Chapter 4 - BEST MANAGEMENT PRACTICE STANDARDS

STORMWATER RETENTION BASINS

(Permanent Practice)

Definition

A basin or depressional area to temporarily retain stormwater on site providing for infiltration, pollution reduction, and downstream water quality improvement.

Purpose

To incorporate pollution control and groundwater recharge concepts into the design and construction of storage areas for the percolation of stormwater runoff so that the adverse impact of urban type development on receiving waters can be reduced.

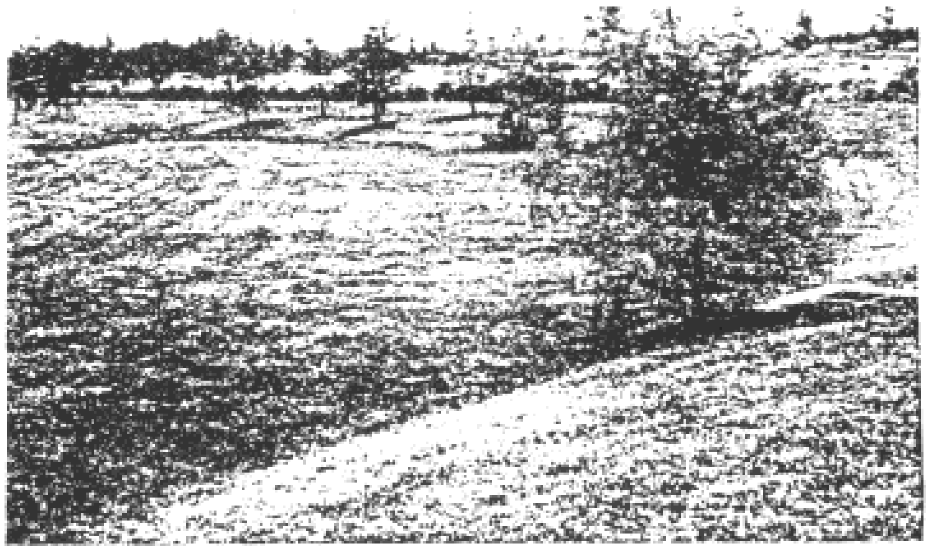

Figure 4-120 Typical stormwater retention basin installations.

Conditions Where Practice Applies

Applicability of this practice is primarily dependent upon the availability of an adequate site for a retention area or for the creation or modifications of a retention area. Geologic, topographic, and soils conditions must be considered in determining site suitability. The most significant limiting factor in many cases is the availability of sufficient land area to provide the necessary storage volume. This is particularly true in densely urbanized areas where land is scarce and property values are high.

The soil and water table conditions must also be such that the system can, within a maximum of 72 hours following a stormwater event, provide for a new volume of storage through percolation and/or evapotranspiration. Retention systems do not release stored waters for surface discharge. Stormwater in excess of storage capacity will be allowed to bypass the retention basin.

Planning Considerations

Retention basins are often designed and constructed for a number of purposes other than nonpoint source pollution control. The purpose may be groundwater recharge, flood protection, aesthetic improvement or any combination. All elements of any impounding structure must be designed, modified, and/or constructed and operated in conformance with good engineering practice.

Basins are generally open excavated depressions of varying size for storage and infiltration of surface water. They can be located in available land areas within a road right-of-way, within open land areas of developments, within recreational sites such as playgrounds or athletic fields, and within natural or landscaped depressions. Their principle drawback is that they require considerable space. However, where space is available, they may be the least expensive recharge system to construct per unit of water handled.

Retention systems are suitable over much of Mississippi, but they are particularly desirable in areas with deep loamy soils. Pollutants in stormwater, including suspended solids, oxygen demanding materials, heavy metals, bacteria, some varieties of pesticides, and nutrients such as phosphorus are removed as runoff percolates through the vegetation and soil profile.

As stormwater percolates through the soil into underlying geologic formations, the form and concentration of pollutants will be subject to alteration by a variety of physical, chemical and biological processes. Unless these interactions are well understood and considered in the design of infiltration and seepage facilities, the possibility of groundwater contamination and/or surface water degradation through lateral transmission is always a threat.

The following recommendations should be followed when planning and designing a retention system:

1. Lateral distances between seepage structures and surface waters should be maintained as large as possible (e.g., at least 100 ft. or more) depending upon site conditions.

2. Treatment practices should take greater advantage of the unsaturated zone for attenuation of pollutants. Where feasible, waterway conveyances are preferable to curb and gutter systems.

3. Control stormwater runoff and its associated pollutants at their source whenever possible. A number of small retention facilities would be preferable to a single large facility.

4. When possible, the bottom of retention facilities should be at least three feet above the mean high water table elevation. This will ensure sufficient soil for vegetation to promote pollutant removal.

5. Seepage systems should not be located in close proximity to drinking water supply wells. Stormwater treatment facilities should be at least 100 feet from any public water supply well.

6. Industrial and commercial land uses may have unusual contaminants in the stormwater runoff. Stormwater discharges that include synthetic organic compounds such as solvents (e.g., from marine maintenance areas, airport, etc.) should be monitored for several storms before final stormwater management plans are made. The presence or absence of pollutants that might not be treatable via filtration through the soil or sand should be established and treatment provided for in the designed system.

7. The basin depth should be as shallow as possible with a flat bottom (no deep spots). The maximum depth recommended is two feet. These retention areas should be incorporated into a project's open space/landscaping.

8. The side slopes and bottoms of all retention basins must be fully vegetated. Vegetation plays a critical role in the removal of contaminants from stormwater and stabilization of side slopes.

9. Pretreatment for stormwater prior to entering the retention basin should be designed into the system whenever possible. Pretreatment of stormwater by using sheet flow, grassed waterways, off-line landscape infiltration areas, or other measures can remove a large percentage of the pollutants (up to 90%) that are contained in stormwater.

10. Projects in areas zoned for industrial land uses shall assure that industrial pollutants do not enter the stormwater system or come in contact with groundwater. Developments permitted in areas zoned for industrial land use should receive more detailed review to assure that they comply with these requirements.

Design Criteria

1. General. All facilities which temporarily impound runoff waters shall be designed to be stable during construction and operation. The facility shall have an overflow bypass for stormwater in excess of storage volume (see Figure 4-121).

2. Calculating Retention Volume. Retention facilities must have the capacity to store and percolate the runoff from the first one-half in of runoff within 72 hours. However, some local review agencies may require greater retention levels. The use of a retention facility is usually associated with some sort of collection system with storage volume regulated by an overflow or bypass spillway. Since retention depends primarily on soil percolation rates, the soils in the vicinity of the pond must be tested to determine infiltration rates and to locate the water table depth.

   Assuming that a retention basin will percolate stormwater before the next storm event, a volume of storage can be calculated using the following formula:

   $$V_M = \frac{A x DI}{12}$$ where:

   V_m = minimum basin volume (acre-feet)
   A = contributing watershed area (acre) (maximum 10 acres)
   DI = diversion volume (.5 inches minimum)
   12 = conversion factor (in/ft)

3. Estimating and Evaluating Drawdown Time Requirements. Retention facilities must be capable of providing a new volume of storage within 72 hours following a storm. Facilities designed for recreation or open space, etc., should consider a shorter storage period.

   For systems in which the water table elevation is below the bottom of the retention basin the drawdown time (T) may be estimated very simply. Percolation or infiltration in a retention basin produces an infiltration hydrograph (time-variable) which describes the draining of the basin. The rate of outflow will be in accordance with Darcy's Equation which is:

   $q = KiA$ where:

   q = rate of seepage or percolation from the facility (ft3/hr)
   K = hydraulic conductivity or percolation rate associated with the soil in the vicinity of the facility (ft/hr)
   i = hydraulic gradient or the loss of hydraulic head per unit distance of flow (ft/ft)
   A = area of the soil profile through which infiltration is occurring (ft2)

When the water table is below the bottom of the basin, the entire surface area of the facility is available for percolation. The average area (A) may be determined by dividing the volume by the depth of the holding area. Assuming a hydraulic gradient of unity (e.g., i = 1), which is a conservative assumption, the rate of outflow may be calculated once the permeability (K) is established using appropriate field testing procedures. The final or constant rate established from these testing procedures must be used, not the initial rate encountered shortly after the beginning of a test run.

Subsequently, drawdown time (T) may be determined by dividing the storage volume (V_m) required for the facility (e.g., one-half inch runoff volume or other appropriate value) by the rate of percolation (q) from the facility as established from Darcy's formula. The appropriate expression is shown below where all terms are as previously discussed in this paragraph.

$$T = V_m/q$$

There are many areas in Mississippi where retention is not an economically feasible alternative. The most common limitations are restrictive soil layers in combination with flat terrain, poorly defined surface drainage systems, and limited elevation differences which severely restrict the movement of water. In most instances, designers elect to use filters and underdrains to provide the prescribed level of stormwater quality treatment.

Surveys and Investigations Required

At a minimum, it will be necessary to determine the infiltration rate of local soils. This information is needed to evaluate drawdown time. Provided the location of the treatment facility is flexible, this type of data is also valuable for situating the facility where it may function the most advantageously.

To develop a discharge-time relationship for the drainage area, sufficient topographic information and data pertaining to the type and condition of the vegetative cover at the site must be available in order to estimate the time of concentration of the watershed.

The site survey should be in sufficient detail to allow the permitting authority to be able to fully assess the potential for groundwater contamination that may be associated with a proposed project. In most cases, the applicant should be prepared to submit:

1. Geologic sections describing the substrate through the retention basin area.

2. A description of all groundwater levels and flow at the site.

3. A description of the site's topography before and after the project construction including information on any surface water drainage features.

4. An inventory of existing wells within a 1000 foot radius of the stormwater basin.

Construction and Design Considerations

1. General. A schematic of an off-line retention basin with an overflow spillway is shown in Figure 4-121. Exfiltration trench BMP may be used to increase storage and/or infiltration.

   Regardless of the type of infiltration system to be constructed, careful consideration should be given to the effects that the design work sequence, construction techniques, and equipment employed will have on future operation and maintenance of the system. Serious problems can be averted, or in large part mitigated, by the adoption of relatively simple measures during the design and construction phase.

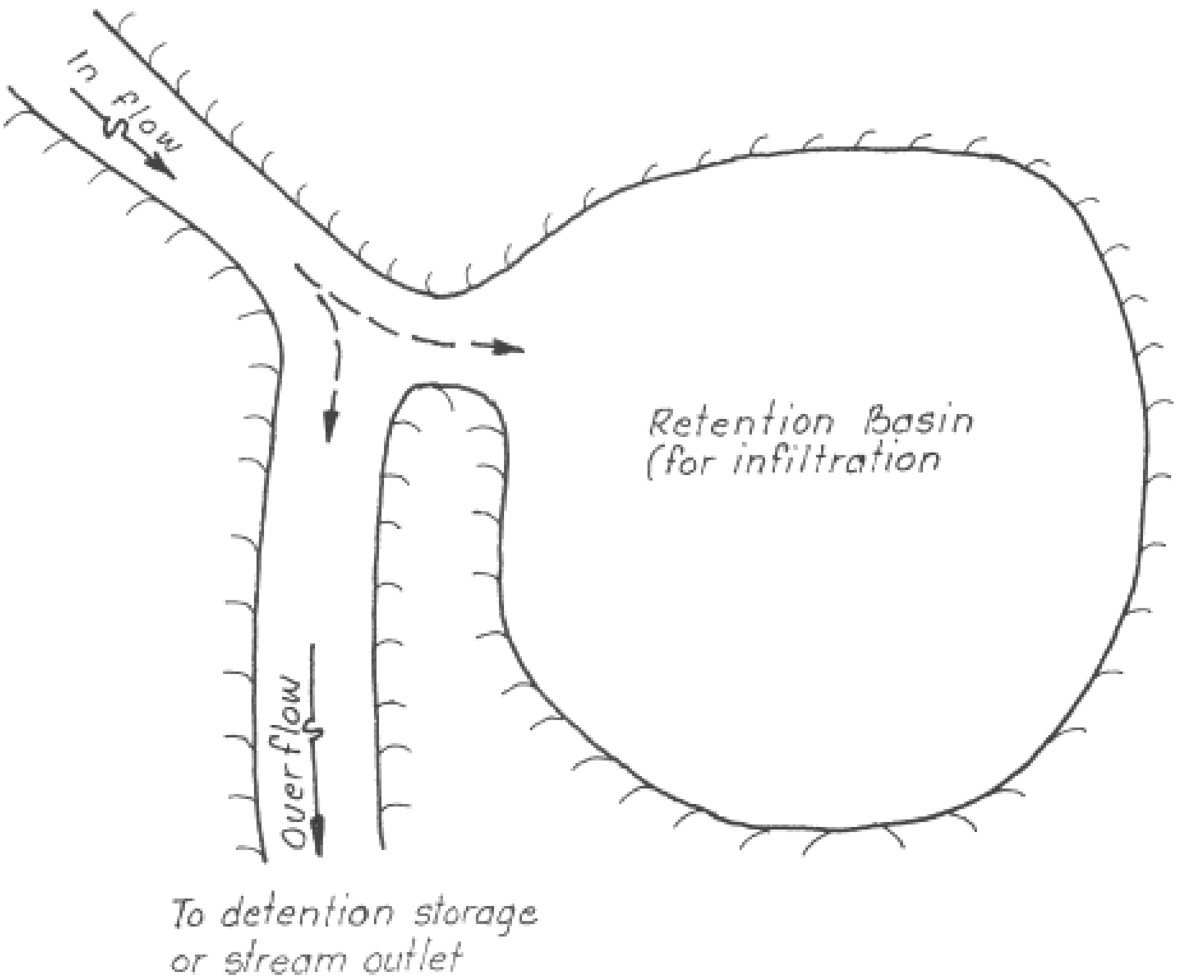

Figure 4-121 Off-line retention basin arrangement.

2. Surface Percolation (Retention Basin) - The sequence of various phases of basin construction has an identifiable relationship to the overall project construction schedule. An ideal program would schedule rough excavation of the basin for the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated basin may serve as a sediment basin BMP to assist in erosion control during construction. Stormwater from untreated, freshly constructed slopes within the watershed area will load the newly formed basin with a heavy concentration of fine sediment. Such circumstances seriously impair the natural infiltration characteristics of the site.

Establishment of vegetation on the basin sides and floor is a must. A dense stand of vegetation will not only prevent erosion, but will also provide a natural means of maintaining relatively high infiltration rates through the surface. When the basin is adequately maintained, removal of any accumulated sediment is a problem only at the basin floor. Little, if any additional maintenance is required to maintain the infiltration capacity of the slope areas.

In design, prevention of scour at the basin inlet is mandatory to reduce maintenance problems and aid in establishing vegetation. Reduction in water energy by providing hydraulic structures and an apron on which water can flow into the basin are effective in reducing scour. If possible, after excavation or earth moving for basin construction, runoff waters should not be permitted to flow into the basin until vegetative cover has been established.

Maintenance of side slopes is important. Recommend using slopes of 3 horizontal to I vertical or flatter to facilitate mowing and maintenance. Basin shape depends largely on the configuration of the available site. The shape providing the greatest area will infiltrate water most rapidly.

Initial basin excavation should be carried to within I ft. (0.3 m) of the final elevation of the basin floor. Final excavation to the finished grade should be deferred until all slopes in the watershed have been seeded and protected with an interim treatment. The final phase excavation should be performed carefully to remove all accumulated sediment. Relatively light equipment is recommended for this operation to avoid deep compaction of the basin floor. After the final grading is completed, the basin floor should be deeply tilled with rotary tillers or disc harrows to open the soil pores and provide a well-aerated, highly porous surface texture for seeding or sodding.

As noted earlier detention or sediment basins can be used prior to retention basins so that suspended solids will settle out before the water is released into the retention basin. These basins must be large enough to hold storm runoff for a sufficient settlement time. This could vary from one or two hours to a day or more depending on soil type and particle size. Where the soil contains considerable amounts of fine textured material of low settling velocity, a sediment basin may be larger and shallower than the actual retention basin.

Landscaping of retention basin facilities creates a pleasing appearance that should always be considered when basins are located near residential areas. The landscaped basin can be used as a park or recreation area. However, such a project requires plants, trees and shrubs capable of withstanding temporary inundation. Basin sides should be gently sloped to give a park-like appearance.

Infiltration basins are sometimes lined with material to help prevent the build-up in impervious silt deposits on the soil surface. A 6-inch (0.15 m) layer of pea gravel on the basin floor can serve to effectively screen out suspended solids and keep infiltration rates high. The gravel layer can be replaced or cleaned when it becomes clogged. However, planting of grass is probably a more economical alternative. Vegetation has been shown to extend infiltration efficiency, keep the soil pervious, reduce maintenance due to clogging and prevent erosion.

Grass serves as a good filter material, particularly the bermudagrass variety which is extremely hardy and can withstand several days of submergence. Well established bermuda on a basin floor will grow up through silt deposits forming a porous turf and thus prevent the formation of an impermeable layer. Bermuda grass infiltration works well with long narrow basins along the fringes of parking areas and highways. Bermuda requires little attention besides summer irrigation during the period of establishment.

Coarse organic material (such as cotton boll hulls, leaves, stems, etc.) is sometimes specified for discing or spading into the basin floor to increase the permeability of clayey soils. The basin floor should be soaked or inundated for a brief period then allowed to dry subsequent to this operation. This is thought to induce the organic material to decay rapidly, loosening the upper soil layer.

Maintenance and Inspection

1. General - All stormwater systems should be inspected on a routine basis to ensure that they are functioning properly. Major inspections can be on an annual or semi-annual basis, but brief inspections should always be conducted following major storms. Systems that incorporate infiltration are most critical since poor maintenance practices can soon render them inefficient. Procedures for maintenance of these systems are discussed in this section. It should be stressed that good records should be kept on all maintenance operations to help plan future work and identify facilities requiring attention. It is also advisable to follow up with a site visit to assure that vegetation (sod) is growing well and that all construction is according to approved design.

2. Retention Basins - Retention basin surfaces are sometimes scarified to break up silt deposits and restore topsoil porosity. This should be accomplished after all sediment has been removed from the basin floor. However, this operation can be eliminated or minimized by the establishment of grass cover on the basin floor and slopes. Such cover helps maintain soil permeability.

Holding ponds or sedimentation basins can be used to reduce maintenance in conjunction with retention basins by settling out suspended solids or removing oil and grease before the water is released into the retention basin.

Cleanout frequency of retention basins will be a function of their storage capacity, infiltration characteristics, volume of inflow, and amount and type of sediment load. Retention basins should be thoroughly inspected at least once a year. Sediment basins and traps may require more frequent inspections and cleanout. These structures should have a prescribed sediment level at which they are cleaned.

Stormwater Retention Basin Design Form

Project Location: City ____________________ County____________________

Section ____________, Range ____________, Township ____________

Planned Construction Date _______________, Ending Date ______________

Basin Data: Drainage Area ______________ sq. ft. or acres ____________

Detention Storage Volume: _________ inch, _________ cu ft

Maximum Detention Period: _________ hours

Soils ________________, Infiltration Rate ________________ in/hour

Overflow Spillway: Width _________ feet, Depth _________ feet,

Outlet to: ____

Vegetation Cover in Basin: ______________________________________

Project/Developer Representative: ____________________ ______________

Name Date

____

Sketch of basin to include inflow area, overflow spillway and outlet, maintenance access, etc.