2G-1 General Information for Detention Practices

A. Introduction

This section provides design guidelines for a group of stormwater management BMPs broadly referred to as detention basins or ponds. Guidance is provided for stormwater runoff storage for meeting stormwater management control requirements (i.e., water quality treatment, downstream channel protection, overbank flood protection, and extreme flood protection). Storage of stormwater runoff within a stormwater management system is essential to providing the extended detention of flows for water quality treatment and downstream channel protection, as well as for peak flow attenuation of larger flows for overbank and extreme flood protection. Traditional systems consist of detention basins for attenuation of peak runoff rates from storm exceeding the 5-year design storm. For water quality control and downstream channel protection, the detention storage volume is often based on the smaller, more frequent events (≤1-year storm event). For these smaller design storms, and for smaller drainage areas (≤ 5-10 acres), smaller volumes of runoff storage can be provided within onsite systems as integrated components of infiltration practice structural controls, and non-structural features and landscaped areas (infiltration basins, bioretention areas, and porous pavement systems). Figure 1 illustrates various storage facilities that can be considered for a development site.

Engineers have designed small and large ponds for many years for a wide rage of applications, including farm ponds, recreational ponds, water supply reservoirs, managing the increased runoff rate from urban development, flood control reservoirs, and multiple uses reservoirs. The collective knowledge of ponds, their design, construction, operation, and maintenance is extensive. However, their use for environmental protection purposes including stream channel protection, water quality treatment, and protection of receiving waters is a recent development, and in many instances requires re-assessing the traditional applications of pond design techniques to meet these new objectives.

There is also some concern regarding the effectiveness of detention practices for providing downstream flood control. The design of detention facilities is often confined to the limits of the property for which the facility is being designed, without much regard for potential downstream impacts. The issue of super-positioning of hydrograph peaks is often overlooked, and yet can result in simply transferring the flood or channel erosion problem to unsuspecting downstream property owners. The use of detention to control stormwater quality was first used in the early 1980s. By the late 1980s, sufficient empirical data was available to design extended detention basins for water quality purposes with reasonable confidence in their performance. Extended detention basins are best at removing suspended constituents, but they are not particularly effective in removing soluble contaminants. Removal rates of solids by wet detention basins tend to outperform dry detention basins. A comparison of constituent removal efficiencies of extended detention basins and detention ponds is presented in Table 1.

Table 1: Comparison of pollutant removal percentages by water quality BMP

Type of Pond	TSS	Nitrogen	Phosphorous	Lead	Zinc	BOD
Dry, extended detention	50-80	0 (dissolved) 10-30 (total)	0 (dissolved) 10-50 (total)	35-80	35-70	20-40
Wet detention	70-85	50-70 (dissolved) 30-40 (total)	50-70 (dissolved) 50-65 (total)	25-85	25-85	20-40
Infiltration basin	60-98	60-98 (total)	60-98 (total)	60-98	60-98	N/A

Source: USEPA (1983), Stahre and Urbonas (1990), ASCE (2001)

1. **Dry detention basins.** A dry detention basin is used to reduce peak discharge and detain runoff for a specified short period of time. Detention volumes are designed to completely drain after the design storm has passed. Detention is used to meet overbank flood protection criteria, and extreme flood criteria where required. While many jurisdictions initially applied this approach to control the 10-year, 25-year, 50-year, or 100-year storm flow rates, the normal application in Iowa jurisdictions has been to control the 5-year storm runoff rate. (Note: this is often a function of the downstream stormwater conveyance capacity, i.e., storm sewer). A small number of jurisdictions have also adopted control for the 2-year peak flow rate as an attempt to control downstream bank erosion. Figure 1 shows a typical dry detention basin.

   Section 2G-2 provides criteria for designing dry detention and extended dry detention BMPs. Criteria are provided for sizing the required pond volume, basin configuration, outlet protection, vegetative cover, and other elements.

Figure 1: Dry detention basin

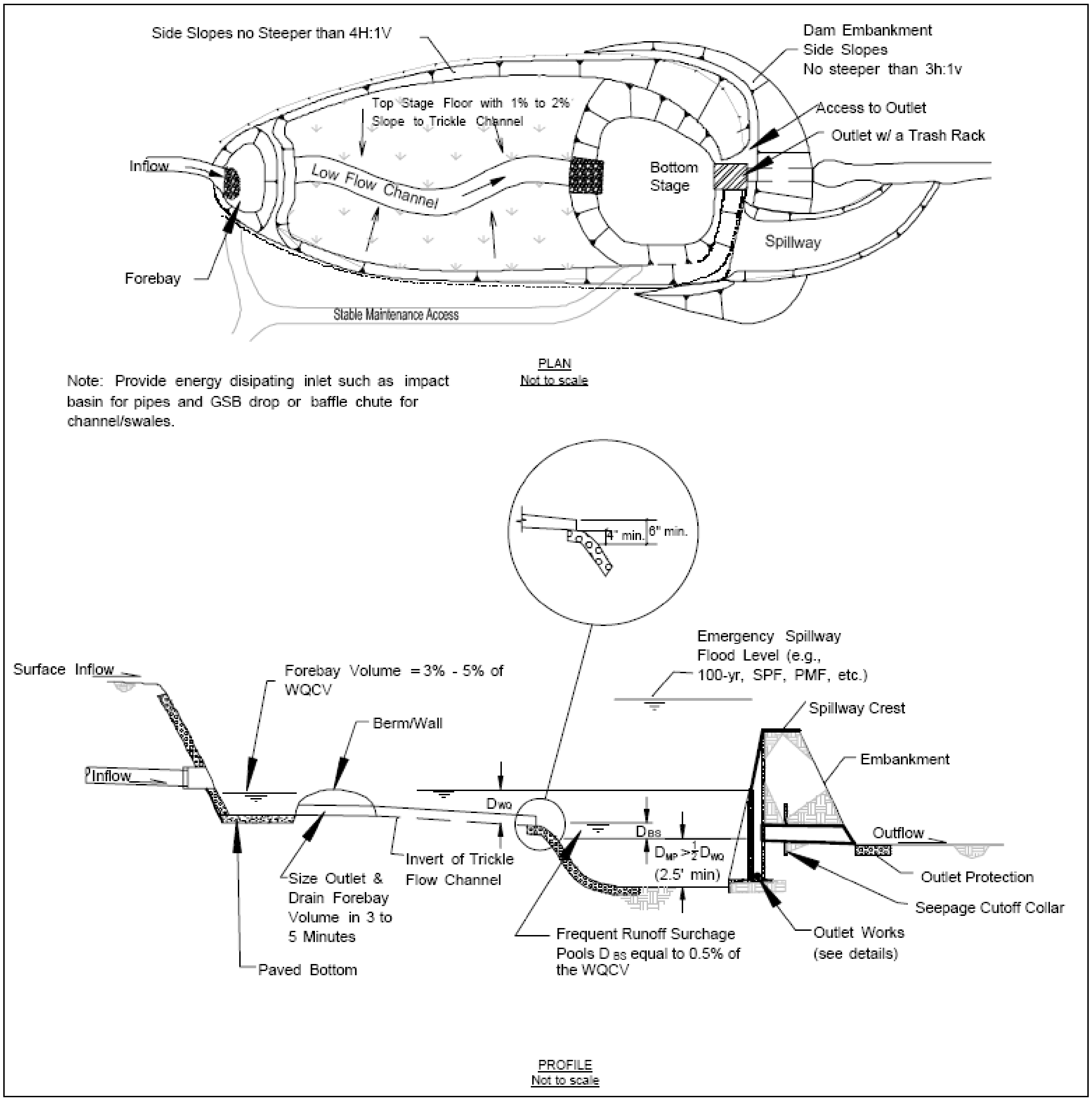
2. **Extended dry detention.** Extended dry detention (ED) is used to drain a runoff volume over a specified period of time, typically 24 hours, and is used to meet channel protection criteria (CPv). Some structural control designs (wet ED pond and micro-pool ED pond) also include extended detention storage of a portion of the water quality volume.

   Extended detention for stormwater quality was first used for new installations of extended detention ponds, or as retrofits of old dry ponds. Extended detention refers to a basin designed to extend detention beyond that required for stormwater peak rate control to provide some water quality affect.

   Extended detention basins are viable and effective treatment facilities. When properly designed, significant reductions are possible in the total suspended sediment load and of constituents associated with these sediments. Typically these basins are less effective in removing soluble solids. The elements of a typical extended detention basin are illustrated in Figure 2. The amount of reduction depends on a wide variety of factors, including:
   - Surface area of the basin
   - Peak outflow rate
   - Size distribution of the particles
   - Specific gravity of particles
   - Fraction of the sediment that is active clay
   - Type of associated pollutant concentrations
   - Fraction of influent solids that are colloidal, dissolved, and non-settleable

   Extended detention basins will sometimes have a small permanent pool below the invert of the low flow outlet. This is normally so small that it does not materially impact trapping of sediment and chemicals, and is typically included for aesthetics or to cover deposited sediments.

Figure 2: Extended dry detention basin

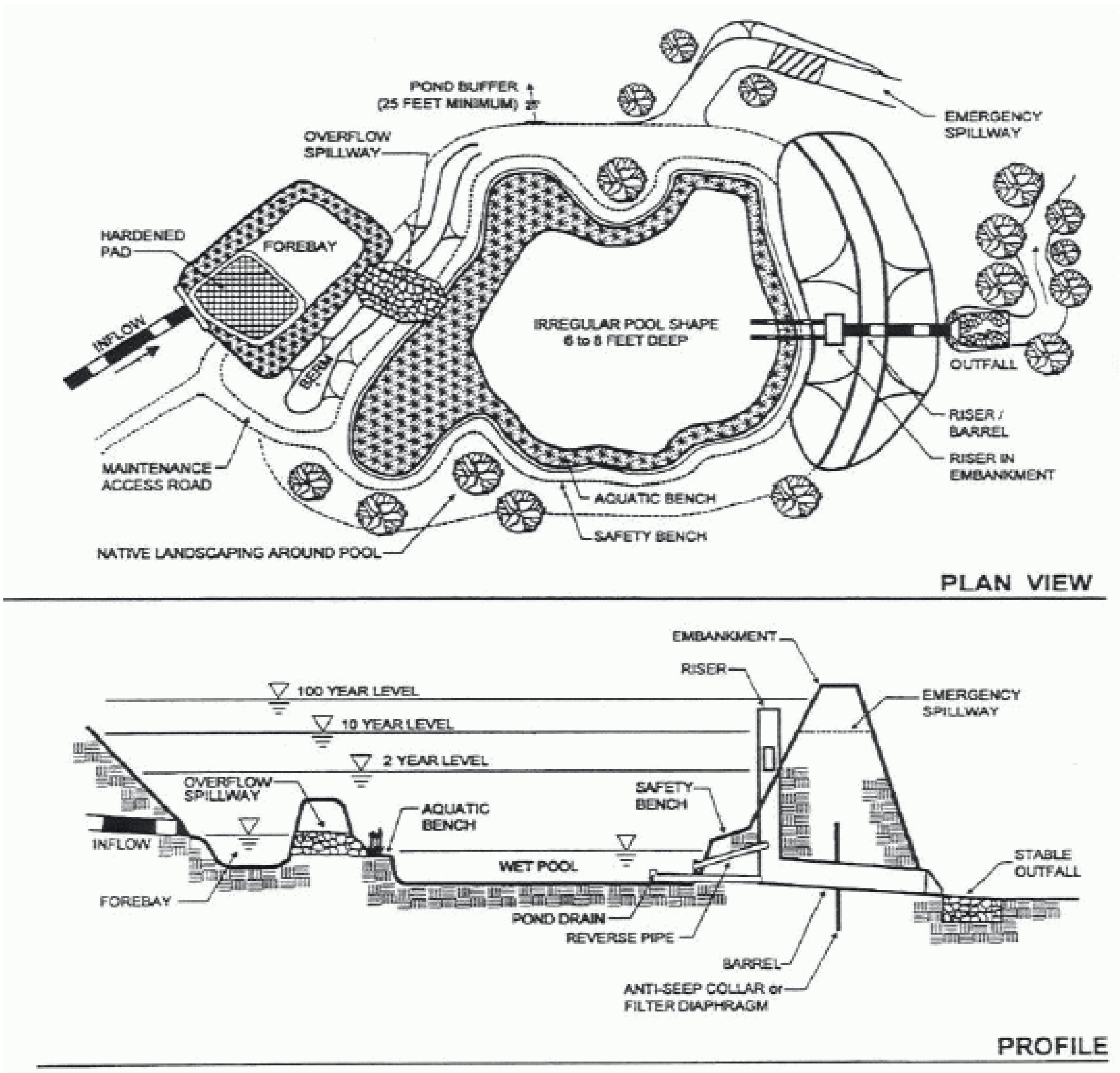


Source: UDFCD, 2005

3. **Wet detention basins.** Wet detention basin facilities (i.e., wet ponds, retention basins) are designed to contain a permanent pool of water with emergent wetland vegetation around the perimeter, designed to remove pollutants from stormwater. These are often called stormwater ponds or stormwater wetlands, and are constructed to provide water quality treatment. Removal rates of solids by wet detention basins tend to outperform dry detention basins. The larger permanent pool of wet detention basins allows water to reside in the interval between storms, when further treatment occurs. A wet detention basin can be sized to remove nutrients and dissolved constituents, while any temporary pool that may be associated with an extended dry detention basin is smaller and is provided for aesthetics, as discussed under the extended detention discussion above. Figure 3 illustrates the elements of a wet detention basin.

   Section 2G-3 provides criteria for the design of wet detention ponds. Guidance is provided for the following design parameters: pool volume, pool depth, surface area of permanent pool, minimum drainage area and pond volume, side slopes, pond configuration, outlets, and other elements. Criteria are also provided for the design of wetland ponds. These criteria include: general feasibility, conveyance, pre-treatment, treatment, and maintenance.

Figure 3: Wet detention basin



Source: Maryland, 2000

4. **Infiltration basins.** Infiltration basins are a special type of detention facility, and are described under infiltration practices. The design of infiltration basins is covered in Section 2E-3. Design criteria are provided for the following elements: general feasibility, conveyance, pre-treatment, treatment, and maintenance. In addition design procedures address the following elements: soil texture, hydrologic design methods, and sizing.

B. Storage facilities

Storage facilities are often classified on the basis of their location and size.

- Onsite storage is constructed on individual development sites.
- Regional storage facilities are constructed at the lower end of a sub-watershed, and are designed to manage stormwater runoff from multiple projects and/or properties. A discussion of regional stormwater controls is found in Section 2D-3. Regional facilities often offer economies of scale and greater reliability in capturing stormwater, while onsite facilities offer institutional and fiscal advantages of implementation as the land is urbanized.

Because of the poorly-documented stormwater pollutant control effectiveness of detention basins designed for flood control, these basins cannot themselves be recommended as viable water quality control measures. However, detention basins can be effective when used in conjunction with other upstream stormwater control practices such as vegetated swales, filter strips, and bioretention area BMPs.

Storage can also be categorized as on-line or off-line.

- Online storage uses a structural control facility that intercepts flows directly within a conveyance system or stream.
- Off-line storage is a separate storage facility to which flow is diverted from the conveyance system.

Figure 4: Online vs. off-line storage