SECTION 10: WET DETENTION BASIN

10.1 General Characteristics and Purpose

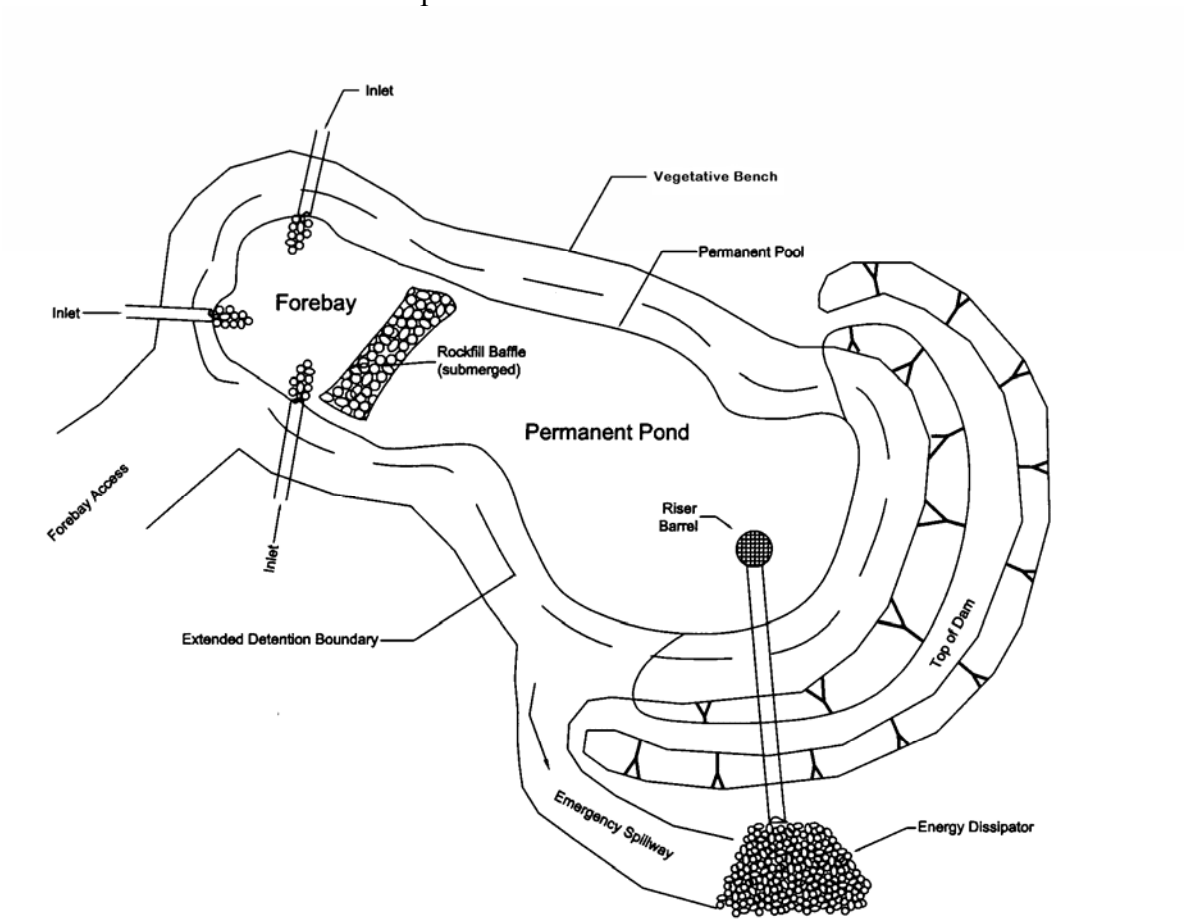
In Greensboro, the wet detention pond is currently the most commonly used BMP for meeting water-supply watershed protection requirements. This stormwater BMP improves stormwater quality primarily by detaining stormwater runoff for an extended period of time (usually 2 to 5 days) to allow pollutants that are suspended in the runoff to settle out. During a storm event, runoff enters the pond and replaces the "treated" water in the permanent pool that has been detained in the permanent pool from the previous storm event(s). As runoff enters the pond, its velocity is significantly reduced allowing suspended pollutants to begin settling. Many pollutant particles found in stormwater runoff are very small in size and, because smaller particles settle slower than larger particles, the pond is designed to provide adequate detention time so smaller particles have a chance to settle out.

The components of the wet detention pond that help increase the pond's pollutant removal efficiency are the permanent pool, temporary pool, and forebay (see Figure 10-1). The permanent pool helps reduce particles that have settled to the pond bottom from re-suspending when runoff flows into the pond. The temporary pool is storage above the permanent pool that is designed to control the WQV. To increase the detention time of the runoff, the temporary pool is slowly released through low flow orifice(s). A separate smaller pond, called a forebay, is placed upstream of the main pond to trap a majority of the coarser fractions of suspended solids in the runoff before it enters the main pond. Figure 10-1 illustrates the main features of a wet detention basin.

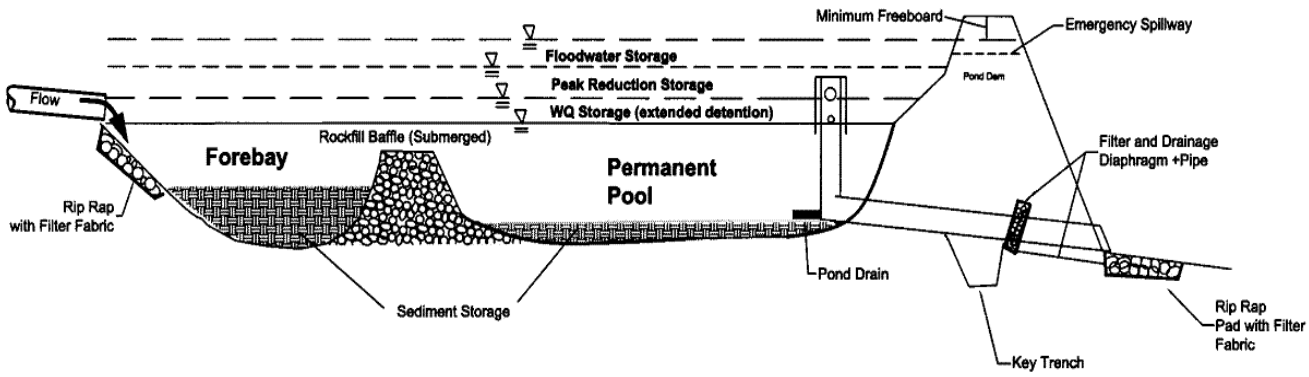
Wet detention ponds, based on findings from the City's periodic BMP inspection program, seem to function better when the pond is larger and receives flow from a larger drainage area. This may be attributed to several factors, such as, in larger drainage areas there is usually a better chance for seasonal or permanent surface or groundwater flow into the pond as opposed to smaller drainage areas. This flow may help the permanent pool to be "flushed" more often (as opposed to only during storm events), which may help to prevent undesirable conditions from developing (for example, stagnate water, fluctuating permanent pool elevation, etc.). It is suggested that owners of smaller properties cooperate to construct and maintain one relatively large pond to serve several properties, rather than several individual smaller ponds. Although the City generally recommends a drainage area of 10 acres or more, wet detention ponds may be used for smaller drainage areas.

Wet detention ponds have a higher tolerance for runoff with significant sediment concentration than the other BMPs. The wet detention pond BMP is most applicable for large industrial and commercial facilities and residential subdivisions where construction will take place in phases or in residential development where site disturbance will occur for a significant period after the BMP is installed. Also, properties where the land may remain fully or partially unstabilized or where sources of sediment remain on the property (e.g. stock yards, gravel/dirt areas, construction equipment storage, etc.), the wet detention pond is a good choice.

Figure 10-1
Example of Wet Detention Basin



PLAN



PROFILE

10.3.2 Siting Issues

Wet detention basins shall not be placed in jurisdictional wetlands, on intermittent or perennial streams. Also, wet detention ponds used to meet water-supply watershed regulations will be required to be designed to treat the total drainage area to the pond, on-site and off-site, per the City's water-supply watershed ordinance.

When designing the dam and spillways, existing and potential future downstream development should be considered. Avoid placing the dam upstream of highly developed or traffic areas whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or if no conveyance is present, the discharge should be directed away from existing development.

10.3.3 Pretreatment and Inflow

Inverts for inlet pipes should be at the elevation of the normal (permanent) pool to allow the pool to dissipate the energy of the inflow to prevent erosion along the embankment slope. Inlets should be designed to discharge to the pond perpendicular to the pool surface to minimize potential erosion problems to the side embankment. Riprap pads should be underlain with a gravel/sand filter or geotextile fabric and extend from the pipe invert to the pond bottom. For pond inlets that carry public runoff the invert must be designed to discharge above normal pool elevation to prevent water from backing up within the public storm sewer system.

The top of the forebay baffle should be one foot below the normal (permanent) pool elevation. The baffle material may be earth, rip rap, etc. If earth baffles are used, provisions should be included to allow the forebay to drain out with the rest of the pond to facilitate sediment removal from the forebay. This could include a rip rap check dam in a section of the earth baffle or a perforated riser pipe connecting the forebay to the main pond.

10.3.4 Length, Width (Area), Depth, Geometry

For ease of maintenance and safety, the pond embankments should be sloped to a maximum of 3H:1V with flatter slopes preferred. The engineering design of a wet detention basin must include a 10' wide vegetated bench (max. slope 10%) placed around the perimeter of the basin pond at the normal pool surface. The inside edge of the shelf shall be no deeper than 6" below the permanent pool elevation, and the outside edge shall be 6" above the permanent pool elevation. The vegetated shelf provides a location for a diverse population of emergent wetland vegetation that enhances biological pollutant removal, provides a habitat for wildlife, protects the shoreline from erosion, and improves sediment trap efficiency.

The pond surface area shall have a minimum 1.5:1 length to width ratio, with 3:1 preferred. The distance between the inlets and outlets should be maximized to increase the pollutant removal capability of the pond.

It is encouraged to create a pond that fits within the natural contours of the land but care should be taken to prevent "dead storage zones" (areas outside the flow path between the inlet and outlet) within the pond. Generally, the pond should be narrower at the inlet forebay area and

become wider at the outlet. Whenever possible one forebay should be created and all pond inlet pipes discharge to the forebay area.

The bottom of the pond should be slightly sloped from the upstream end to the downstream end. This will allow the pond and captured sediments to drain better when cleanouts are necessary.

It is encouraged where appropriate to use educational signs at the pond describing the function of the pond and the purpose it serves.

To meet NCDWQ requirements, if the pond outlet ties into an existing storm drainage system then the pond surface area must be designed for 90% TSS. In this case, a filter strip would not be required or practical.

10.3.6 Sediment Accumulation

The engineering design of a wet detention basin must allocate additional volume for sediment accumulation between cleanouts. For design purposes, a sediment storage depth of a minimum of 0.125 inches of depth over the drainage area should be provided with approximately 75% of this volume allocated to the forebay. In no event should the depth of sediment storage be less than 1 foot in both the forebay and main pool. An access to the forebay for future sediment cleanouts is to be provided. The forebay access shall have a maximum slope of 15-20%, extending from the top of the embankment to the toe. This access will allow construction equipment to get down in the forebay and minimize disturbance to the vegetation.

10.3.7 Plant and Landscape Requirements

Earthen embankments for wet detention basins can be surfaced with turf grass, riprap or other protective measures. The use (or growth) of trees and shrubs is not permitted on earthen embankments due to their capability to undermine the embankment structural stability.

10.3.8 Surrounding Soils and Liners

When a wet detention basin is to be located in sandy or gravelly soils or in fractured bedrock, the BMP design shall incorporate an impervious clay or synthetic liner to sustain the permanent pool of water or alternatively incorporate designed features to cutoff seepage through the foundation and the abutments. The liner shall extend over the entire bottom surface of the permanent pool and water quality volume pool.

If, at the time of BMP certification in accordance with Section 30-7-1-6 of the Greensboro Development Ordinance, the pond does not have a permanent pool established per the approved plans, one of the following requirements must be met:

- Submit a performance bond to the City to cover all costs to upgrade the pond in the event it is determined that a permanent pool of water cannot be established.
- For non residential development, obtain a letter from the owner stating all necessary corrective measures will be undertaken to upgrade the pond in the event it is determined that a permanent pool of water cannot be established.

- Submit supporting technical analysis / soil investigative reports confirming the geotechnical composition of the pond bottom and embankments is conducive to holding a permanent pool.

10.3.9 Outlet Design

The principal spillway should be a riser/barrel, concrete free overfall weir, or concrete chute, with capacity to handle the 10-year, 24-hour rain storm event at a minimum. The riser/barrel material of construction shall be either reinforced concrete, ductile iron, PVC, HDPE, or corrugated aluminum piping. The use of aluminized steel or other type of corrugated metal is not allowed. Reinforced concrete (where the joints are sealed and specified watertight) and ductile iron pipes (being rigid pipes) are preferred for this type of application. To prevent distortion of flexible conduit, such as corrugated aluminum piping, special care (including construction oversight) must be taken during compaction of the soil around it and result in internal soil erosion problems potentially leading to failure of the embankment around and above the conduit. The minimum diameter of the principal spillway barrel section (horizontal pipe) shall be twelve inches (12") to allow outflow to be limited to pre-developed peak for small sites.

For wet detention basin design purposes, the capacity of the principal spillway is the 10-year, 24-hour storm event. The 10-year, 24-hour storm event shall not activate the emergency spillway unless the spillway structure is integrally designed to handle both the 10-year, 24-hour and 100-year, 24-hour storm events. Riser/barrel assemblies shall be properly anchored to resist buoyancy forces.

The low flow orifices are to be protected from clogging due to floating debris using a trash guard. The trash guard should be durable and secure and should extend at least six inches below the normal pool surface. A common method when using a riser/barrel is to extend the principal spillway trash rack assembly below the normal pool. When the low flow orifice will be placed in a concrete dam or spillway, an inverted or submerged orifice can be used or a half aluminum pipe bolted to the concrete (see Section 5.8.8 for example trash protection devices). Refer to Section 3.5.2 for the preferred method for calculating the orifice drawdown time.

The capacity of the emergency spillway (in conjunction with the principal spillway) shall be based on the spillway design flood storm event per N.C. Dam Safety regulations and at a minimum be the 100-year, 24-hour rain storm event. The spillway should be located where it will not adversely affect the integrity of the dam and downstream properties such as roadways and building structures. As noted above, the emergency spillway may be incorporated into the principal spillway where accommodating the emergency spillway elsewhere is not feasible for the given site characteristics. **The emergency spillway shall be cut into existing soils outside the fill section of the dam.** Where this placement requirement cannot be met, the emergency spillway shall be designed to meet the chute or free overfall spillway requirements as listed in Section 5.8.6 of this supplement. The emergency spillway may be grass lined, when velocities permit, or lined with rip rap, concrete, or other erosion resistant materials. **Grass lined spillways are to be planted with a dense cover of erosion resistant grasses,** preferably incorporating turf reinforcement matting (TRM).

The City of Greensboro strongly recommends a minimum eight foot (8') width emergency spillway be used for the 100-year flow if it can be placed in in-situ soil regardless of whether the

calculations indicated the principal spillway will pass the flow. The separate spillway provides an additional factor of safety that can be incorporated in the grading of the pond at a small cost and allows storm flow if a problem occurs with the riser/barrel assembly.

To meet NC Dam Safety requirements, a minimum freeboard of 1 foot above the maximum stage associated with the spillway design storm event is required. The City of Greensboro encourages BMP designers to maximize the freeboard to the maximum extent practicable. The Engineer's Statement of Pond and Dam Safety as listed in Section 5.6 of this Supplement shall be listed along with the BMP design elements.

10.3.11 Safety Considerations

Although not required by State Regulations or Local Ordinance, the use of fencing around wet detention basins is encouraged where safety risks are posed by children. The designer is encouraged to incorporate engineering design features (gentle contours, inlet and outlet screens, etc.) that minimize safety risks.

10.4 Construction

A concrete retaining wall may be used for the pond's dam provided the requirements listed under Section 10.3.2 of the State's Stormwater Best Management Practices Manual are met.

For earth dams, the top width of the dam shall be 10 feet minimum. A key trench shall be excavated under the entire length of the dam and located at or upstream of the centerline of the dam. The key trench should be filled with highly impervious and well compacted clay material. The key trench should have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, with a minimum width of 4 feet. Side slopes should be no steeper than one horizontal to one vertical. The minimum recommended depth of fill material is 3 feet below the stripped grade (or shallower should bedrock be encountered). The fill material should be placed in lifts not to exceed 8 inches in loose thickness and compacted to at least 95% standard proctor. The fill material and compaction specification for the key trench shall be specified on the BMP design plans. Incorporating a drainage blanket (preferably with a chimney drain) should be considered to reduce the potential for seepage problems. Also refer to Section 5.6.1 of this manual.

A "filter and drainage diaphragm" shall be used to prevent piping along the barrel within the earth fill. Refer to Section 5.6.1 of the BMP Design Supplement for seepage control requirements for conduits that extend through an embankment dam.

For large ponds that have a considerable fetch, wind-generated wave action during storms shall be considered in the freeboard. Also protection (stone riprap layer laid on a gravel or geotextile bedding) against wave induced erosion should be provided covering the range of pool elevation above the minimum pool.

Appropriate energy dissipation shall be used at the spillway exit to prevent erosive velocities for up to the 10-year peak discharge rate, at a minimum. The basin discharge shall be evenly distributed across a minimum 30 foot long vegetated filter strip. Every effort should be made to discharge in defined conveyances and parallel to the existing flow to prevent bank erosion.

Downstream channels may need to be modified and lined with rip rap to prevent erosion of the channel. Modifications to the downstream channel should be minimized as much as possible to prevent excessive disturbance in the channel.

A pond drain is to be provided to drain the pond for routine maintenance or structural repairs in an emergency situation. The pond drain is to have the discharge capability to completely drain the pond in 24 hours, in the event of an emergency posed by impending failure of the pond dam. The upstream slope of the pond dam should be designed to be flat enough to prevent slope failure due to "quick drawdown" of the pond (NC Dam Safety Code specifies a factor of safety of 1.25) in an emergency. Care should be taken to minimize transport of settled sediment from the pond during draining.

Eliminating a conduit through the embankment eliminates the requirement for seepage control.

10.5 Maintenance

10.5.1 Common Maintenance Issues

The wet detention basin should be easily accessible for maintenance. A 20' wide access easement shall be provided from the public street right-of-way to the basin's DMUE. A drainage maintenance and utility easement (DMUE) shall be placed over the basin and extend 15' beyond the toe of embankments and outside edges of erosion protection structures (energy dissipators concrete or riprap pads, etc) so as to include all key components of the basin. The access easement should be kept easily accessible for maintenance.

The presence of some vegetation in ponds is desirable for aesthetic appearance and enhancement of fish habitat. Excessive growth of aquatic vegetation is, however, detrimental to the functional sustainability of ponds. Therefore, a good balance between aquatic vegetation and other aquatic life in ponds is desirable. Recommendations for the management of aquatic weeds are beyond the scope of this supplement. However, the owner of a pond experiencing excessive aquatic weed problems is advised to contact the NC State Fisheries & Pond Management Extension for assistance with the identification of the aquatic weeds and recommendations for appropriate management strategy. The website for the NC State Fisheries & Pond Management Extension is http://www.ces.ncsu.edu/nreos/wild/fisheries/index.html. Pond owners can also contact the local Guilford County Cooperative Extension Service at (336)375-5876 for advice and guidance.

10.5.10 Dam Safety

Preserving the structural integrity of the dam of a pond BMP is important in protecting downstream life and property. There are at least four aspects of the dam that require specific attention: (1) *assessment of hazard potential* due to changes in downstream development; (2) *seepage*; (3) *dam material problems*; and (4) *vegetation growth* on the dam embankments

(1) Assessment of Hazard Potential

Before any dam is constructed, the design engineer is responsible for notifying the NC State Dam Safety Office of the proposed dam. If the dam falls under State Dam Safety jurisdiction, the dam must be constructed, maintained and operated according to their design and construction guidelines. Even if the dam does not fall under the NC Dam Safety Office's jurisdiction, the

dam should be designed and constructed in accordance with current good engineering practice. The City has requirements concerning the maintenance of dams associated with required BMPs.

As new development occurs downstream of the BMP, the chance of significant property damage or danger to human life may increase if catastrophic failure of the dam occurs. Although the dam may be initially exempt from regulation by the State, the owner is responsible for reporting to the State Dam Safety Office downstream development that may affect the hazard classification of the dam.

(2) Seepage

The downstream side of the dam should be inspected regularly for evidence of significant seepage. Seepage can emerge anywhere below the normal pool elevation, including the downstream slope of earth dams, areas beyond the toe of the dam, and around the spillway or pond outlet conduit. Indications of significant seepage include areas where the soil is saturated or where there is a flowing "spring" or leak. If "sinkholes" in the dam embankment are noticed, or if constant flowing water is noticed on the downstream side of the dam, then seepage has become excessive and professional engineering advice should be sought immediately to avert a major structural problem or a catastrophic failure of the dam.

(3) Dam Material Problems

For earth dams, pronounced cracks on the embankment surface indicate the first stages of potential dam failure. Transverse cracks (running perpendicular to the embankment face) generally indicating differential settlement of the dam, can provide pathways for excessive seepage. Longitudinal cracks (running parallel to the embankment face) may be due to inadequate compaction of the dam during construction or shrinkage of the clay (desiccation) in the top of the embankment during prolonged dry conditions. These cracks may eventually lead to slope failure such as sliding or sloughing.

For reinforced concrete dams, the concrete should be checked for pronounced cracking, leakage from the joints, and displacement (noticeable leaning or bulging). Also, excessive seepage, leakage, or springs just downstream of the concrete dam could be indicative of potential seepage-related "piping" problems under the dam.

If such problems or other structural problems are observed, professional engineering advice should be sought.

(4) Vegetative Growth on Dam Embankment

Trees and other woody vegetation are not permitted on the top slopes of dam embankments. Large root systems from woody vegetation can weaken the dam structure and provide seepage pathways. Thick vegetative cover can also provide a haven for burrowing animals such as muskrats and/or groundhogs. These animals can create a network of burrows in the dam embankments that can significantly weaken the dam, by creating seepage paths, which may eventually lead to dam failure. Mowing of the dam embankments should occur, at a minimum, once every 6 months to prevent woody vegetation growth and cover for burrowing animals.

The exception to this rule is for existing woody vegetation that already exceeds six inches (6") in diameter and is located on the upstream or downstream face of the dam. Removing this large woody vegetation may cause the already established root system to decay, thus allowing seepage

to occur where the root system once existed. In this case, the least potentially hazardous situation is to just leave the root system in place and intact.

10.5.11 Reduction of Pollutants Entering BMPs

Stormwater BMPs are not 100% efficient in removing pollutants; therefore, when the amount of pollutants into the BMP is higher, the amount of pollutants discharged from the BMP will be higher. Also, increased amounts of pollutants entering the BMP will increase the maintenance required to keep the BMP functioning properly.

To assist the stormwater BMP in removing pollutants, every effort should be made to reduce the initial pollutant load entering the BMP. Pollution prevention activities described elsewhere in this manual should be implemented along with the following efforts:

- ⇨ Outside trash dumpsters should be kept covered, and the area around the dumpster should be kept neat and clean.
- ⇨ Chemicals, petroleum products and other pollution sources (such as machinery) should be stored in a covered area away from possible stormwater contact. Spent chemicals are to be properly disposed or recycled.
- ⇨ Fertilizers and pesticides should be used conservatively on the property grounds. Excessive amounts of these chemicals can be washed away with stormwater runoff increasing the nutrient load to the pond.
- ⇨ Chemicals such as copper sulfate used to inhibit algae growth in the water quality pond degrade water quality. Since the pond's main function is to enhance water quality, these chemicals should not be used. Rather, reducing the amount of fertilizer application and ensuring that the pond outlets are properly functioning so the pool is flushed periodically will help to deter algae growth.
- ⇨ Trash and vegetative floatables (grass clippings, leaves, limbs, etc.) should be cleaned from the pond surface and surroundings periodically to promote a healthy, aesthetically pleasing environment, and to prevent blockage of the pond outlets. Studies have shown that people are less likely to litter ponds that are aesthetically pleasing and support wildlife.

10.5.12 Stabilization of BMP drainage area

The area draining to the BMP pond should remain stabilized to prevent excessive sediment from entering the BMP facility. When the bare soil is directly exposed to precipitation the sediment concentration in runoff is much higher than for soil that is stabilized. A stabilized area is covered by impervious surfaces (pavement, buildings), grass cover, landscaped cover (mulch, pine straw), etc.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly "seal" the filtration bed, drastically decreasing its filtration capacity.

Erosion Concerns
The inlet and outlet areas, side slopes (swales), and the rest of the conveyance area should be inspected for erosion problems.

Where water discharges from a pipe and where the stormwater runs off impervious area onto pervious area, there may be erosion problems. The BMP should have riprap protection at the end of pipes and a gravel trench at the edge of impervious areas to help prevent erosion. These devices should be inspected to ensure they are functioning properly. If erosion is noticed in within the rip rap pad or along the edges of the pad, more rock may be needed or it may have been improperly placed (no geotextile liner or improper placement of liner, rip rap not well graded, etc.) If the rock or gravel is displaced downstream, a larger size rock or gravel should be used.

Rill erosion (small channels or gulleys in the ground) is a common problem found in these control devices where the water runoff is naturally trying to channelize. Rill erosion can be repaired by filling in the rills with suitable (clayey) soils and reseeding. It may be necessary to use a temporary erosion resistant matting or to use sod to repair these areas.

10.5.13 Blockage of Outlets

Wet extended detention ponds are designed for the water to exit the pond through the low flow orifice(s), the principal spillway, and the emergency spillway. It is important to check all three outlets for blockage that would impair the pond's water quality and hydraulic functionality.

Low Flow Orifice(s)

Unless an inverted orifice is used, some type of trash guard is to be maintained over the low flow orifice(s) to prevent clogging. When the orifice becomes clogged the water level rises to the principal spillway elevation and the benefits associated with temporary storage and its gradual release are lost. To preserve "extended detention" the low flow orifice should be inspected for blockage **twice a month and after large storms.**

10.5.14 Principal and Emergency Spillway

Principal and emergency spillways are designed to safely convey larger than one inch storms that produce runoff which exceed the water quality volume of the BMP. If these spillways are blocked so they do not operate at full capacity, the risk of dam overtopping or other uncontrolled releases may result. To ensure the hydraulic capacity of the spillways, the spillways should be inspected for blockage **twice a month and after large storms.**

If a riser/barrel is used for the principal spillway, a trash rack is to be maintained on the riser. Vegetative growth in the riser should be removed promptly so that the design capacity of the spillway is maintained. Also, the outlet area where the barrel projects from the fill should be clear of tree limbs, sediment accumulation, etc.