2D-1 General Information for BMPs

A. Description and performance of stormwater BMPs

A stormwater best management practice (BMP) is a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner. BMPs can be either:

1. **Non-structural BMPs**. Include a range of pollution prevention, education, or institutional management and development practices designed to limit the conversion of rainfall to runoff and to prevent pollutants from entering runoff at the source of runoff generation.

2. **Structural BMPs**. Engineered and constructed systems that are used to treat the stormwater at either the point of generation or the point of discharge to either the storm sewer system or to receiving waters (e.g. detention ponds or constructed wetlands).

No single BMP can address all stormwater problems. Each type has certain limitations based on drainage area served, available land space, cost, and pollutant removal efficiency; as well as a variety of site-specific factors such as soil types, slopes, depth of groundwater table, etc. Careful consideration of these factors is necessary in order to select the appropriate BMP(s) for a particular location. Regardless of the type, stormwater BMPs will be most effective when implemented as part of a comprehensive stormwater management program that includes proper selection, design, construction, inspection, and maintenance. Descriptions of commonly-used BMPs, along with important factors for design, advantages, disadvantages, and maintenance considerations for each BMP can be found in Part 2D.

B. Goals of stormwater BMPs

In existing urbanized areas, BMPs can be implemented to address a range of water quantity and water quality considerations. The applicability of individual practices will vary depending on the needs of the practitioner. For new urban development, BMPs should be designed and implemented so that the post-development peak discharge rate, volume, and pollutant loadings to receiving waters are as close as possible to pre-development values. In some instances, the application of BMPs can improve water quality and or reduce runoff volume when the watershed had been altered from its natural condition. In order to meet these goals, BMPs are typically implemented to address three factors:

1. Flow rate control (peak flow reduction)

2. Reduction of runoff volume from urbanizing areas

3. Pollutant removal and pollutant source reductions

Properly designed, constructed, and maintained structural BMPs can effectively remove a wide range of pollutants from urban runoff. Pollutant removal in stormwater BMPs can be accomplished through a number of physical and biochemical processes. The efficiency of a given BMP in removing pollutants is dependent upon a number of site-specific variables, including the size, type, and design of the BMP; the soil types and characteristics; the geology and topography of the site; the intensity and duration of the rainfall; the length of antecedent dry periods; climate factors such as temperature, solar radiation, and wind; the size and characteristics of the contributing watershed; and the properties and characteristics of the various pollutants.

C. Pollutant removal processes

Removal of pollutants from urban runoff can occur through the following mechanisms:

1. **Sedimentation.** Sedimentation is the removal of suspended particulates from the water column by gravitational settling. The settling of discrete particles is dependent upon the particle velocity, the fluid density, the fluid viscosity, and the particle diameter and shape. Sedimentation can be a major mechanism of pollutant removal in BMPs such as ponds and constructed wetlands, and can remove a variety of pollutants from stormwater runoff. Pollutants such as metals, hydrocarbons, nutrients, and oxygen-demanding substances can become adsorbed or attached to particulate matter, particularly clay soils. Removal of these particulates by sedimentation can therefore result in the removal of a large portion of these associated pollutants.

   The main factor governing the efficiency of a BMP at removing suspended matter by sedimentation is the time available for particles to undergo settling. Particle size directly affects the pollutant settling ability: the smaller the particle size, the longer it takes to settle. Conversely, the larger the particle, the faster its settling velocity is. Fine particulates such as clay and silt can require detention times of days or even weeks to settle out of suspension. Therefore, it is important to evaluate the settling characteristics of the particulates in runoff before BMP design in order to determine the detention time necessary for adequate settling to occur.

   The overall efficiency of a BMP in removing particulates by settling is also dependent upon the initial concentration of suspended solids in the runoff. In general, when runoff contains higher initial concentrations of suspended solids, the BMP will achieve greater removal efficiency. In addition, some particles, such as fine clays, will not settle out of suspension without the aid of a coagulant. As a result, there is usually a minimum practical limit of approximately 10 mg/l of TSS (total suspended sediment), below which additional TSS removal cannot be expected to occur (UDFCD, 1992). Turbulence, eddies, circulation currents, and diffusion at inlets and outlets affect the settling ability of particles. Each of these factors can move particles back up into the water column. In general, the larger the stormwater loading rate, the lower the removal of sediment by settling. Settling will also take place after stormwater is trapped and ponded between storms. Because the time interval between storm events is variable, understanding the effective ratio of storage volume to mean runoff rate and the ratio of sediment volume removed to mean runoff rate is essential to predicting long-term averages.

2. **Flotation.** Flotation is the separation of particulates with a specific gravity less than that of water. Trash such as paper, plastics, and other low-density materials can be removed from stormwater by flotation. If the inlet area of a BMP is designed to allow for the accumulation of floatable materials, then these accumulated materials can periodically be manually removed from the BMP. Significant amounts of floatables can be removed from stormwater in properly-designed BMPs in this manner. In addition, oils and hydrocarbons will frequently rise to the surface in stormwater BMPs. If the BMP is designed with an area for these materials to accumulate, then significant removals of these pollutants can occur. Many modular or drop-in filtration systems incorporate an oil and grease or hydrocarbon trap with a submerged outlet pipe that allows these contaminants to accumulate for periodic removal.

3. **Filtration.** Filtration is the removal of particulates from water by passing the water through a porous media. Media commonly used in stormwater BMPs include soil, sand, gravel, peat, compost, and various combinations such as peat/sand, soil/sand and sand/gravel. Filtration is a complex process dependent on a number of variables. These include the particle shape and size,

the size of the voids in the filter media, and the velocity at which the fluid moves through the media. Filtration can be used to remove solids and attached pollutants such as metals and nutrients. Organic filtration media such as peat or leaf compost can also be effective at removing soluble nutrients from urban runoff.

4. **Infiltration.** Infiltration is the most effective means of controlling stormwater runoff since it reduces the volume of runoff that is discharged to receiving waters *and* the associated water quality impacts that runoff can cause. Infiltration is also an important mechanism for pollutant control. As runoff infiltrates into the ground, particulates and attached contaminants such as metals and nutrients are removed by filtration, and dissolved constituents can be removed by adsorption. However, infiltration is not appropriate in all areas.

5. **Adsorption.** Adsorption, while not a common mechanism used in stormwater BMPs, can occur in infiltration systems where the underlying soils contain appreciable amounts of clay. The clay and organic particles in soil hold negative charges. The ability of soil and organic matter to hold cations, such as phosphorus and aluminum, represent the soil's cation exchange capacity. This process is most readily used to remove soluble pollutants from stormwater. Dissolved metals that are contained in stormwater runoff can be bound to the clay particles as stormwater runoff percolates through clay soils in infiltration systems. Organic matter, such as peat or leaf matter in the filter media, can remove pollutants using the cation exchange capacity of the media. The treatment of runoff with media filters, such as the bioretention cell (Clar and Green, 1993), is an example of a cation exchange process combined with filtration. A shallow basin collects the runoff and gradually discharges through a filter media filled with planting soil, peat, or composted leaf media. The filter media traps particulates (through filtration) and adsorbs organic chemicals, removing up to 90% of solids, 85% of oil and grease, and 82-98% of heavy metals (through cation exchange from leaf decomposition) in stormwater that passes through the filter.

6. **Biological uptake.** Biological uptake of nutrients is an important mechanism of nutrient control in stormwater BMPs. Urban runoff typically contains significant concentrations of nutrients. Ponds and wetlands can be useful for removing these nutrients through biological uptake. This occurs as aquatic plants, algae, microorganisms and phytoplankton utilize these nutrients for growth. Periodic harvesting of vegetation in BMPs allows for permanent removal of these nutrients. If plants are not harvested, however, nutrients can be re-released to the water column from plant tissue after the plants die.

7. **Biological conversion.** Organic contaminants can be broken down by the action of aquatic microorganisms in stormwater BMPs. Bacteria present in BMPs can degrade complex and/or toxic organic compounds into less harmful compounds that can reduce the toxicity of runoff to aquatic biota.

8. **Degradation.** BMPs such as ponds and wetlands can provide the conditions necessary for the degradation of certain organic compounds, including certain pesticides and herbicides. Open pool BMPs can provide the necessary conditions for volatilization, hydrolysis, and photolysis of a variety of organic compounds to take place.