposed land development will contribute pollutants that already cause water quality impairment, the design professional must provide assurance that measures and controls will be implemented to prevent further problems to the impairment.

The techniques and controls discussed in Chapter 9 shall be utilized to provide the removal of any harmful pollutants. There is not a specific methodology that must be followed in determining the BMPs selected and utilized to follow the Anti-degradation Rules. However, the calculations and descriptions must show that the water quality BMPs to be installed will ensure that runoff from the site will not cause or contribute to further degradation of the impaired waterbody.

In an effort to aid the design community as well as to provide the County quantifiable assurances for meeting MS4 permit goals, the County has developed and made available the IDEAL computer program. With the IDEAL model, designers can calculate the annual loading for the pollutant of concern for the pre-developed condition as a baseline and the developed condition (with no increase) for impaired waters discharge compliance.

For pollutants causing impairment for which a numeric water quality standard has been adopted (fecal coliform, pH, metals), calculations shall be performed and submitted showing that the pollutants in the runoff from the development site will not exceed the applicable in-stream water quality standards. The runoff discharged through the last water quality BMP shall have a water quality level equal to or better than the in-stream standard. The design professional shall provide insurance in a different manner when the water quality impairment is not a pollutant itself, but is affected by a pollutant that can be regulated such as dissolved oxygen levels are affected by biochemical demand. In these situations, a reasonable approach to show that runoff will not further degrade the adjacent impaired waterbody is to show that the post-development loading of a particular pollutant is less than or equal to pre-development loading. This insures that there will be no net increase of loading of that particular pollutant and no further lowering of the water quality standard.

In most cases, the effectiveness of the designed water quality BMPs will not require water quality sampling. However, for certain situations, it may be required for the applicant or landowner to collect monitoring data to confirm the effectiveness of the BMPs.

9.9.4 Total Maximum Daily Loads (TMDLs)

A TMDL is the total amount of pollutant a waterbody can receive from all sources and still meet the required water quality standard. For some waterbodies DHEC and Greenville County will develop a TMDL that includes recommended limits or loads for both point sources and nonpoint sources. For other waterbodies the identified load may be only for nonpoint sources or for point sources only.

A standard policy has been developed in anticipation of TMDLs that apply to the Greenville County MS4. The Waste Load Allocation (WLA) percent reduction from the first impaired station downstream of a proposed project will be applied to the land disturbance Permit requirements. The applicant will have to demonstrate (with IDEAL) that the annual pollutant of concern loading for the site in a developed condition will be reduced by the respective amount as compared to the pre-developed condition.

9.10 Special Pollution Abatement Permit

A Special Pollution Abatement Permit is required when development or re-development occurs within a watershed that drains to a waterbody listed as impaired by SCDHEC or has an established TMDL developed and implemented for a pollutant(s) of concern to ensure that effective BMPs are used to control water quality for these waterbodies. A Special Pollution Abatement Permit will be valid for a period of five (5) years, at which point it must be renewed. At the time of renewal, any deficiencies in the control of the targeted pollutants or management method must be corrected. Any development that occurs without a required permit shall be a violation of Division 9 of the Greenville County Storm Water Management Ordinance.

Development in other areas known to have particular adverse water quality pollutant impacts may be required to comply with this requirement at the discretion of the Director. Areas that qualify have been identified by sampling and monitoring results and are given as priority areas for water quality treatment. Outstanding resource waters may also qualify for compliance with this requirement for protection of their classification.

All special pollution abatement permit requests shall include as a minimum the following information:

- Name of the development.
- Physical location of the development.
- Name of impaired waterbody that receives storm water discharge from the development.
- Pollutant(s) of concern that is responsible for the designated impairment.
- Supporting information for the permit request, including:
  - Name of contact person for permit compliance.
  - Site map (minimum scale of 1”=50’) of development with buildings, parking, drives, other impervious surfaces, ditches, pipes, catch basins, drainage basin limits, acreage of offsite water draining onto the development, discharge points to “Waters of the United States” or “Waters of the State,” and locations of storm water treatment facilities and BMPs.
- Storm water treatment facilities and BMPs including manufacturer, model, flow rates of runoff draining to each facility or BMP for the 1-year and 10-year 24-hour storms, and the verified

treatment and bypass flows for each facility and BMP.

- Inspection and maintenance program and schedule for each facility or BMP.

- Certification by the engineer of record that the storm water treatment facility or BMP will address the pollutants listed in the TMDL or on the impairment for the waterbody on the 303(d) and meets the requirements in the TMDL for the subject waterbody.

- Certification by the person responsible for the land disturbing activity that the facility or BMP will be maintained and inspected according to the inspection and maintenance program detailed in the permit request. Certified quarterly reports shall be submitted to the Director by the operator of the facility or as the Director requires as given in the permit conditions. Sampling and monitoring may be required to verify the performance of the facility and compliance with the requirements in the Special Pollution Abatement Permit.