11/23/09

Draft Industrial Stormwater Multi-Sector BMP Guidebook

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Introduction to the Industrial Stormwater Best Management Practices Guidebook

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Many of the requirements within the Industrial Stormwater Multi-Sector General Permit (ISW MSGP) are new to permittees, even to those who have had previous industrial stormwater permit coverage. The Minnesota Pollution Control Agency (MPCA) has made a commitment to provide guidance materials to permittees to help them comply with the requirements. The Industrial Stormwater Best Management Practices Guidebook (Guidebook) intends to give users of the Guidebook ideas and choices for which Best Management Practices (BMPs) they may want to consider for their facility. The Guidebook's BMP options range from simple/non-structural BMPs to structural BMPs. Often, the simplest solution is the best one. This Guidebook has many direct ties to permit requirements, allowing the user to understand the relationship between Control Measures, Best Management Practices, monitoring, and permit compliance.

Chapter 1: Introduction to Industrial Stormwater

Industrial Stormwater Management

Minnesotans value the state's natural resources and expect them to be protected through proactive stewardship, responsible enjoyment and protective management. The Minnesota Pollution Control Agency's mission of working with state residents and businesses to protect, conserve and improve our environment reflects these values as do the regulatory actions we are authorized to take. The industrial stormwater permit is an example of this commitment.

1.1: What is stormwater? Why is it regulated?

The term "stormwater" generally refers to precipitation, snowmelt and surface runoff as well as drainage to groundwater. Stormwater is the ultimate source of all the fresh water in our lakes and streams that we all use for drinking, fishing, swimming, agriculture, industries, and many other uses. As these waters are impacted, we lose the benefits of these uses.

Sediment and other pollutants can impact aquatic habitats, and the water we all value. Stormwater can contribute pollutants to waters when stormwater contacts significant materials at industrial facilities. Examples of pollutant sources include: equipment, machinery, raw materials, intermediate products and, waste handling equipment, final products, and waste. When those materials are being stored, handled, loaded, unloaded or transported, there's a potential for precipitation to come into contact with them, resulting in contaminated stormwater runoff. Through the regulation of Industrial Stormwater, we help to protect our waters and the uses they provide.

1.2 Introduction to Best Management Practices

"Best Management Practices" or "BMPs" are practices to prevent or reduce the pollution of waters of the state, including schedules of activities, prohibitions of practices, and other management practices, and also includes treatment requirements, operating procedures, and practices to control industrial stormwater runoff, spillage or leaks, sludge, or waste disposal or drainage from raw material storage (Minn. R. 7001.1020, subp.5).

Control Measures and BMPs
Permittees are required to implement "control measures" to prevent or reduce impacts to water from industrial stormwater discharges. Some control measures are specific and well defined. Other control measures are general in nature and the permittee must decide what specific steps taken to implement the control measures. The steps taken to implement control measures are the BMPs that are specified in the permit or the BMPs that the permittee selects when the permit allows options.

BMP Systems
BMPs should be considered as a system or series of activities that accomplish management measures and permit compliance. Such systems may include multiple management options, ranging from avoidance (by education, training and planning) to minimization (by litter control, street sweeping and secondary containment) and mitigation (by construction of treatment structures). Although stormwater ponds and wetland-treatment systems are most often the tools for treatment and storage of stormwater runoff, they are only some of the tools in this process.

Avoid, Minimize, Mitigate
It is generally the policy of this permit that the first priority is to consider BMPs to avoid impacts. No Exposure should be the first option considered but it may or may not be the best option in all cases. Training, housekeeping practices and spill plans are examples of BMPs that help minimize potential impacts. Treatment is mitigation for unavoidable impacts and is the last, but not least important, level of protection of the environment.

BMP Selection Options
The recommendations of this manual are suggested with the realization that designing a BMP system is very complex and site-specific to be reduced to a "cookbook" guidance. Rather, the recommendations in this guidebook are intended to help the design team adopt and modify the implementation process to meet local conditions and facility requirements.

Most permittees will select BMP options that avoid, minimize, and mitigate potential impacts. Select and implement BMP options on a system-wide, and waterbody basis, as appropriate to meet the permit, industry needs and environmental goals. Also, determine the appropriate measures after considering a variety of factors, including:

- the characteristics of the facility
- the characteristics of the resource to be protected
- the feasibility of implementation
- public demands and
- permit requirements.

It is important to adopt an interdisciplinary approach when designing BMP systems. Creating a design team is an integral part of this approach. Members of the design team should have expertise in the facility's industrial process, stormwater engineering, natural resource management skills, and other skills such as landscaping and construction of BMPs, as needed. The design team should work together through a process that begins with a facility-wide assessment and ends with facility BMP implementation.

Consider the simple solutions first

In general, the least-impacting BMP that will solve the problem should be chosen. Note that structural methods and treatment are the third priority level. This prioritization is due to the expense and physical alteration necessitated by treating contaminated runoff after it is generated. If it is feasible to meet the project objectives, including protection of downstream water quality characteristics, without structural methods such as construction of stormwater ponds, this is usually more cost effective and creates less disruption, but it is not always possible.

Effect on Other Resources

When planning BMPs, consider the effect it will have on other resources. Without proper design and planning, BMPs may simply shift a water quality problem elsewhere or creating a new water quality problem. Creating a large impervious surface to meet the No Exposure exclusion may create runoff problems by dramatically increasing the runoff volume and discharge rate. While this may meet the permit requirements it could cause erosion, flooding and temperature increases, problems that may be more environmentally harmful than intended.

Improperly designed structural BMPs can adversely affect stream hydrology, fish, and wildlife. For example, improperly designed stormwater ponds can increase temperature and may actually increase peak-flow because of runoff timing, aesthetics can be affected if excessive algae growth occurs, and groundwater may be affected if pollutants are not captured by soils underneath infiltration practices.

Physical Suitability

BMPs should only be used in areas where the physical site characteristics are suitable. Some of the important physical site characteristics to consider when choosing BMPs are soil type, watershed area, and water table, depth to bedrock, facility size and topography. If these conditions are not suitable, a BMP can lose effectiveness, require excessive maintenance or may stop working after a short period of time. Unfavorable site conditions can often be overcome with special design features. For example, the bottom of a detention pond can be sealed to prevent seepage at a facility where a permanent pool is desired. In other cases, a practice will be excluded from consideration when a facility presents impractical conditions. An example would be where a high water table or clay soils eliminate an infiltration basin from consideration. The physical site conditions must be examined for each practice.

Maintenance Requirements

Studies have shown that pollutants, such as metals, can bioaccumulate in plants and fish that live where sediment from stormwater is trapped. Many structural BMPs capture pollutants that ultimately need to be disposed of in an environmentally safe manner. The potential for odor, insects, weeds, turbidity and trash are also important to residents who live near structural BMPs. With regular maintenance, these problems can usually be overcome or be made very temporary.

Maintenance is an important part in the operation of any structural BMP and should be considered during the initial design. A feature, such as a forebay in a detention pond, may increase annual maintenance costs slightly, but the interval between costly sediment cleanouts of the whole pond may be extended significantly. Locations for disposal of sediments and floatable solid waste should be taken into account during this phase of planning a structural BMP.

Maintenance for non-structural BMPs (e.g., spill prevention or employee training programs) are often the BMP themselves. For example, a non-structural BMP may be development of a spill prevention and response plan. Maintenance for this BMP is simply ensuring that spill prevention plan is enforced and that prevention and response measures are in place.

Cost Effectiveness

A continuous tradeoff exists between building structural BMPs and other resource commitments. Pond construction and maintenance can be expensive and may reduce the availability of utilizable areas. Conversely, properly constructed and operated stormwater ponds may increase aesthetic amenities of the property. These same ponds may reduce the cost of constructing downstream storm sewers or may provide flood-protection measures.

Economics is an important consideration in the selection of BMPs that will achieve the water quality goal at the least cost. This should be considered when selecting BMPs and deciding how they will be implemented. To properly compare alternatives, all costs for the design life of a BMP should be included. These include expected maintenance costs as well as the initial costs for land, engineering and construction. To create a true economic picture of a BMP, benefits other than water quality and flood prevention should also be considered. Some benefits, such as increases in land values for property next to an attractive detention pond, are direct economic benefits. Other benefits, such as incidental recreation or wildlife benefits may be more difficult to quantify.

Connectivity to BMPs to Industrial Stormwater Permit Requirements

Industrial Stormwater Permittees are required to implement control measures, which in turn require the permittee to install and implement BMPs to manage their Industrial Stormwater Runoff. BMPs range from No Exposure and simple, nonstructural BMPs to large and complex structural BMPs. Facilities regulated by the Industrial Stormwater Program have some choices among BMPs, as long as permit control measures and other requirements are met or exceeded.

Chapter 2: Pollutants of Concern for Industrial Stormwater

Many of the everyday activities at industrial facilities can contribute substantial amounts of toxic material to receiving waters. Essentially, anything that is applied to the land or released from storage piles, waste management systems, fertilizer or pesticide applications, a smokestack vent, or a vehicle's tailpipe or tires can be deposited on and washed off impervious surfaces.

The Multi-Sector General Permit addresses the management of industrial stormwater discharges in a number of ways; ranging from choosing and installing BMPs to sampling and monitoring.

This chapter outlines the main pollutants of concern for industrial stormwater discharges. This chapter does not address all pollutants that will be monitored by Industrial Stormwater Permittees; please review the sector-specific monitoring table(s) for a complete list of parameters.

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2.1: Introduction to Total Suspended Solids (TSS)

Total Suspended Solids (TSS) is made up of particles that are washed or blown into lakes and streams. TSS is considered one of the more damaging pollutants in Minnesota, and it makes up the major pollutant by volume in the state's surface waters. Suspended particulates and bed-load solids are composed of inorganic (sand, metals) and organic (vegetative and animal waste) debris that enter the water through runoff and erosion.

Some of the problems that are caused by pollutants in receiving waters are turbidity (cloudiness), destruction of the aquatic habitat (burying, alteration of bottom material), transport of adsorbed contaminants such as metals or organic chemicals, clogging of drainage systems, and direct impact on aquatic organisms (altered respiration, reduced light penetration). TSS fills in road ditches, ponds, streams, lakes, rivers and wetlands and can affect aquatic life by smothering fish eggs and larvae. Suspended soil particles also cause water to become turbid. Excessive turbidity reduces light penetration in water, impairs sight-feeding fish, limits growth of vegetation through photosynthesis, clogs fish gills, and increases the cost of treating drinking water. Fine TSS also acts as a vehicle to transport other pollutants, including nutrients, metals and hydrocarbons, to nearby surface waters.

<u>BMPs frequently used to treat TSS:</u>

Control of solids (TSS) can be achieved by avoiding or minimizing erosion from activities such as clearing, grading and filling. BMPs that capture or reduce TSS load include detention ponds and prevention measures such as street sweeping.

2.2: Introduction to Oxygen-Demanding Substances

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While land animals extract oxygen from the air, aquatic life depends on oxygen dissolved in water. Dissolved oxygen is utilized by oxygen-demanding substances and can only be replenished by air-entrainment, or significant mixing with the water surface. A "pulse" of high oxygen demand can be created during storm runoff and deplete oxygen supplies in shallow, slow-moving or poorly flushed waters, which often results in fish kills. Stormwater runoff can deposit large quantities of oxygen-demanding substances in lakes or streams.

Carbonaceous (carbon based) Biological Oxygen Demand (CBOD) occurs when aquatic microorganisms consume organic matter and dissolved oxygen in the process. The CBOD load of typical stormwater runoff is about as large as that of effluent from an efficiently run secondary wastewater treatment plant (USEPA, December 1983).

The Chemical Oxygen Demand (COD) is a measure of all oxidizable materials including carbonaceous (carbon based) materials, metals and nutrients (e.g. ammonia) all of which require some oxygen as they break down into more simple chemicals. If the concentration of these materials becomes large, oxygen otherwise available for aquatic life is depleted, resulting in stress or death for these organisms.

<u>BMPs frequently used to capture oxygen-demanding substances:</u>
Oxygen-demanding substances can be captured by BMPs such as erosion control, litter management, stormwater detention ponds constructed wetlands, filtration, and infiltration. Some treatments use methods such as media or chemicals specifically for materials which may cause oxygen demand.

2.3: Introduction to Nutrients (Phosphorus, Nitrogen and Ammonia)

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Many naturally occurring materials are essential for life, and are therefore termed "nutrients." However, an excess of some nutrients can lead to explosive growth of nuisance or noxious life, such as some forms of algae, or can be toxic to some forms of life (as is the case with nitrates and ammonia). In Minnesota, the effects of nutrients are a major concern for surface water quality Most of the complaints received by the Minnesota Pollution Control Agency (MPCA) about lake water quality concern problems that are caused by excessive nutrient concentration (Munson, W., 1988).

Phosphorus
Phosphorus can cause algal blooms and excessive aquatic plant growth. Phosphorus is usually the limiting nutrient that controls the growth of algae in freshwater lakes. As phosphorus loadings rise, the potential for algal blooms and accelerated lake eutrophication (aging, oxygen depletion and filling in) also increases.

Nitrate/nitrogen

Most commonly, Nitrate/nitrogen come from fertilizer or similar chemicals. These chemicals can affect surface water but can also adversely impact groundwater when concentrated. Control of nutrients before discharge can be achieved by such measures as source control (fertilizer application limits), housekeeping (pet control ordinances, street sweeping), detention ponds and enhanced infiltration which removes the Nitrogen based chemicals (see the MPCA Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment Systems).

The nitrate form of nitrogen is very soluble, and it is present naturally in water at low concentrations. When nitrogen fertilizer is applied to lawns or other areas in excess of plant needs, nitrates can be washed off with stormwater runoff or leach below the root zone, eventually reaching groundwater. Water contaminated with large concentrations of nitrates presents a health hazard to young infants who consume formula prepared with it. Adults can tolerate larger concentrations of nitrates in drinking water; however, studies suggest that long-term consumption of drinking water with elevated nitrate concentrations may cause some forms of cancer (Freshwater Foundation, 1988).

Ammonia

Some facilities may use ammonia-based materials to wash and rinse equipment outside. Ammonium (NH_2) can have severe effects on surface water quality. The ammonium is converted to nitrate and nitrite in a process called "nitrification." This process consumes large amounts of oxygen and can kill fish by lowering dissolved oxygen concentration. These conditions can impair many important uses of these waters, including recreation, fish habitat and water supply.

BMPs frequently used to treat nutrients:

Prevent runoff and leaching of nutrients by properly storing and applying fertilizer. Minimize contamination by considering appropriate good housekeeping techniques such as cleaning up fertilizer (or related chemicals) from impervious surfaces. Consider structural BMPs as treatment systems such as ponds (including wetland ponds), filters, and infiltration. For nitrogen control, review the Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment System with information on nitrification-denitrification processes.

2.4: Introduction to Metals

The toxic effects that metals can have on aquatic life are a major water-quality concern. The most common metals found in stormwater runoff are lead, zinc and copper. These metals were found in more than 90% of the samples taken as part of the Nationwide Urban Runoff Program (NURP, US EPA, December 1983). Chromium, cadmium and nickel were also detected frequently in the NURP sampling. These metals originate from galvanizing, chrome plating and other industrial operations in urban areas. Automobile emissions used to be a major source of lead in urban areas, but while the emissions have been eliminated, urban and industrial soils still retain lead.

As metals corrode, dissolve or settle out of the air, small amounts are carried away by wind or water and concentrate in stormwater runoff. The toxicity of some metals in runoff varies with the hardness of the receiving water. As total hardness of the water increases, the threshold concentration for adverse biological effect increases. Many of these metals become attached to fine sediment and are carried with it until the sediment settles out. When these sediments settle out, the metals can accumulate over time to concentrations that are harmful to aquatic life. Studies have shown that metals bio-accumulate in plants and aquatic life in areas where they are contained in sediment (Meiorin, December 1986; USFWS, 1988). A major example of metal bioaccumulation is mercury, which has toxic effects and also bio-accumulates in fish and humans.

BMPs frequently used to treat metals

The first BMP to consider is No Exposure of metals to stormwater. Processes, storage or handling of metals may be able to be modified. Many industries have removed highly toxic forms of metals from their processes (e.g. chromium +6). Many industries have recovery and recycling of specific metals in their processes so that they do not become a waste product.

If treatment is required, most metals are highly associated with TSS, and removal of TSS can be the primary metals removal mechanism. Settling in ponds, filtration and other methods that remove TSS may be sufficient to meet benchmark or effluent limit discharge requirements. Depending on the amount and nature of metals, Permittees may need specific treatment to get proper removal, such as chemical additives or specific filters. Vendors may be the main supply of these devices.

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2.5: Introduction to Other Pollutants

There are many other pollutants that may be associated with certain types of industrial facilities or processes, including hydrocarbons, chloride, and temperature. Many pollutants are associated with suspended solids and BMPs designed to remove TSS will also result in a reduction of those pollutants. It is important to note that this section does not contain all other possible pollutants of concern and the intent of this section is to discuss the most common pollutants. Please review the sector-specific requirements for a complete list of pollutants of concern. Dissolved pollutants can be difficult to remove with conventional BMPs and may require chemical treatment.

Hydrocarbons

As part of the NURP study, residential runoff was sampled to determine the presence of more than 100 hydrocarbons (i.e., organic compounds, USEPA, 1983). These materials can result in significant water quality problems if they are not properly handled and applied. Hydrocarbons and organic chemicals permeate commercial, industrial and highway runoff, and can be toxic to aquatic life. These materials also move easily, exist for extended periods in a toxic state, and concentrate in sediments, from which they can be re-suspended later. Petroleum products and the combustion products of gas and oil, such as Poly Aromatic Hydrocarbons (PAHs) that leak from cars or emitted as exhaust, or the pesticides applied to urban lawns, can wash into gutters and eventually into a water body.

Petroleum-derived hydrocarbons commonly found in stormwater runoff often initially float on the surface of the water and create the familiar rainbow-colored film, or sheen. However, hydrocarbons have a strong affinity for sediment and fats and oils in living tissue and they quickly become adsorbed to these substances. They can then be transported with the sediment and go up the food chain to fish and humans. Hydrocarbons are a concern because they are known to be toxic to aquatic organisms at relatively low concentrations (Stenstrom *et. al,* 1984). Common sources of hydrocarbons are spillage at oil-storage and fueling facilities, leakage from crankcases and improper disposal of drained oil (MacKenzie and Hunter, 1979).

Chloride
In Minnesota, a tremendous amount of salt is used each year to melt ice from roads, parking lots and sidewalks (i.e., de-icing). Although the Minnesota Department of Transportation, counties, and municipalities have reduced the amount of sodium chloride applied to highways in the Twin Cities metropolitan area by about 50% in the last 10 to 15 years, a significant amount of salt is still being applied. Because it is extremely soluble, almost all salt applied ends up in surface or groundwater (Pitt *et al.,* 1994a). If the concentration of chloride becomes large, it can be toxic to many freshwater organisms. Normal application of de-icing salt to roads is unlikely to create toxic conditions due to elevated chloride concentration, but there have been many documented cases of surface and groundwater contamination caused by runoff from inadequately protected stockpiles of salt and sand-salt mixtures. Contaminants or materials added to salted-icing agents to prevent caking may also be of concern. Refer to Section 8.1 for more information on extreme weather events and de-icing.

Bacteria and Viruses
High concentrations of many bacteria and viruses are found in stormwater runoff. The NURP study found that total coliform counts exceeded U.S. Environmental Protection Agency (EPA) water-quality criteria at almost every facility and almost every time it rained (USEPA, 1983). Coliform bacteria may not be a health risk, but are often used as an indicator of more dangerous pathogens. The sources of pathogens can include sanitary sewer leaks, pets, vermin, and infected waste material. Soil can act as a source of bacteria even when it is very unlikely that the source is human or that the bacteria pose a significant human health risk (Barrett *et al.*, 1996). The result of contact with these pathogens can be disease. Pathogens can often be controlled by reduction of sources, detection and disconnection of illegal sanitary sewer connections, and pet control.

Temperature Changes
Permittees are required to design and implement BMPs specifically for water quality protection of trout streams and trout lakes from excess turbidity, Total Suspended Solids (TSS), phosphorus and temperature increases. Temperature differences can significantly impact small streams and temperature-sensitive species (e.g., trout). Various types of temperature criteria can affect the success and mortality of organisms in waterways. Temperature changes that occur over a short period can cause shock, and result in death. There can also be long-term temperature effects, which cause changes in the growth, reproduction, or mortality of organisms. These mean and maximum temperature criteria vary by organism and can be different for even the same organism in a different waterway. In Minnesota, the water-quality standards reflect daily maximum average temperatures for most waterways, or changes above the ambient which are limited to a few degrees on a monthly average basis (Minn. R. ch. 7050).

<u>BMPs frequently used to treat other pollutants</u>:
Most pollutants are highly associated with TSS, and removal of TSS can be the primary metals removal mechanism. Settling in ponds, filtration and other methods that remove TSS may be sufficient to meet benchmark or effluent limit discharge requirements. Depending on the amount and

nature of a facility's pollutants, Permittees may need specific treatment to get proper removal, such as chemical additives or specific filters. Vendors may be the main supply of these devices.

Hydrocarbons: Hydrocarbons in stormwater are often associated with sediments or floating on the water surface. Stormwater treatment for hydrocarbons includes settling (i.e., sedimentation) and surface skimming. Some hydrocarbons can accumulate in wet pond sediments to concentrations that require hazardous waste disposal. Research is currently being conducted into remediating wet ponds sediments contaminated with hydrocarbons for reuse.

Chloride: Currently, most BMPs cannot remove chloride from stormwater. The most effective strategy is reducing the sources of chloride by properly storing and applying de-icing agents or other chloride-containing salts.

Bacteria & Viruses: Bacteria and viruses in stormwater are often associated with sediments and therefore most can be captured with sedimentation practices such as wet ponds, constructed wetlands, etc.

Temperature: Elevated temperature in stormwater is most commonly reduced by infiltration and filtration. It is important to note, however, that some stormwater BMPs can also increase temperature. Stormwater BMPs that store and expose stormwater to the sun for long periods of time can significantly increase the temperature of the stormwater.

Chapter 3: Planning Stormwater Control Measures and BMPs

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This chapter will help Permittees to get a stormwater program started. Implementing stormwater control measures should be part of a Permittee's everyday operations; just another part of the facility's industrial process. Once Permittees have established procedures and responsibilities for industrial stormwater management, it should be part of the daily operations to make sure that industrial stormwater discharges are being addressed.

Whenever significant materials or activities are exposed to stormwater, there is a potential for stormwater runoff to become contaminated. Significant materials can be any type of raw or finished items that are stored, handled, used, processed or generated at a facility. One of the highest priorities of stormwater regulations and the use of BMPs is to improve the quality of surface waters by reducing or eliminating the contact of pollutants with stormwater. Planning stormwater control measures and BMPs and regularly ensuring the plan is implemented is the most cost-effective way to satisfy permit and other regulations.

3.1 Implementation

Most management of stormwater for runoff from **industrial activities** can be accomplished through the use of best management practices (BMPs), which, for the purposes of this manual, have been classified in two groups:

- Nonstructural BMPs
- Structural BMPs

Nonstructural BMPs focus on changing behavior and management to reduce sources of pollutants. These measures can be described as "good common sense" and can include such practices as moving materials inside to reduce exposure, prohibiting certain practices, training, and employing spill-prevention plans. These practices prevent pollutants from interacting and becoming associated with stormwater runoff. Nonstructural BMPs are discussed in this chapter, Chapter 4, and Chapter 5.

Structural BMPs are measures that control or manage stormwater runoff and drainage. Examples of structural BMPs include enclosures used for covering exposed significant materials, swales, dikes or stormwater-treatment practices (e.g., ponds, filtration, infiltration basins, etc.). Structural BMPs are discussed in Chapter 7.

3.2 Planning and Organization

When preparing a Stormwater Pollution Prevention Plan (Plan) and making recommendations for BMPs, the following factors should be taken into account: implementability, cost effectiveness, and contaminant/pollutant removal effectiveness. The Plan will only be valuable if it is effective, workable and affordable (*i.e.,* if it can and will be implemented).

The steps involved in the development of the Plan, as well as the interaction between various phases, should be considered. For example, observations made during the monitoring phase may indicate it is necessary to reassess a facility for a specific activity or material or to reevaluate the BMPs originally selected. This "continuous loop" evaluation process will improve the Plan concepts and implementation.

The planning and organization phase starts with a layout the organization for the Plan. For larger facilities they may want to form a pollution prevention team to research existing conditions, gather maps and drawings develop procedures for spill and response plans, or gather Material Safety Data Sheets and other documents that may be used to assist in preparing and implementing the Plan. The Plan should specify roles and responsibility for each team member. The permit conditions are the primary guide to development of a pollution-prevention plan, but site-specific conditions should be addressed as needed.

A simple way to organize the pollution prevention team is to align tasks with the people carrying out the tasks. The follow list can be used as a guide for aligning tasks to individuals:

1. List all the responsibilities (using the permit as a guide).
2. Assign a title/position that is compatible with the responsibility.
3. Assign an individual to each title/position.
4. Link assignments to skills and abilities of individuals such that all responsibilities are met.

This procedure will identify the pollution prevention team members and their respective responsibilities. The responsibility/title correlation makes it easier to re-assign team members as employees are promoted or leave the organization. The responsibilities assigned to a title can be used to define job descriptions for new employees.

Team responsibilities/tasks that could be assigned to titles/individuals include the following examples (as applicable):

- stormwater manager (individual or director of the team)
- individual to perform detailed site assessment
- individual to maintain material inventory and to evaluate handling and storage practices,
- maintenance supervisor
- individual overseeing housekeeping practices (litter control, lawn management and erosion control)
- individual overseeing fueling practices
- individual overseeing de-icing practices
- individual overseeing spills/releases
- individual overseeing training/education program
- record keeper, for documentation of meetings and records
- individual overseeing water quality monitoring

The pollution prevention team should meet as often as required (daily, monthly, quarterly, semiannually or otherwise) to review the plan, discuss plan-implementation results and make revisions, as required, to meet the plan's goals and objectives. Discussions, meeting notes and revisions should be documented in stormwater-management files.

The following are general requirements of a Plan:

1. <u>Drainage map</u>

The map should indicate the following items at or adjacent to the facility:

- drainage areas and directions of runoff (indicated by arrows)
- monitoring locations from the facility (structures, such as ditches or storm sewers, that carry runoff from the facility)
- the name and location of surface waters that receive facility runoff (if surface waters are too distant from the facility to be indicated on the facility map, indicate the name, direction and shortest distance to the lake, river, stream or wetland that receives runoff from the facility boundary)
- areas where materials or waste products (which may include solid waste, by products, or air emissions) are exposed
- locations of storm sewer inlets and an indication of which, if any, structures have floor drains connected to stormwater or wastewater
- or loading dock drains that are connected to storm sewers
- locations and types of BMPs currently installed at the facility to reduce or eliminate stormwater pollutants
- location of benchmark and effluent monitoring locations(s), if needed

2. <u>Exposed Product and Raw Materials</u>

Indicate the types of materials handled or stored at the facility. The following are examples of materials that, if exposed, must be included in the inventory:

- raw materials, such as fuels, solvents, petroleum products, detergents, materials used in food processing or production, stockpiled sand, salt or coal
- by-products or intermediate products, such as wood dust, chips or bark, screened limestone, sand and gravel by products, silage, or food by products
- finished materials, such as metallic products, including scrap metal and recycled or scrap motor vehicle parts, old process equipment/machinery, taconite pellets
- waste products, such as ashes, sludge, solid and liquid waste, slag
- hazardous substances designated under section 101(14) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA)
- any chemical the facility is required to report under section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA)

3. <u>Other Materials and Activities</u>

In creating the inventory of exposed materials, the person or team developing the plan must, at a minimum, evaluate the following other areas at the industrial facility (and other areas where appropriate) to determine whether or not there is a potential for significant materials being exposed in these areas:

- vehicle and equipment maintenance, parking and storage areas, including fueling and washing/cleaning areas. Determine whether there is discolored soil in these areas as a result of fuel or lubricant leaks or spills

- liquid storage tanks and other bulk material stockpile areas
- loading and unloading areas
- outdoor manufacturing, processing or storage areas and industrial plant yards, to determine whether there is discolored soil in these areas as a result of leaked or spilled solvents, fuels or lubricants
- dust- or particulate-generating areas, including dust-collection devices that may release dust;
- rooftops contaminated by vents from industrial activity or operation of a pollution-control device
- onsite waste disposal areas, such as waste ponds, dumpsters, solid waste storage or management areas
- exposed (non-vegetated) soil areas where there is a potential for erosion to occur

4. BMPs

Permittees must include all BMPs that will be used at the facility to minimize, eliminate or control pollution. The description must include an objective for each BMP, as well as a description of how to evaluate proper functioning of the BMP and any maintenance requirements of the BMP. BMPs should target materials and areas identified in the Plan. The following general categories of BMPs shall be considered and one or more shall be incorporated into the facility's Plan if applicable:

- **Source reduction**: Reduce or eliminate the materials that are exposed. Materials-management practices should be evaluated to determine whether inventories of exposed materials can be reduced or eliminated. This can include cleanup of old equipment yards, periodic checking of dust-control equipment to ensure there is no accumulation of dust in the area around the control equipment, removal and treatment of petroleum-contaminated soil, consolidation of materials from many areas into one area, and training employees regarding proper handling and disposal of materials. Materials may also be moved indoors or covered with a tarp or structure to eliminate contact with precipitation.
- **Diversion:** Divert drainage away from exposed materials through the use of curbing, berms, sewers or other forms of drainage control or elevate exposed material above surrounding drainage.
- **Treatment:** Where contact of materials is unavoidable, use treatment devices to reduce the concentration and amount of pollutants in the discharge. Such devices include oil/water separators, detention/retention ponds and vegetated swales.

5. Illicit or Avoidable Discharges

Evaluate all discharge conveyances (storm sewers, pipes, tile lines, ditches, etc.) to determine whether liquids other than uncontaminated stormwater are being discharged from these devices. This should be done during dry weather when stormwater discharge is not occurring. The evaluation should cover sewer inlets and floor drains to determine which inlets/drains are connected to sanitary sewer lines, storm sewer lines, or septic tanks/drainage fields. Appropriate methods, such as dye or smoke testing or video imaging, should be used to determine the source of discharges. The Plan must certify that discharges from the facility have been evaluated for the presence of non-stormwater discharges. The certification shall indicate the date of testing, location of testing, the methods used to determine the source of discharges, and the results of testing. Discharge of non-stormwater (such as sanitary sewer or floor drain connections to storm sewers) is *not* authorized. Before such discharge may continue, authorization under an appropriate NPDES permit must be obtained.

6. Preventive Maintenance Program

The preventative maintenance program must require regular inspection and maintenance of management devices (*e.g.*, cleaning oil/water separators and catch basins), as well as inspecting and testing plant equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants (*e.g.*, hydraulic leaks, torn baghouse filters) to surface waters.

7. Spill Prevention and Response Procedure

In order to develop this procedure, the person or team developing the Plan should evaluate where spills have occurred and where they have the potential to occur. Determine drainage points for potential spill areas and develop appropriate spill-prevention-and-containment measures. Detailed procedures for cleaning up spills shall be identified and made available to appropriate personnel. If the facility has any other spill contingency plan that satisfies the above requirements, that plan may be incorporated by reference into this Plan to satisfy this requirement.

8. Employee Training Program

An effective Employee Training Program is beneficial to inform appropriate personnel of the components and goals of the Plan. Training shall address spill response, good housekeeping and materials-management practices. The Plan shall identify periodic dates for such training.

9. Managing and Implementing the Plan

Name the personnel as well as those responsible for the reporting requirements of the permit. This should include the facility contact person as indicated on the permit application. Identified personnel must be available at reasonable times of operation.

3.3: Sector-Specific Requirements Summary

In addition to the control measures and SWPPP requirements for all permittees, the Industrial Stormwater Multi-Sector General Permit requires specific BMPs for some sectors/sub-sectors. Parts V, VI, and VIII of each section highlights any additional required sector-specific BMPs, while part VII highlights specific monitoring required for the sector. **NOTE:** For Part VII of the permit, monitoring requirements, many facilities actually fall within a subsector and may not have to monitor for all of the pollutants listed below, or may have co-located activities and may need to monitor for several sectors or sub-sectors. See the individual sector requirements for detailed requirements, pages 38-162 of the Multi-Sector General Permit.

Additional Sector Specific Requirements in Part VII of the permit

Sector A: Timber products (pages 38-43) **SIC Codes:** 2411, 2421, 2426, 2429, 2431-2439 (except 2434), 2441, 2448, 2449, 2451, 2452, 2491, 2493, 2499	
Part 5: Stormwater Controls	• Inspections • Other Industry Specific Control Measures
Part 6: SWPPP Requirements	• Inventory of Exposed Materials • Description of Stormwater Controls
Part 7: Monitoring	• Arsenic, Chromium, COD, Copper, Phenols, pH, TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• Limitations for expanding or building new infiltration systems. See sector chapter for more details.

Sector B: Paper and Allied Products Manufacturing (pages 44-45) **SIC Codes:** 2611, 2621, 2631, 2652-2657, 2671-2679	
Part 5: Stormwater Controls	• *No additional requirements*
Part 6: SWPPP Requirements	• *No additional requirements*
Part 7: Monitoring	• COD, TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector C: Chemical and Allied Products Manufacturing (pages 46-50) **SIC Codes:** 2812-2819, 2821-2824, 2833-2836, 2851, 2861- 2869, 2873-2879, 2891-2899, 3952	
Part 5: Stormwater Controls	• Inspections
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Aluminum, BOD, Fluoride, Iron, Lead, Phosphorus, Nitrate + Nitrite, TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector D: Asphalt, Paving and Roofing Materials Manufacturers and Lubricant Manufacturers (pages 51-53) **SIC Codes:** 2951, 2952, 2992, 2999	
Part 5: Stormwater Controls	• Inspections
Part 6: SWPPP Requirements	• *No additional requirements*
Part 7: Monitoring	• pH, TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector E: Glass, Clay, Cement, Concrete, and Gypsum Product Manufacturing (pages 54-56) **SIC Codes:** 3211, 3221, 3229, 3231, 3241, 3251-3259, 3261-3269, 3271-3275, 3281, 3291-3299	
Part 5: Stormwater Controls	• Good Housekeeping • Inspections • Preventive Maintenance
Part 6: SWPPP Requirements	• Facility Map
Part 7: Monitoring	• Aluminum, Iron, pH TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector F: Primary Metals (pages 57-60) **SIC Codes:** 3312-3317, 3321-3325, 3341, 3351-3357, 3363-3369, 3398, 3399	
Part 5: Stormwater Controls	• Good Housekeeping • Inspections

Part 6: SWPPP Requirements	• Facility Map • Inventory of Exposed Material
Part 7: Monitoring	• Aluminum, Copper, Iron, TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector G: Metal Mining [Ore Mining and Dressing] (pages 61-70) **SIC Codes:** 1011, 1021, 1031, 1041, 1044, 1061, 1081,1094, 1099	
Part 5: Stormwater Controls	• Employee Training • Management of Runoff • Other Industry specific Controls Measures
Part 6: SWPPP Requirements	• Facility Map • Inventory of Exposed Materials • Potential Pollutant Sources • Description of Stormwater Controls
Part 7: Monitoring	• Antimony, Arsenic, Beryllium, Cadmium, COD, Copper, Hardness, Iron, Lead, Mercury, Nickel, Nitrate + Nitrite, pH, Selenium, Silver, Zinc, TSS, Turbidity,
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector H: Coal Mines and Coal Mining-Related Facilities (pages 71-75) **SIC Codes:** 1221-1241	
Part 5: Stormwater Controls	• Employee Training • Erosion and Sedimentation Controls • Good Housekeeping
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources • Description of Stormwater Controls
Part 7: Monitoring	• Aluminum, pH, Iron, TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector I: Oil and Gas Extraction and Refining (pages 76-79) **SIC Codes:** 1311, 1321, 1381-1389, 2911	
Part 5: Stormwater Controls	• Inspections • Preventive Maintenance
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Ammonia, Lead, Nickel, Nitrate + Nitrite, Nitrogen, pH, TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector J: Mineral Mining and Dressing (pages 80-85) **SIC Codes:** 1411, 1422-1429, 1442, 1446, 1455, 1459, 1474-1479, 1481, 1499	
Part 5: Stormwater Controls	• Erosion and Sedimentation Control • Inspections
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Nitrate + Nitrite, pH, TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector K: Hazardous Waste Treatment, Storage or Disposal (pages 86-90) **Narrative Activity Code**: "HZ"	
Part 5: Stormwater Controls	• *No additional requirements*
Part 6: SWPPP Requirements	• *No additional requirements*
Part 7: Monitoring	• Alpha Terpineol, Aniline, Arsenic, Ammonia, Benzoic Acid, BOD, Cadmium, Chromium +3 Total, COD, Cyanide, hardness, Lead, Mercury, Naphthalene, pH, Phenol, p-Cresol, Pyridine, Selenium, Silver TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• Limitations for expanding or building new infiltration systems. See sector chapter for more details.

Sector L: Landfills and Land Application Sites (pages 91-96) **Narrative Activity Code**: “LF”	
Part 5: Stormwater Controls	• Erosion and Sedimentation Control • Good Housekeeping • Inspections • Preventive Maintenance Program • Other Industry Specific Stormwater Control Measures
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Alpha Terpineol, Ammonia, , Benzoic Acid, BOD, Iron, P cresol, pH, Phenol, TSS, Zinc
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector M: Automobile Salvage Yards (pages 97-101) **SIC Code:** 5015	
Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections • Spills and Leaks
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Aluminum, Hardness, Iron, Lead, TSS

Part 8: Use of Infiltration Devices/Stormwater Ponds	• Limitations for expanding or building new infiltration systems. See sector chapter for more details.

Sector N: Scrap Recycling Facilities (pages 102-106) **SIC Code:** 5093	
Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections Management of Runoff
Part 6: SWPPP Requirements	• Facility Map
Part 7: Monitoring	• COD, TSS, Aluminum, Copper, Iron, Lead, Zinc, PCB, Hardness, pH
Part 8: Use of Infiltration Devices/Stormwater Ponds	• Limitations for expanding or building new infiltration systems. See sector chapter for more details.

Sector O: Steam Electric Generating Facilities (pages 107-110) **Narrative Activity Code: “**SE”	
Part 5: Stormwater Controls	• Good Housekeeping • Inspections • Preventive Maintenance • Spills and Leaks • Management of Runoff • Other Industry Specific Stormwater Control Measures
Part 6: SWPPP Requirements	• Facility Map
Part 7: Monitoring	• TSS, Iron
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector P: Land Transportation and Warehousing (pages 111-115) **SIC Codes:** 4011, 4013, 4111-4173, 4212-4231, 4311, 5171	
Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections • Preventive Maintenance • Spills and Leaks • Other Industry Specific Stormwater Controls
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• TSS,
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector Q: Water Transportation (pages 116-120) **SIC Codes:** 4412-4499

Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections • Preventive Maintenance • Other Industry Specific Stormwater Controls
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• TSS, Aluminum, Lead, Zinc, Iron
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector R: Ship and Boat Building and Repair Yards (pages 121-124) **SIC Codes:** 3731, 3732	
Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections • Preventive Maintenance
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector S: Air Transportation (pages 125-131) **SIC Codes** 4512-4581	
Part 5: Stormwater Controls	• Employee Training • Good Housekeeping • Inspections Preventive Maintenance • Spills and Management of Runoff
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources • Description of Stormwater Controls
Part 7: Monitoring	• BOD, COD, Ammonia, TSS, pH
Part 8: Use of Infiltration Devices/Stormwater Ponds	• Limitations for expanding or building new infiltration systems. See sector chapter for more details.

Sector T: Treatment Works (pages 132-135) **Narrative Activity Code:** "TW"	
Part 5: Stormwater Controls	• Employee Training • Inspections
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• TSS, BOD
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector U: Food and Kindred Products (pages 136-140) **SIC Codes:** 2041-2048, 2074-2079, 2011-2015, 2021-2026, 2032-2038, 2051-2053, 2061-2068,2082-2087, 2091-2099, 2111-2141	
Part 5: Stormwater Controls	• Employee Training • Inspections
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• TSS, BOD, COD, Ammonia, Total Nitrogen, Nitrate + Nitrite, Nitrogen, Phosphorus
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector V: Textile Mills, Apparel, and Other Fabric Products (pages 141-144) **SIC Codes:** 2211-2299, 2311- 2399, 3131-3199	
Part 5: Stormwater Controls	• Employee Training • Preventive Maintenance
Part 6: SWPPP Requirements	• Potential Pollutant Sources
Part 7: Monitoring	• TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector W: Furniture and Fixtures (page 145) **SIC Codes:** 2434, 2511-2599	
Part 5: Stormwater Controls	• *No additional requirements*
Part 6: SWPPP Requirements	• *No additional requirements*
Part 7: Monitoring	• TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector X: Printing and Publishing (pages 146-148) **SIC Codes:** 2711-2796	
Part 5: Stormwater Controls	• Preventive Maintenance
Part 6: SWPPP Requirements	• Potential Pollutant Sources
Part 7: Monitoring	• TSS, Silver, Hardness
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector Y: Rubber, Misc. Plastic Products, and Misc. Manufacturing Industries (pages 149-151) **SIC Codes:** 3011-3069, 3081-3089, 3931, 3942-3949, 3951-3955 (except 3952), 3961, 3965, 3991-3999	
Part 5: Stormwater Controls	• Preventive Maintenance
Part 6: SWPPP Requirements	• Potential Pollutant Sources

Part 7: Monitoring	• Zinc, Lead, TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector Z: Leather Tanning and Finishing (pages 152-154) **SIC Code:** 3111	
Part 5: Stormwater Controls	• Preventive Maintenance
Part 6: SWPPP Requirements	• Facility Map • Potential Pollutant Sources
Part 7: Monitoring	• Aluminum, Iron, Zinc, TSS, Nitrate + Nitrite
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector AA: Fabricated Metal Products (pages 155-158) **SIC Codes:** 3411-3499, 3911-3915, 3479	
Part 5: Stormwater Controls	• Good Housekeeping • Inspections • Preventive Maintenance • Spills and Leaks
Part 6: SWPPP Requirements	• **Facility** Map • Potential Pollutant Sources
Part 7: Monitoring	• Aluminum, Iron, Zinc, TSS, Nitrate + Nitrite
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector AB: Transportation Equipment, Industrial and Commercial Machinery (pages 159-161) **SIC Codes:** 3511-3599, (except 3571-3579), 3711-3799, (except 3731and 3732)	
Part 5: Stormwater Controls	• Inspections
Part 6: SWPPP Requirements	• Facility Map
Part 7: Monitoring	• TSS
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

Sector AC: Electronic/Electrical Equipment and Components, Photographic and Optical Goods (pages 162-163) **SIC Codes:** 3571-3579, 3612-3699, 3812-3873	
Part 5: Stormwater Controls	• No additional requirements
Part 6: SWPPP Requirements	• Facility Map
Part 7: Monitoring	• TSS, Copper, Lead
Part 8: Use of Infiltration Devices/Stormwater Ponds	• *No limitations for expanding or building new infiltration systems*

3.4: Stormwater Control Topics by other media

The following are Control Measures and recommendations dedicated to other media and/or incorporated into the SWPPP by reference. They should be incorporated into the SWPPP and integrated into the processes of the SWPPP. Make sure that staff is trained in all applicable programs so that there are no program gaps with:

a. **Solid Waste-**this includes waste from industrial activities that is not hazardous waste and it includes litter, or floatables from water collection and treatment such as ponds. This material must be properly disposed of as solid waste. The processes and procedures must be documented in the SWPPP. **Heidi Kroening-staff**

b. **SPCC Plan-**if required to meet the requirements of this program, permittees can incorporate the requirements by reference and keep the plan with the SWPPP. If a Spill Prevention and Response Plan (required by Minnesota's "Spill Bill") is also required, it can also be incorporated. **Note**: this may be different than the regular/other spill prevention and response plan requirement of the permit. **Joe Hauger**

c. **Hazardous Waste**-if hazardous waste is stored in outdoor containers, taking the following measures will not only meet the mandatory requirements of both the stormwater and hazardous waste rules, but will also protect property and employees. Outdoor hazardous waste storage areas must be curbed and protected from unauthorized access with a locked fence or other wall. Because a curbed storage area may retain rain, snow, and ice, some method to safely drain the curbed area or somehow ensure that it will always retain enough capacity to contain the contents of the largest hazardous waste container in the storage area must be provided. A storage area for Ignitable or Reactive hazardous wastes must also be roofed, which can also help prevent precipitation collecting in the storage area or collecting on and corroding containers. Hazardous waste containers, whether in a roofed area or not, must always be stored completely closed. Finally, outdoor hazardous waste storage area should be inspected at least weekly and inspections should be documented. **Josh Burman**

d. **Above ground storage tanks and underground storage tanks**-if required to meet the requirements of this program, permittees can incorporate the requirements by reference and keep the plan with the SWPPP. If petroleum or hazardous materials are stored in tanks, taking the following measures will help ensure compliance with rules and minimize environmental and safety hazards. Visually inspect pumps, hoses, and piping connections looking for leaks and maintenance issues such as loose fittings. Gaskets and rubber nozzles on fuel dispensers degrade over time and begin to leak, particularly if diesel fuel or biodiesel blends are being dispensed. Fuel filters in dispensing equipment can begin to leak as well, especially in cold winter weather. Underground storage tank equipment, including dispensers, must be visually inspected once a month for leaks and secondary containment areas. Aboveground storage tanks must be inspected weekly for leaks and monthly for deterioration and maintenance issues such as cracks. Create an inspection log and retain a record of the inspections. Keep areas and equipment used to transfer substances to or from the tanks clean by immediately cleaning up drips or small spills that occur during transfer. Keep in mind that storage tanks are required to have other periodic system testing requirements, such as leak detection and corrosion protection. **Joe Hauger**

e. **Sediment and other removed substances-**all sediment and other materials removed from stormwater treatment systems must be properly disposed of in accordance with Agency solid waste requirements. Contact the Agency for proper disposal methods and document the contacts with the SWPPP. **Heidi Kroening**

Chapter 4: No Exposure: the First Option to Consider for BMPs

Whenever significant materials or activities are exposed to stormwater, there is a potential for stormwater runoff to be contaminated. One of the highest priorities of stormwater regulations and the use of BMPs is to improve the quality of surface waters by reducing or eliminating the contact of pollutants with stormwater.

Placeholder for photo

No Exposure means that rain, snow, and runoff do not contact "Significant Materials" that might contain pollutants. Note that runoff from separate office buildings and their associated parking lots do not need to be considered when determining No Exposure at an industrial facility.

Facilities may qualify for a five-year, conditional exclusion from the permit if they can certify that no significant materials or activities are exposed to stormwater. Some facilities may need to take simple actions in order to qualify for the exclusion, while others will need to make more extensive efforts.
All facilities may benefit by removing significant materials from exposure to stormwater, even those requiring permit coverage.

The following situations limit the applicability of the No Exposure exclusion:

- The exclusion from permitting is available on a facility wide basis. Generally, if any exposed industrial materials or activities are found on any portion of a facility, the No Exposure exclusion is not available to that facility.
- Past sources of stormwater contamination that remain at the facility, causing a condition of exposure.
- If changes at a facility result in industrial activities or materials becoming exposed, the No Exposure exclusion ceases to apply.

Table 1. General list of materials and activities can cause contaminated stormwater runoff:

Materials	Activities
Fuels, solvents, coolants, lubricants and cleaners	Outdoor storage activities
Raw, intermediate, and final products	Outside manufacturing areas
Metallic materials	Vehicle & equipment washing, maintenance and storage areas
Chemicals	Loading and unloading operations
Wastes and scrap materials	Substance Transfer areas
Hazardous materials/wastes	Outdoor manufacturing or processing activities
Processing or production operations	Significant dust or particulate generating activities
Machining fluids	Onsite waste disposal practices
Dust or residuals	Outside storage areas for raw materials, by-products, and finished products
Fueling stations	Grinding, cutting, degreasing, buffing, and brazing
Above-ground tanks for liquid storage	Industrial waste management areas (landfills, waste piles, treatment plants, disposal areas)

Note: If a permittee is unable to immediately apply for the No Exposure Exclusion because significant materials are exposed to stormwater, the permittee will need to complete a Stormwater Pollution Prevention Plan and then complete the permit application. The permittee can subsequently make changes to the facility and then apply for the No Exposure Exclusion at a later date.

4.1: Common Sources of Exposure and No Exposure Options

The following materials and activities are common sources of exposure at many facilities and addressing these materials and activities may help Permittees get one step closer to achieving a condition of No Exposure:

Products/Materials Meant to be outside

Many final products which are meant to be used outdoors (concrete culverts or stop signs) pose little risk of stormwater contamination, and these products cannot be mobilized by precipitation or runoff, and are thus exempt from the requirement that these products be sheltered to qualify for No Exposure. Similarly, the containers, racks and other transport platforms (e.g., wooden pallets) used for the storage or conveyance of these final products can also be stored outside, providing the containers, racks and platforms will not contaminate stormwater runoff.

Storm Resistant Shelters

Storm-resistant shelters include completely roofed and walled buildings or structures, as well as structures with only a top cover but no side coverings, provided material under the structure is not otherwise subject to any run-on and subsequent runoff of stormwater. Materials and activities may be sheltered with temporary covers (e.g., tarpaulins) until permanent structures are created.

Industrial Materials/Activities That Do Not Require a Storm Resistant Shelter

While the intent of the No Exposure exclusion is to promote a condition of permanent No Exposure, a storm-resistant shelter is not required for drums, barrels, tanks, and similar containers. Drums, barrels, tanks, and similar containers that are sealed ("sealed" means banded or otherwise secured and without operational taps or valves) and not opened while outdoors are not exposed provided those containers are not deteriorated and do not leak. Inspect all outdoor containers to ensure they are not and have not been open, deteriorated, or leaking. Any time external containers are open, deteriorated or leaking, they must immediately be closed, replaced or sheltered. Containers, racks and other transport platforms (e.g. wooden pallets) used with the drums, barrels, etc., can be stored outside providing they will not contaminate stormwater runoff.

Above Ground Storage Tanks (ASTs)

In addition to generally being considered not exposed ASTs may also be exempt from the prohibition against adding or withdrawing material to/from external containers. ASTs typically utilize transfer valves to dispense materials which support facility operations (e.g., heating oil, propane, butane, chemical feedstocks) or fuel for delivery vehicles (gasoline, diesel, compressed natural gas). For ASTs to be operational and qualify for No Exposure, there must be no piping, pumps or other equipment leaking contaminants that could contact stormwater and be surrounded by some type of physical containment (e.g., an impervious dike, berm or concrete retaining structure) to prevent runoff in the event of a structural failure or leaking transfer valve.

Lidded Dumpsters

Lidded dumpsters containing waste materials qualify for No Exposure, providing the containers are completely covered and nothing can drain out holes in the bottom or is lost in loading onto a garbage truck. Industrial waste and trash that is stored uncovered, however, is considered exposed.

Adequately Maintained Vehicles

Adequately maintained vehicles include trucks, automobiles, forklifts, trailers or other general purpose vehicles - but not industrial machinery - which are not leaking or are otherwise a potential source of contaminants. Non-leaking vehicles awaiting maintenance at vehicle maintenance facilities are not considered exposed.

Particulate Emissions from Roof Stacks or Vents

As stated in the Phase II regulation, particulate emissions from roof stacks or vents do not cause a condition of exposure, provided they are in compliance with other applicable environmental protection programs (e.g., air quality control program) and do not cause stormwater contamination. Deposits of particles or residuals from roof stacks/vents not otherwise regulated and which could be mobilized by stormwater runoff, are considered exposed. Exposure also occurs when, as a result or particulate emissions, pollutants can be seen being "tracked out" or carried on the tires of vehicles.

Pollutants Potentially Mobilized by Wind

Windblown raw materials cause a condition of exposure. This is to alert operators to situations where materials sheltered from precipitation can still be deemed exposed if the materials can be mobilized by wind.

4.2: Non-structural BMPs for Achieving No Exposure

Many facilities may likely already be able to certify a condition of No Exposure, or many need to take small steps to do so. Consider the following BMP options, broken down by the “Stormwater Control Measures” categories in the MSGP:

Good Housekeeping:

- Shelter and/or enclose stored containers and drums (as allowed by other regulations), even closed containers can leak
- Shelter loading and unloading areas
- Cover materials or operations with permanent covers and provide curb or slopes designed to prevent stormwater run-on or runoff
- Shelter unused industrial equipment
- Maintain dumpsters: keep lids closed and sealed, plug drain holes, and replace when seams crack or holes develop

Eliminating and Reducing Exposure:

- Store steel parts coated with oil or subject to corrosion in sheltered areas
- Move materials or operations into buildings or warehouses
- Store materials in weather-proof containers, shelters, or dumpsters
- Do grinding, cutting, degreasing, buffing, brazing, blasting, sanding, cleaning, washing, welding, and painting operations indoors
- Place scrap or waste products directly into covered transport containers rather than stockpiling until a full load is obtained

- Avoid uncontrolled exhaust. Make sure there are no particulate matter or visible deposits of residuals from roof stacks and/or vents no otherwise regulated (i.e. under an air quality control permit) and evident in the stormwater outflow
- Eliminate or minimize use of coolants or lubricants used in machining processes
- Optimize process efficiency through lean manufacturing technique
- Outsource operations like fueling, equipment maintenance, finishing, or warehousing that cannot be conducted under shelter onsite.
- Install particulate collection equipment to prevent dust or material accumulation
- Shelter, monitor, maintain, and properly operate all pollution control equipment

Salt Storage:
- Store salt inside in containers in good condition-keep containers closed when not in use
- Outdoor storage of salt should be covered and on impervious surfaces-temporary cover such as a tarp is acceptable while a permanent cover is being constructed

Erosion Prevention and Sediment Control:
- Minimize any exposed soils by planting or paving
- Minimize run-on from adjacent properties and stabilized areas to areas with exposed soil with diversion dikes, berms, vegetated swales, etc
- Minimize clearing, grading and stockpiling of soil
- Pave driveways and parking areas in lieu of gravel surfaces
- If exposed soils are present, use down gradient sediment control BMPs such as silt fences or compost logs

Management of Runoff:
- Prevent stormwater from flowing into exposure areas with dikes or berms
- Minimize run-on of stormwater into the fueling area by use of a canopy over the fueling area, berms or other diversionary measures

Spill Prevention and Response Procedure:
- Keep hazardous product and waste containers closed when not in use

Mercury Minimization Plan:
- If applicable, store mercury switches in covered, leak-proof containers in a way that prevents the glass capsule from breaking and dispose of them appropriately

Employee Training Program:
- Educate employees about No Exposure

Resources
- http://www.maine.gov/dep/blwq/docstand/stormwater/multisector/permit/appae.pdf
- MPCA No Exposure fact sheet
- EPA sector-specific fact sheets

Chapter 5: Stormwater Reduction and Reuse

Stormwater reduction and reuse can provide significant benefits to facilities that do not qualify for No Exposure and have good housekeeping practices in place, but still need additional stormwater control measures to satisfy permit or other requirements. Reduction and reuse of stormwater either diverts stormwater from surface outflows (e.g., reduced impervious cover) or reuses stormwater for onsite processes (e.g., lawn watering).

5.1 Stormwater Runoff Reduction

Reducing the amount of stormwater runoff that leaves a facility can satisfy permit and other requirements and significantly benefit water quality. Stormwater runoff reduction results in less runoff, less pollutant loading to receiving waters, and less erosion in downstream channels and water bodies. Some stormwater runoff reduction practices, such as rain gardens, can also increase aesthetic value and potentially property values. While no BMP is the best in all situations, the following are encouraged as among the first options to consider for industrial stormwater management.

Upside down umbrellas that shade an employee plaza and collect rainwater for the plaza's landscaping. **Source: Forgotten Rain L.L.C.**

Reduction techniques:

- Reducing runoff by reducing impervious surfaces through: green roofs, porous pavement, porous pavers, or planned minimal impact development
- Storing precipitation or roof runoff in large tanks or small barrels for industrial processes or landscaping irrigation (cisterns)
- landscaping with rain gardens, infiltration basins, and infiltration trenches to promote infiltration
- Swales for conveyance instead of pipes
- De-compaction of lawn areas to promote infiltration

5.2: Stormwater Reuse

According to the Pennsylvania Stormwater Management Manual, Cisterns, Rain Barrels, Vertical Storage, and similar devices have been used for centuries to capture stormwater from the roofs of buildings, and in many parts of the world these systems serve as a primary water supply source. Around the world, from the University of Minnesota to the city of Melbourne, Australia, cities, organizations, and industrial facilities are realizing the value of reusing stormwater. This chapter will highlight various ways a facility can accomplish this, as well as actual examples of facilities reusing stormwater. Sometimes called rainwater harvesting, reusing of stormwater has many benefits including improving surface and groundwater quality, using less potable water, and saving money on water use costs. Also, there are several options for reusing collected stormwater, including:

- Car/vehicle wash water
- General cleanup wash water
- Onsite irrigation of grass and plants

- Cooling tower water
- Boiler feedwater
- Process water

Note: Once stormwater is used in an industrial process, any discharges are regulated as an industrial process wastewater and no longer regulated by the Industrial Stormwater Permit.

The Pennsylvania Stormwater Management Manual has a chapter dedicated to stormwater capture and reuse, which recommends consideration the following:

Key Design Elements
- Storage devices designed to capture a portion of the small, frequent storm events
- Storage techniques may include cisterns, underground tanks, aboveground vertical storage tanks, rain barrels, or other systems.
- Systems must provide for overflow or bypass of large storm events
- Collection and placement of storage elements up gradient of areas of reuse may reduce or eliminate pumping needs
- Water must be used or discharged before next storm event
- Most effective when designed to meet a specific water need for reuse.

Potential Applications	**Stormwater Functions**	**Pollutant Removal**
Commercial: Yes	Volume Reduction: Med/High	Total Suspended Solids: Yes
Ultra Urban: Yes	Recharge: Low	Nutrients: Yes
Industrial: Yes	Peak Rate Control: Low*	Metals: Yes
Retrofit: Yes	Water Quality: Medium	Pathogens: Yes
	**depending on scale*	

Design Considerations
1. The designer must calculate the water need for the intended uses. For example, what will the collected water be used for and when will it be needed? If a 2,000 square foot area of lawn requires irrigation for 4 months in the summer at a rate of 1 inch per week, how much will be needed and how often will the storage unit be refilled? The usage requirements and the expected rainfall volume and frequency must be determined.
2. Drawdown: the designer must provide for use or release of the stored water between storm events in order for the necessary stormwater storage volume to be available.
3. The catchment area on which the rain falls must be considered. The catchment area typically handles roof runoff.
4. The conveyance system must keep reused stormwater or graywater from other potable water piping systems. Do not connect to domestic or commercial potable water system.
5. Pipes or storage units should be clearly marked: “Caution: Reclaimed water-Do Not Drink.”
6. Screens may be used to filter debris from storage units.
7. The first flush runoff may be diverted away from storage in order to minimize sediment and a pollutant entry.
8. Storage elements should be protected from direct sunlight by positioning and landscaping (limit light into devices to minimize algae growth).
9. The proximity to building foundations should be considered for overflow conditions.

10. Climate is an important consideration, and capture/reuse systems should be disconnected during winter to prevent freezing.
11. Cisterns should be watertight (joints sealed with nontoxic waterproof material) with a smooth interior surface, and capable of receiving water from rainwater harvesting system.
12. Covers (lids) should have a tight fit to keep out surface water, animals, dust and light.
13. Positive outlet for overflow should be provided a few inches from the top of the cistern.
14. Observation risers should be at least 6 inches above grade for buried cisterns.
15. Reuse may require pressurization. To add pressure, a pump, pressure tank and fine mesh filter can be used, which adds to the cost of the system, but creates a more useable system.

For more information, check out Pennsylvania Stormwater Management Manual BMPs, specifically the "Capture Reuse BMP" link.

Checklist of general issues to consider:

☐ Building codes

☐ Mosquitoes

☐ Concentrated chemicals, pathogens or microbial hazards

☐ Additional local and state regulations

☐ Storage

☐ Use

☐ Plumbing

☐ Distribution

☐ Treatment

☐ Maintenance

☐ Cost

5.3: Existing examples of Stormwater Reduction and Reuse Techniques

A number of companies and organizations have been using a variety of reduction and reduce techniques to manage their stormwater runoff. While many of the examples below are not regulated by the MSGP, they may still serve as examples for industrial facilities on how they may manage their industrial stormwater runoff:

- Great River Energy's corporate headquarters. According to the Great River Energy's website, the facility collects their stormwater runoff with their 20,000 gallon cistern, which allows them to use 90% less water than similarly sized buildings, saving up to 1.6 million gallons of water per year. **(reduction)**
- St. Anthony Village. The city installed an underground cistern that they use to irrigate some ball fields. **(reduction/reuse)**
- City of Minneapolis. The Minneapolis city hall has a cistern on its roof that's used for irrigation of its green roof. Their 10,000-gallon cistern in the building's interior courtyard will collect stormwater from the City Hall roof for irrigation of the building's new green roof. The cistern is 14 feet in diameter and 11 feet tall. **(reduction/reuse)**

- The Green Institute. Stormwater is contained largely by a shallow depression constructed in the midst of a half acre restored prairie and a quarter acre wetland; supplemental stormwater is managed by parking lot islands and a 4,000 square foot roof top garden. Their stormwater management qualified the Green Institute for a reduced City Stormwater Fee and is now promoted by the City as a best practice. **(reduction)**
- Century College. To conform to the local watershed district's rules, Century College constructed two underground stormwater infiltration systems to treat half inch of runoff from a re-constructed 22-acre parking lot. For additional treatment, the college constructed three rainwater garden parking islands, two permeable asphalt areas, and an alternative stormwater treatment educational area that includes a subsurface integrated tree and stormwater system, pervious concrete, pervious pavers, and a rainwater garden. **(reduction)**
- Science House, MN Science Museum. Science House was built on reclaimed land over unstable landfill on the banks of the Mississippi River. All stormwater is retained on site, and native species and permaculture landscaping retain and enhance the infiltration of runoff. **(reduction)**
- 7-Sigma. According to the 7-Sigma website, rainwater garden surrounding the parking lot collects runoff from the roof and parking lot. The storm water irrigates and nourishes the rain garden as it infiltrates into the soil. The project is located in an urban area of South Minneapolis and illustrates that a near-zero runoff facility is possible even in a highly developed area. Technologies have now been designed and developed to direct stormwater to infiltration locations, and are designed to percolate run-off directly into the soil. Subsequently, the stormwater, with its accompanying pollution, is filtered by plant root systems located in engineered collection ponds, travels to natural groundwater sources. The landscaped areas serve to collect and filter stormwater. The stormwater swales collect 50% of the stormwater run-off. All of the gardens manage approximately 90% of the polluted stormwater run-off from our paved areas, preventing the majority of this polluted water from traveling to the Mississippi River. This project was undertaken as part of 7-SIGMA's ongoing commitment to environmental sustainability in the workplace. **(reduction)**
- Murphy Warehouse Company, Minneapolis**.** In 2007-2008 designed and constructed a stormwater system with a retention basin and three additional rain gardens to collect 95% of the rainwater that falls on campus. The project took six weeks to construct was voluntarily constructed on an existing, heavy use commercial facility in Minneapolis. Murphy also installed native prairies around the stormwater system, increasing its efficiency, eliminating polluting fertilization and water waste from automatic sprinklers, and saving additional money through reduced maintenance costs of a traditional lawn. (**reduction)**

Additional Resources: Reuse/reduction

- http://www.waterproofingadelaide.sa.gov.au/NR/rdonlyres/35079955-5BF1-4EFC-B4B8-7FEC3ABC84D6/0/Stormwater_Reuse.pdf
- http://www.dep.state.fl.us/WATER/wetlands/erp/rules/stormwater/docs/stormwater_reuse_0808.pdf
- http://www.iccsafe.org/news/green/pdf/0605BSJ36.pdf
- http://www.forgottenrain.com/index.html
- http://greatriverenergy.greentouchscreen.com
- http://www.melbournewater.com.au/content/library/wsud/conferences/melb_1999/stormwater_reuse_-_a_balanced_assessment.pdf

- http://www.oracwa.org/Pages/PDXBDSSWREUSEGUIDEDraft.pdf
- http://www.greeninstitute.org/documents/PEECRetrospective.pdf
- http://www.bfenvironmental.com/pdfs/CaptureReuse.pdf
- http://www.bfenvironmental.com/bmps.php
- http://www.7-sigma.com/
- http://www.murphywarehouse.com/content/Murphy-Stormwater-System-Backgrounder.pdf
- http://www.fhwa.dot.gov/environment/ultraurb/uubmp3p6.htm http://www.fhwa.dot.gov/environment/ultraurb/3fs15.htm
- http://www.metrocouncil.org/environment/Watershed/BMP/CH3_RPPImpGreenRoof.pdf
- http://zeb.buildinggreen.com/overview.cfm?projectid=284 (science house)

Placeholder for photo

Chapter 6: Stormwater Control Measures/Management Measures

Stormwater control measures are a required part of the Multi-Sector General Permit, and provide key elements of stormwater management. Individual facilities may be able to come up with a myriad list of site-specific BMPs that work well for their facility. The list of BMPs in this chapter is provided as examples of BMPs and is not an exhaustive list of BMPs that would satisfy the following control measures:

- Good Housekeeping
- Eliminating and Reducing Exposure
- Salt Storage (if present at the facility)
- Erosion Prevention and Sediment Control
- Management of Runoff
- Facility Inspection Requirements
- Maintenance Requirements
- Maintenance Requirements (General and Preventive Maintenance)
- Elimination of Unauthorized Non-Stormwater Discharges (illicit discharges).
- Spill Prevention and Response Procedure
- Mercury Minimization Plan
- Employee Training Program

6.1: Good Housekeeping

Pollution-prevention practices include good housekeeping/facility maintenance BMPs, such as litter pick-up, lawn-management practices, sweeping, erosion control and maintenance of stormwater conveyance systems. These practices usually take a minimal amount of effort compared to cleanup efforts, and should be part of the routine of businesses, personnel and users.

Waste-Handling and Waste-Storage Areas:

Litter and other improper disposal not only ruin the beauty of Minnesota's waters and the environment, it can also injure and kill aquatic life. Encourage staff to collect their trash and return it to proper disposal facilities by providing waste disposal service as part of normal practice. Post signs to encourage disposal of wastes in the proper waste containers. Separate waste streams, such as recycled water and solid waste.

Dust Control:

Dust from smokestacks and vents as well as from stockpiles, cleared ground, gravel roads, and open areas, often called "fugitive dust," is a form of air pollution. The surface and air movement of dust from disturbed surfaces may cause offsite damage, health hazards and traffic problems. Industries and local governments sometimes use various methods to control this dust. Filters and scrubbers are often used on regulated discharges, so this BMP is directed more toward fugitive dust, which may or may not be regulated by an air permit. Construction activities that disturb soil can also be a significant source of fugitive dust, especially in "heavy" construction activities, such as land grading for road construction and commercial, industrial or subdivision development.

Other BMPs to consider:

- Frequently remove debris and wastes to avoid stockpiling or buildup at loading docks, truck unloading entrances, paint booths, and material handling operations
- Layout storage systems for easy year-round housekeeping and monitoring

6.2: Eliminating and Reducing Exposure

Chapter 4 outlines a number of opportunities to eliminate or reduce exposure of materials and activities to stormwater. Reducing and reusing stormwater or minimizing its contact from materials and activities can benefit any type of facility, even those who are not able to certify for No Exposure. Stormwater reduction and reuse options are described in Section 5.1.

Cover

Inventories of materials should be managed so that needed materials can be stored in covered buildings. Tarps or similar temporary covers may be appropriate for large stockpiles and storage areas, but do not provide long-term coverage.

Pads

Pads placed under material piles should be impervious. They prevent infiltration to the groundwater and allow the stormwater to run off the material pile and be collected for treatment. Because material-pile runoff can be very acidic or corrosive, a material must be chosen that is impervious to the discharge. Asphalt and concrete can crack, resulting in infiltration to the groundwater. Also, concrete will not hold up under exposure to acidic runoff. Compacted clay pads are often a good option, but are expensive, as the clay should be 3 ft thick. A pervious base, such as gravel, will allow the water to infiltrate to some extent and will help control sediment loss. Gravel may be used, but runoff and leachate from storage yards should be sampled to determine whether the runoff should be allowed to infiltrate into the gravel (*i.e.,* that they will not pollute groundwater). The pad should be sloped to facilitate runoff to the proper areas, such as detention basins, when such treatment is required.

Berms

Berming is a practice that can prevent uncontaminated stormwater from washing across the exposed stockpile and becoming contaminated. It also can keep stormwater from carrying particulates off the facility. The topography of each facility should be evaluated for direction of surface flow. Impermeable berms can be used to route surface flows away from stockpiles, which should be on high ground so that surface water flows away from them. A berm can keep offsite flows from storage areas and also help to slow down and capture yard runoff. **Significant materials** and **industrial activities** can be bermed on all sides with a ramp for truck and equipment access. If soil is used for the berm, it should be stabilized to keep it intact and prevent erosion from the berm itself.

Vegetative Buffer Strips

Vegetative buffer strips or areas of vegetation can also be used to control water entering or leaving the facility. A vegetative strip will slow down water flowing from the facility and can capture some of the sediment. Sediment controls in the yard, such as gravel, should also be used, as most vegetative strips will not be able to handle large sediment loads. Do not allow material storage or traffic through the buffer strips; the soil compaction may reduce infiltration and be detrimental to the health of the vegetation in the strip.

Source Area Controls

Many of the pollutants associated with storage facilities can be controlled with source area controls. Sediment and debris control can reduce total suspended solids, biological oxygen demand, chemical oxygen demand, floatables and the pollutants associated with wood chips, bark, sawdust and other natural materials. Control of processing material can eliminate most of the stormwater pollutants associated with these materials. Many processing facilities retain all products and collected waste inside a building. The products and waste can then be loaded directly onto a truck for sale or use at the plant for fuel or other purposes. If other chemicals, such as petroleum products or insecticides, are used at the facility, special management may be required. Infiltration of storage area leachate should not be allowed until it has been determined that a discharge of this leachate to the groundwater will not violate groundwater standards.

Reduce Amount of Significant Materials Stored at the Facility

Source-reduction options include reducing the amount of significant material used and stored at the facility. This should be given consideration in the facility pollution-prevention plan. When adding to a pile, compact it and keep it as confined as possible. This will reduce the amount of material that comes in contact with stormwater and reduce the potential for contaminants to be dissolved or dislodged and washed into a nearby water body. The following actions will help keep the pile intact:

- Keep only one pile onsite, if possible
- Areas may be combined or moved to a more suitable location to reduce management needs
- Each area where materials are stored should be evaluated for need

Sediment Control in the Yard

Regularly sweep the area back onto the pile to pick up any spillage and dust generated during loading and unloading. Spray piles and roads as needed to suppress dust; however, do not spray to the extent that runoff from the facility is occurring. The addition of 0.01 inch of water, either as rain or spray, will usually produce a dust-free condition. The storage area should be paved to prevent sediment from being discharged and tracked off the storage yard.

Collection of Debris and Yard Material

As materials are removed from the storage area for processing, the areas on which they were stored should be cleaned. Loose material should be picked up. If there is a significant amount of soil mixed with debris, the material may be composted. A solid waste permit may be required for the compost pile. The compost pile should be constructed and operated to avoid groundwater and surface water contamination. It can be placed on a pad, with runoff collected and sprayed back onto it. The compost can be used for landscaping operations.

Loading and Unloading Concerns

A great deal of dust and spillage can take place when materials are bagged, conveyed or loaded. The following practices should be considered when materials are processed or loaded:

- Many materials should be handled indoors so dust may be contained. After handling operations, the dust should be swept up and disposed.
- If dust is generated when a truck is loaded a chute or boom should be used to place the materials in the truck and the truck should then be tarped. The area should be swept after the truck is loaded.
- Significant dust and spillage can occur as material is unloaded onto a pile and subsequently loaded onto vehicles for shipment offsite. The following practices should be followed when material is being moved:
    - If dust is being generated during loading, unloading or transfer, the material should be sprayed to control the dust. Many facilities must do this as a requirement of their air permit. Spray should be controlled to avoid creating runoff from the facility.
    - Spillage into a water body during loading and unloading must be prevented. The use of covered chutes or booms should be considered to prevent spillage.
    - Uncovered storage piles should be evaluated for dust-control needs. Blowing material can be an irritant to neighbors and may damage vegetation near the area.

Capture and Recycling of Yard Runoff

If there is more stormwater and process water generated from the yard operations than can be safely infiltrated in the yard, it should be directed toward a ponding area. Sediment can then be allowed to settle out. The water can then be recycled and reused. Once the water is removed or recycled from the low-lying area, the debris should be collected. This debris can then be treated, disposed or reused. It is important to design the low-lying area so that it can be frequently drained and cleaned to avoid a buildup of waste.

Recycling of Runoff Back onto the Pile

When infiltration of contaminated stormwater is not a concern, the best treatment practice may be to spray the water back onto the material pile. If the pile is not on an impervious pad, extensive monitoring of the leachate should be done before the runoff is sprayed back onto the pile. The owner or operator must avoid allowing infiltration of leachate that will violate ground-water standards. The runoff from the material pile can be collected in a detention ditch or basin. To avoid clogging the spray equipment, the runoff may need to be filtered before it can be recycled back onto the pile. Evaporation from the detention area may also reduce the amount of water to be recycled. Recycling back onto the material pile can be especially advantageous for piles that need dust control.

Detention and Settling

In some instances, settling of the material pile runoff may be enough to reduce pollutants to acceptable levels. The detention basin should be designed to remove 90% of the suspended solids from the runoff from a 1.25-inch or 0.3-year return frequency 24-hour storm event. The settling times needed will vary with the contaminant levels in the runoff and type of solids that were washed from the material pile during the rain event. The treatment outflow rate will not necessarily be the same as the rate defined for ordinary stormwater. The treatment discharge rate depends on the particle size distribution and needs to be adjusted to reflect the stockpile particle distribution size. Also note that settling alone may not bring the runoff to acceptable levels unless suspended solids are the only pollutant of concern.

Filtration and Vegetative Strips

Both filtration and vegetative areas can be used to keep stormwater from washing across the material storage area and picking up contaminants. Vegetative filtration areas can be used to allow infiltration of uncontaminated stormwater into the ground before the stormwater reaches the material pile. The amount of stormwater moving towards the pile should be calculated. A filtration area can then be designed to allow all of this water to infiltrate before it reaches the material-storage area. Both filtration and vegetative areas can be designed as shallow depressions to capture stormwater and allow it to infiltrate over time. These practices should not be used with contaminated stormwater unless approval has been obtained from the proper regulatory agency. When source area controls do not keep pollutant levels low enough to avoid violating a water-quality standard or effluent limit, treatment of the material-pile runoff must be considered. When considering the following treatment options, the owner or operator may want to consider primary treatment of the initial runoff.

Adjustment of pH

The runoff and leachate from some stockpiles, such as coal piles, can be very acidic. pH values of stormwater discharges from material-pile runoff must be between 6.0 and 9.0 to meet federal water quality effluent limits. Sampling results have shown that many times pH values of runoff from material piles are below pH 6. If there is a direct discharge to surface water, the pH may need to be adjusted. One method of pH adjustment is the addition of lime to the runoff, which requires an equalization basin for homogenous mixing of the runoff, a storage facility for the lime, a feed system, instrumentation, electrical connections and piping.

Removal of Metals

A number of metals, including chromium, copper, lead, nickel, antimony, mercury, selenium, zinc, beryllium, arsenic, aluminum and cadmium, have been shown to be of concern in material pile runoff. A long settling time may be enough to remove metals so the discharge meets water quality limits. If not, these metals must be further treated or removed to prevent the material-pile discharge from causing a violation of a water-quality standard (and from exceeding benchmark concentrations for monitoring). Chemical precipitation or flocculation is one method to remove metals. A polymer can be added to the discharge to allow the metals to settle out. Using a lime-feed system to elevate pH can also be used to settle out metals which are less water soluble at higher pH levels. The sediment will need proper solid waste disposal. A polymer-feed system can include storage hoppers, chemical feeders, solution tanks, solution pumps, interconnecting piping, electrical connections, and instrumentation.

Subgrade Cutoff Walls to Prevent Groundwater Contamination

In instances where material pile infiltration or runoff is causing contaminated ground-water concerns and an impervious pad is not an option, a subgrade cutoff wall may be an option. The cutoff wall can be a slurry or grout curtain. This wall is built around the material pile. It should extend to relatively impermeable subsoil to prevent movement of groundwater under the slurry wall. The wall should have a permeability of less than 1 x 10-7 cm/sec. A drainpipe system is placed inside the slurry trench below the groundwater table. Collection pumps located at various points around the slurry wall keep the groundwater level inside it slightly lower than outside it to prevent migration of material pile leachate into the surrounding groundwater. This system also prevents excessive migration of uncontaminated groundwater into the material pile area. The sumps empty into an impervious basin. This water is then treated as necessary to remove any pollutants that could cause a violation of a water-quality standard.

Other BMPs to consider:

- Use temporary shelters, like tarps, on a short term basis only until permanent structures can be installed
- Recycle unused equipment rather than stockpiling
- Drain, collect, store, dispose of or recycle fluids and lubricants from equipment
- Use drip pans and empty frequently
- Reuse liquids when possible
- Contain and frequently collect and recover scrap, dust, and other wastes at the generating process
- Minimize or eliminate wastes produced and dispose of or recycle promptly
- Manage operations to avoid buildup of dust or other deposits on exhaust vents and roof stacks
- Optimize material utilization to generate less scrap
- Minimize emissions from electroplating and anodizing baths through use of proper controls

6.3: Salt Storage (if present at the facility)

Addressing stockpiles of salt is a requirement of the Multi-Sector General Permit. Consider the following BMPs to manage salt storage:

- For cold weather activities, reduce or eliminate the need for deicing products by manually clearing sidewalks, driveways, and parking lots prior to deicer use
- Use environmentally-friendly deicing products when possible, apply sparingly and store properly if used
- If any salt is tracked out of the salt storage area, sweep it up
- Train employees on salt and abrasive application and storage

6.4: Erosion Prevention and Sediment Control

Any area where soils are exposed to water, wind or ice can result in soil erosion. Erosion is a process in which soil and rock material is loosened, becomes suspended in water or air, and is transported to another location (typically receiving water bodies.

Erosion can be accelerated by human activities such as removing vegetation, compacting or disturbing the soil, changing natural drainage patterns, and by covering the ground with impermeable surfaces (e.g., pavement, concrete, buildings). When the land surface is covered with impermeable surfaces, stormwater and snowmelt cannot infiltrate into the ground. This results in larger amounts of water moving more quickly across a site, which can carry more sediment and other pollutants to streams and rivers and can cause erosion within streams and rivers. A construction stormwater permit is required for any construction activities greater than 1 acre. Activities less than one acre should follow similar practices to minimize exposure.

Plans must be developed for areas that may have a high potential for soil erosion. This includes areas with such heavy activity that plants cannot grow, such as soil stockpiles, stream banks, steep slopes, construction areas, demolition areas and any area where the soil is disturbed, denuded (stripped of plants) and subject to wind and water erosion. Steps to limit this erosion must be implemented as needed.

There are several ways to limit erosion and control sediment:

- Leave as much vegetation onsite as possible
- Minimize the time that soil is exposed
- Prevent runoff from flowing across disturbed areas (divert the flow to vegetated areas)
- Stabilize disturbed soils as soon as possible
- Slow the runoff flowing across the site
- Provide drainage ways for the increased runoff (use grassy swales rather than concrete drains)
- Remove sediment from stormwater runoff before it leaves the site

Using these measures to control erosion is an important part of stormwater management. Selecting the best set of erosion-prevention measures for an industry depends upon the nature of the industry activities (*i.e.*, how much construction or land disturbance there is) and other site-specific conditions (soil type, topography, climate and season). Chapter 7 of this guidebook describes more structural ways to control sediment.

6.5: Management of Runoff

Stormwater BMPs implemented by a Permittee should be described within the Stormwater Pollution Prevention Plan to indicate how the facility will manage runoff. This includes the permanent structural BMPs used to divert stormwater runoff away from fueling, manufacturing, treatment, storage, and disposal areas, and BMPs that treat, infiltrate, reuse, contain, or otherwise reduce pollutants in stormwater discharges. See Chapter 7 for stormwater management using structural BMPs.

Consider the following BMPs:

- Install adequate containment around liquid storage areas
- Properly maintain containment structures, keep drains closed, and properly dispose of stormwater collected
- Discharge wash waters, contaminated cooling water, condensates, and boiler blow-downs to sanitary sewer with appropriate approvals

6.6: Facility Inspection Requirements

Facility inspections should be conducted at least once every month by an appropriately trained person. The purpose of these inspections is to (1) determine whether structural and nonstructural BMPs require maintenance or changes, and (2) to evaluate the completeness and accuracy of the Plan. Inspections should be documented using an inspection form provided by the owner. The following compliance items should be inspected, and documented where appropriate:

- evaluate the facility to determine that the Plan accurately reflects facility conditions and is in compliance with the permit, document any inaccuracies;
- evaluate the facility to determine whether newly exposed materials have been added to the facility since completion of the Plan, documenting any new materials;
- during the inspection conducted during the runoff event, observe the runoff to determine whether it is discolored or otherwise visibly contaminated, documenting observations; and
- determine whether the nonstructural and structural BMPs as indicated in the Plan are installed and functioning properly in accordance with the implementation schedule.

On the inspection form, indicate the date and time of the inspection as well as the name of the inspector. If conditions observed at the facility require changes in the Plan, the changes should be made as soon as possible. If the Permittee identifies BMPs that are not functioning properly, the Permittee shall replace, maintain or repair the BMPs within seven (7) calendar days of discovery. If BMP replacement, maintenance, or repair cannot be completed within seven (7) calendar days, the Permittee shall implement effective backup BMPs (temporary or permanent), until effectiveness of the original BMPs can be restored. The Permittee shall document the justification for an extended replacement, maintenance, or repair schedule of the failed BMPs, and store it with the SWPPP.

Records
A copy of the SWPPP should be retained onsite, and be available upon request. The following records should be maintained:

- dates of inspections;
- findings of inspections;
- corrective actions taken;
- documentation of all changes to the Plan; and
- annual reports.

Notification
If a spill, bypass or release occurs, it must be reported to the appropriate authority. The spill plan must specify who shall report and where the report shall be made. Minnesota Department of Public Safety Duty Officer at 1-800-422-0798 (toll free) or 651-649-5451 (metro area) per Minn. Stat. § 115.061.

Other BMPs to consider:

- Start good habits for routine inspections. Consider inspecting at times where other regulatory programs require inspections to save time, if possible
- Inspect maintenance areas regularly for proper implementation or issues
- Inspect storage tanks and piping systems (pipes, pumps, flanges, couplings, hoses, and valves) for failures or leaks and perform preventive maintenance
- Inspect containers for leaks or damage prior to loading/unloading
- Inspect BMPs to ensure they are operating correctly
- If fuel storage tanks are present, perform inspections and preventive maintenance on them to detect potential leaks before they occur
- Schedule frequent inspections of equipment for signs of spills, leakage of contents, oil, fuel, hydraulic fluids

- Inspect for accumulation of particulate matter on and around equipment and clean-where possible cover these areas to prevent losses to wind and precipitation

6.7: Maintenance Requirements (General Facility Preventive Maintenance Activities)

Maintaining equipment is a common and beneficial BMP for facilities to implement. In order to maintain a warranty for equipment, routine maintenance is often required. Keeping equipment in good condition not only can help to prevent problems or equipment failure, but can also save money by possibly eliminating potentially costly unexpected repairs on equipment.

Vehicle and Equipment Maintenance

Fluids from vehicle and equipment maintenance activities and breaking hoses also contribute to stormwater contamination onsite or on a storage pile area. Any maintenance that has the potential to result in the loss of fluids or solvents should be done indoors on an impervious pad. Any spills should be cleaned up immediately. All fluids and solvents should be properly disposed.

The primary sources of stormwater contamination related to the maintenance of vehicles or equipment are leaking fluids and the improper disposal of fluids removed during routine maintenance. A regular maintenance schedule for vehicles or equipment provides periodic checking for leaks. Excess fluids in parking areas indicate the need for maintenance and/or checking for potential leaks. Parking vehicles in specified locations will identify slow, recurring leaks, and visual inspections of the pavement around specified parking areas will identify releases which may otherwise go unnoticed. Also, keeping vehicles washed and cleaned assists in identifying oil or other fluid releases from the vehicles. Once a leak is detected, the following actions can be taken:

- Use an absorbent to clean up the spill and place a drip pan under the leak. If possible, move the vehicle or equipment inside. Schedule maintenance and identify the leak location. After maintenance complete, visually confirm that the problem has been corrected.
- When possible, perform all maintenance of vehicles and equipment inside. This greatly reduces the potential for spills to be exposed to stormwater. If maintenance activities must be performed outside, provide drip pans and/or spill cloths for use under the area being worked on. Once maintenance has been completed, take the drip pan inside and place the fluids that accumulated in the pan in the designated container. Upon completion of the outside maintenance activity, inspect the maintenance area and clean it, if needed.
- Properly dispose of used oils and fluids. Keep documentation on file to prove that fluids were properly disposed. A regular schedule for proper offsite disposal of accumulated fluids should be established. Do not spread used oils or fluids outside to control dust or kill weeds. Clean drip pans when not in use and return them to their designated inside storage area.
- Traction sand, degreasing wastes, motor oil, motor oil filters, oil sorbent pads and booms, transmission fluid, power steering fluid, brake fluid, antifreeze, radiator-flush wastewater and spent solvents must be collected and disposed of in accordance with applicable solid- and hazardous-waste-management rules, including Minn. Stat. § 115A.916. These materials, which include the non-aqueous portion from flammable traps and oil/water separators, must not be released to surface or groundwater.
- As part of the regular maintenance schedule, check for releases from equipment and vehicles at least twice a year. The identification of releases and spills and the maintenance operations to

repair or clean up these incidents are BMPs that will help decrease the amount of oil and grease or other materials exposed to stormwater.

The following suggestions will help prevent pollution from vehicle and equipment repair operations:

Keeping the Workplace Clean

- Clean shop floors by sweeping, spot cleaning or other methods to prevent runoff into storm drains.
- Sweep clean surfaces that drain to the storm drainage system and properly dispose of the sweepings.
- Use drip pans in shops to hold fluids while doing repair work.
- Conduct repair work indoors.
- Clean up shavings, paint chips, dust and sandings and properly dispose of them.
- Drain cars, engines, transmissions, differentials, and equipment of all fluids when dismantling them for parts, and properly dispose or recycle the fluids.

Maintaining Drainage Systems

- Routinely inspect catch basins and clean when needed.
- Inspect the oil/water separator (inside or outside) and maintain appropriately.
- Handle removed wastes in accordance with part Hazardous Waste Fact Sheet 4.18, Managing Floor Drains and Flammable Traps.

Washing Vehicles and Equipment

- Wash vehicles only with water; follow best management practices such as infiltration to manage these discharges.
- If vehicles and equipment are washed with soaps, wash them only in a designated area that is covered and leads to a properly approved sanitary sewer system connection, recirculating system or sump.

Handling and Storing Materials

- Recycle or reuse hazardous materials whenever possible.
- Keep hazardous waste containers and dumpsters covered and any drain holes plugged to prevent the contents from leaking out.
- Dispose of hazardous materials that are not recycled or reused through a treatment, storage and disposal facility.
- Properly label containers waiting to be recycled or disposed of as to their contents.
- Provide secondary containment for all hazardous materials.
- Handle materials carefully and keep the workplace orderly to prevent spills.
- Develop and maintain a Spill Prevention and Cleanup Plan for each potentially harmful liquid, such as gasoline or oil.
- Post the Spill Prevention and Cleanup Plan where it can be easily accessed.
- Dispose of used tires in an approved manner.

Other BMPs to consider:

- Clean equipment and parts prior to storing outdoors
- Increase maintenance to avoid leaks and spills

- Perform preventive maintenance on equipment and vehicles
- If applicable, schedule maintenance of dust collection system and baghouse
- Conduct routine preventive maintenance of equipment per original manufacturer's equipment recommendations-replace worn or malfunctioning parts
- Conduct periodic maintenance and clean out of all sumps, oil/water separators, media filters-dispose of residual waste materials properly, e.g., according to hazardous waste disposal requirements
- Use berms, curbs, or similar means to ensure that stormwater runoff from other parts of the facility does not flow over the maintenance area
- Maintain parking lots frequently and especially in the spring and fall by sweeping, picking up litter, and repairing deterioration; pressure wash pavement only as needed and minimize the use of cleaning agents.

6.8: Elimination of Unauthorized Non-Stormwater Discharges (illicit discharges)

Illicit discharges are discharges that are not legal. Unauthorized discharges are any discharge not covered by permit; some are legal and some are not. The MPCA permit regulates stormwater discharges and allows certain types of non stormwater to be discharged with stormwater under this permit. Other discharges that are not stormwater may be legal or illicit depending on the situation. Examples of illicit and discharges not authorized under the Industrial Stormwater Permit are sewage and septic flows, washwater, spills, dumped materials. Other types of non stormwater discharges that can be discharged under the permit (under specific circumstances) include groundwater flows, tap water, irrigation or lawn watering, water from fire fighting activities.

BMPs to consider:

- Inspect and test floor drains, sinks, and process drains; eliminate any connections to storm sewers, or surface or subsurface drains
- Prevent the mixture of non-stormwater discharges with stormwater discharges; the mixture becomes non-stormwater and must be appropriately managed.

6.9: Spill Prevention and Response Procedure

Some facilities may already have a Spill Prevention Control and Countermeasures (SPCC) Plan which addresses the proper handling and storage of materials and the availability of equipment needed to prevent or respond to a spill. The Pollution Prevention Plan should incorporate parts of the SPCC and other management plans located at a facility.

List of Industrial Activities within the SPCC Plan

The facility SWPPP shall include a current list of all industrial activities (SIC codes or narrative activities) that are summarized in Table 5 of Appendix D of the Multi-Sector General Permit that are potential sources of pollutant spills and must include, if applicable, the following operational activities:

1. Fueling
2. Vehicle and equipment maintenance
3. Loading and unloading of dry bulk materials or liquids
4. Liquid storage tank
5. Outdoor manufacturing and processing
6. Outdoor storage of significant materials

7. Access roads, rail cars, and tracks
8. Waste treatment, storage, or disposal (including waste ponds, dumpsters, and solid waste storage or management)
9. Dust or particulate-generating processes including dust collection devices
10. Rooftops contaminated by pollution control devices

Fueling Facilities

Fueling systems usually consist of two major components, the fuel-storage tank and the fuel dispensing system. Other related fueling activities include mobile fueling and checking airplane fuel with a fuel sampler during the pre-flight check. Fueling-related releases are a major source for contamination of surface waters and aquifers. Proper design and operation of fueling facilities and systems are high environmental priorities.

BMPs for Fueling Areas

- Use dry cleanup methods for the fuel area rather than hosing it down. Use dry sweeping compounds, which can be reused as long as they remain absorbent.
- Install treatment devices, such as filter strips, sediment traps or sedimentation ponds, to remove pollutants from runoff before it discharges from the facility.
- Developing an underground storage tank (UST) inventory control management plan can aid in detecting releases from UST systems and in minimizing the impacts associated with a release.
- For AST (Aboveground Storage Tank) installations, provide for containment of a spill or a leak through use of a dike, berm or double-walled tank. Information on specific design requirements for above-ground fuel-storage tanks can be obtained by contacting the MPCA AST program.
- When filling above-ground or underground fuel-storage tanks, follow standard procedures and the guidelines given in the MPCA AST/UST programs.
- Clean up minor spills with absorbent materials and dispose of these materials properly.
- Clean up spills and releases in accordance with an established Spill Prevention Response plan.

Fuel Dispensing

Spills often occur when fuel is dispensed into airplanes, vehicles and equipment. These spills tend to be small volumes, which may accumulate on the ground over time and/or get washed off by each rainfall. Visually, these small spills may not appear to merit concern, but they can result in a substantial quantity of pollutants being discharged from the facility over time. Simple activities that help minimize the potential for spilled fuel to be discharged into stormwater from the fuel dispensing area are:

- Avoid topping off fuel tanks, which may cause spills by overfilling.
- Remove locking devices on fuel dispensing handles so that operators must hold the handle open and cannot walk away while filling tanks.
- Have absorbent materials available at the fueling area for use in cleaning up small spills.
- Instruct the operators on how to use absorbent materials and where to properly dispose of them.
- Do not wash or rinse fueling areas with water, which could cause fuel spills to be discharged into stormwater systems. Use absorbent materials to soak up spills.
- Provide a spill-containment system and education on spill-response procedures. Topping off fuel tanks is probably the largest source of small spills. Simply educating operators and
- Encourage good fueling habits.

More extensive dispensing area BMPs that could be implemented to minimize stormwater contact with fuel spills include:

- Install a canopy over the fueling island to keep precipitation from falling directly upon the fueling pad.
- Provide impervious pavements at all fueling locations. This allows for spill cleanup using dry absorbent materials before precipitation can wash these spills away.
- Install a diversion berm and/or trench around the fuel-dispensing pad to minimize the quantity of run-on from outside areas. This, in turn, will keep fuel from small spills from being washed off the pad.
- Report all reportable spills to the Minnesota Department of Public Safety Duty Officer at 1-800-422-0798 (toll free) or 651-649-5451 (metro area) per Minn. Stat. § 115.061.

Mobile Fueling

Mobile fueling is more difficult to manage than fixed fueling facilities. The disadvantage of mobile fueling is the difficulty in controlling the following items for each of the many potential fueling locations:

- providing proper surface drainage conditions and discharge outlets,
- providing an impervious ground surface at the fueling locations, and
- providing containment/absorbent materials by each fueling location.

A major advantage of having mobile fueling is that it is more likely that fully trained, experienced individuals will dispense that fuel rather than less trained general users at stationary fueling stations. The most effective BMP for mobile fueling is the identification of specified locations where this activity can be performed. Cleanup of spills in these areas can then be facilitated by having the appropriate cleanup equipment and materials adjacent to the fueling activity.

Preventing Spills

- Do regular preventive maintenance on tanks and fuel lines.
- Train employees in proper management of hazardous materials, hazardous wastes and tanks.
- In facility leases, include a clause that allows employees to enter and conduct emergency measures.
- Do not fill gasoline tanks to the very top or allow overflowing.
- Post signs or provide information on spill prevention and clean-up methods to patrons.

Responding To Spills

Even with the best care and training, accidental spills will happen. Be prepared to contain and clean them up as quickly as possible. If a spill happens:

1. Contain the spill.
2. Report the spill. Notify the State Duty Officer when there is a release of a reportable quantity (five gallons or more for petroleum spill). Spills of all other chemicals or materials of any quantity may be reportable. If in doubt, report. Call the Minnesota Department of Public Safety Duty Officer at 1-800-422-0798 (toll free) or 651-649-5451 (metro area).
3. Clean up the spill. Generally the following procedures should be followed as appropriate for the situation: Stop the source of the spill immediately. Contain the liquid until cleanup is complete. Deploy oil containment booms if the spill may reach waters of the state or drainage ways to waters of the state. Cover the spill with absorbent material. Dispose of cleanup materials properly.

Other BMPs to consider:

- Clean up spills from previous events
- Stop and contain spills and leaks immediately
- Use squeegee and dustpan for cleanup of liquids
- Install monitoring equipment to detect and control leaks and overflows

6.10: Mercury Minimization Plan (if present at the facility)

Mercury containing devices may be present at any type of facility, not just at Automobile Salvage Yards or Scrap Recycling Facilities. All facilities with mercury-containing devices must management appropriately. Mercury containing devices include:

- Fluorescent bulbs
- Mercury lamps
- Mercury switches
- Mercury thermometers, gauges and other medical/scientific equipment
- Certain batteries

BMPs to consider:

- Make sure that spent fluorescent bulbs, mercury lamps, mercury switches, and other mercury containing devices are stored in a safe manner to prevent breakage. Make sure devices are recycled or disposed of appropriately
- Understand which types of batteries contain mercury and proper disposal procedures. Separate and manage accordingly. Mercuric oxide batteries are often marked with a plus sign inside a circle. See the "Managing Dry Cell Batteries" fact sheet for more information.
- If applicable, remove all mercury switches as soon as possible from vehicles or devices
- For Automobile Salvage Yard Facilities, enroll in the voluntary National Vehicle Mercury Switch Recovery Program

6.11: Employee Training Program

Successful waste-reduction activities need support from all employees, including top management and production personnel. Less waste is generated if employees are trained to operate equipment and handle materials safely and correctly. Occupational and safety hazards are reduced as well.

Issues

Employees should be made aware of the costs and environmental issues related to waste generation and disposal. One way to do this is to post these costs and any waste-reduction savings on bulletin boards throughout the company. Waste reduction usually happens in production processes. Explain how waste is generated by each process so employees understand that they share the responsibility for waste generation. Employees that are well informed can make valuable waste-reduction suggestions. Incentive programs can be useful in encouraging employees to participate in waste-reduction activities.

Implementation

Employees should be trained to look for practices which:

- generate less waste by making existing processes more efficient.

- are common-sense measures that apply to the human side of business rather than to the technological side; therefore, they can be used in all areas of production.
- are easy and inexpensive to implement, and practical for a Permittee's operations.
- have health and safety benefits for employees, the general public and the environment.

Good operating practices include:

- improved inventory management
- waste segregation
- improved production scheduling
- preventive maintenance
- spill and leak prevention
- employee training and education
- employee participation in planning
- materials usage, handling and storage
- clear labeling

Other BMPs to consider:

- Schedule operations to allow ordering and use of materials as needed to avoid storing onsite
- Change operations or install collection equipment to minimize dust generation from material handling
- Train employees on proper waste control and disposal procedures
- Provide employee training on proper installation and maintenance of sediment and erosion controls, if applicable

•Chapter 7: Structural BMPs for treating contaminated Industrial Stormwater

As explained in the introduction, there are several types of structural BMPs to treat pollutants that are present in stormwater runoff from industrials facilities. This chapter will explain various types of structural BMPs and which pollutants it can treat, providing specific information on efficiency, maintenance issues, and limitations. This chapter contains more technical information than previous chapters because this information is required for making informed decisions about structural stormwater BMPs. It is recommended that a licensed professional engineer be consulted before structural stormwater BMPs are installed.

7.1: Sedimentation Ponds

Placeholder for photo

Sedimentation ponds capture and store stormwater runoff while sediment settles out of the water. Sedimentation systems are best for removal of TSS and related parameters including most metals, organic compounds, and to some degree removal of oxygen demanding substances and nutrients. Ponds are a typical example of sedimentation systems and are usually the final BMP, used after other management measures except for filtration. All sectors could consider utilizing sedimentation systems as a BMP since all sectors are required to monitor for TSS. Ponds are constructed to contain a volume of water and, as stormwater runs into the pond, release the water at a rate that allows settling to occur.

Effectiveness

The effectiveness of sedimentation ponds depends on the size of the sediments in the stormwater runoff and the size of the pond compared to the size of the area that drains to the pond. Larger ponds hold stormwater runoff longer and allow more sediments to settle out. Ponds that capture runoff from smaller drainage areas hold stormwater runoff longer and capture more sediments. Larger sediments settle out faster than smaller sediments and are therefore captured more in sedimentation ponds. On average, wet ponds in the United States capture 65% of total suspended solids (TSS) (Weiss et al. 2005).

Design and installation considerations

<u>Permanent Storage (wet) Ponds</u>: Most ponds have some permanent storage. In this manual, permanent storage, or wet, ponds are designed to primarily treat runoff in the storage area between events by inter-event settling and biological and chemical activity. They usually provide a large permanent storage area below the outlet, and if properly sized, provide control of dissolved contaminants such as phosphorus, as well as treatment of suspended particulates.

<u>Detention Ponds</u> All ponds have some aspects of detention, but in this manual, “detention” describes ponds that may have some dead storage but the primary control is the outlet, which is designed to use detention above the outlet as their primary method to control the physical settling of pollutants. In many instances, detention ponds with no wet storage, designed as flood-control structures can be modified to meet the criteria of a permanent storage pond for a relatively low initial cost. Ponds that

empty completely are called dry ponds but these ponds do not generally provide treatment unless associated with other BMPs such as filtration or infiltration.

Wetland ponds or constructed wetlands are simply extended detention treatment ponds with vegetation-enhanced features. These ponds usually utilize active settling and other design concepts described above, but they require additional measures to protect vegetation (Schueler, 1992). Wetland pond treatment involves passing a carefully controlled volume of runoff through a constructed wetland to remove or treat pollutants. Sedimentation and an intense pool of biological activity may help to remove nutrients and other dissolved materials during the growing season. Although wetlands are effective for removing pollutants, care must be taken in the design and operation of wetland treatment systems.

Restrictions/Limitations

Although very versatile, ponds are limited in what they can accomplish. Sediment removal is based on the concept that gravity pulls things to the earth. Many substances are dissolved or are very small and will not settle entirely. Small particles such as clay particles and dissolved materials such as salt will remain in solution almost indefinitely. Depending on the type of materials in a facility's industrial stormwater discharge, there may be 55% to 97 % removal of solids with a well designed system.. (Pitt, R. E. , Wet Detention Ponds, May 23, 1997). Removal of dissolved materials, such as phosphorus, could be accomplished if there is chemical or biological activity that reduces the dissolved fraction. (Walker, W.W. , Phosphorus Removal By Runoff Detention Basins In Minnesota, September, 1985). This requires more detention time than traditional sedimentation methods. Other dissolved materials, chlorides for example, would not be expected to be removed by either of these processes.

Maintenance considerations

Ponds generally have large installation costs but low maintenance costs depending on frequency of excavation of accumulated sediments and methods of disposal. Some ponds can become a source of pollutants (metals, nutrients, etc) under certain (e.g., anaerobic) conditions. Ponds must be maintained regularly to prevent accumulated sediments from washing out during large storm events.

Other considerations

Ponds and other sedimentation devices are usually very large; if properly designed they may require from 3.0 % to 0.5 % of the watershed area to the pond. This can be especially significant if the watershed to the pond is larger than your facility. Ponds can also be affected by large events that can remove the settled material from the pond pushing it downstream with potential detrimental effects, and possible resulting monitoring exceedances.

The material in this section is adapted from "Assessment and Maintenance of Stormwater Treatment Practices," published by the University of Minnesota (Gulliver et al., 2009), which contains information and about assessment and maintenance of stormwater treatment practices.

The primary failure mechanism for sedimentation practices is buildup of sediment such that treatment is significantly reduced (Kang, et al., 2008). Significant buildup of accumulated sediment can result in minimal treatment and flooding of surrounding areas. Like all stormwater treatment practices,

sedimentation practices need annual inspection and maintenance to ensure proper function and extend useable life. Maintenance recommendations are given in Tables 12, 13, and 14.
If there is any indication that the practice is not draining or will not drain the design runoff volume within the suggested time based on design, the following steps can be taken to address the problem:

1. Inspect all outlet structures for clogging and/or structural damage. Remove debris and repair/ replace outlet structure, if necessary.
2. Inspect the outflow location(s) for water backing up from downstream of the pond which may impede discharge from the pond. If this occurs, determine the cause of the water backup and remediate the situation.
3. Redesign the pond geometry, outlet structure, or both to allow for proper draining of captured runoff.

Annual maintenance costs for sedimentation practices can be significant, ranging from approximately 2% to 3% of the total construction cost per year for dry ponds 2% to 10% for wet ponds, and 2% to 14% for constructed wetlands (U.S. EPA, 1999; Weiss et al., 2007). Additional information on construction, maintenance, and total present cost is provided in Tables 9, 10, and 11. Most maintenance for sedimentation practices is minimal or simple although some maintenance (e.g., sediment removal by dredging) can be significantly more complex. Most maintenance addresses buildup of sediment, litter, and debris and pipe clogging.

Table 9: Quick Facts: Dry Ponds (adapted from Weiss et al., 2007)

Impervious Area (acres)	**2.5**	**5**	**10**
Estimated Construction Cost	$43,000	$66,000	$100,000
Estimated Annual Maintenance Cost	$1,290 - $2,580	$1,980 - $3,960	$3,000 - $6,000
Estimated Total Present Cost	$73,000	$114,000	$177,000
Estimated Total Suspended Solids Capture (pounds per year)	1,600	3,100	6,200
Estimated Land Required (acres)	< 0.125	< 0.25	< 0.5

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 10: Quick Facts: Wet Ponds (adapted from Weiss et al., 2007)

Impervious Area (acres)	**2.5**	**5**	**10**
Estimated Construction Cost	$67,000	$100,000	$150,000
Estimated Annual Maintenance Cost	$1,273 - $6,834	$1,900 - $10,200	$2,850 - $15,300
Estimated Total Present Cost	$118,000	$168,000	$239,000
Estimated Total Suspended Solids Effectiveness (Annual lb reduction)	1,900	3,800	7,600
Estimated Land Required (acres)	< 0.025	< 0.05	< 0.125

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 11: Quick Facts: Constructed Wetlands (adapted from Weiss et al., 2007)

Impervious Area (acres)	2.5	5	10
Estimated Construction Cost	$31,000	$48,000	$75,000
Estimated Annual Maintenance Cost	$1,240 - $4,340	$1,920 - $6,720	$3,000 - $10,500
Estimated Total Present Cost	$56,000	$83,000	$123,000
Estimated Total Suspended Solids Effectiveness (Annual lb reduction)	2,000	4,000	8,000
Estimated Land Required (acres)	< 0.125	< 0.25	< 0.5

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 12: Maintenance Recommendations: Dry Ponds

Action	Typical Frequency	Notes	Reference
Remove retained sediment	Variable (Once every 5 to 10 years is typical in stable watersheds)	In unstable watersheds (i.e. those with active construction), the frequency is typically once a year.	Hunt and Lord (2006)
Monitor sediment depth	Once per year	--	
Maintain outlet structures	Once per month and after every storm over 2 inches	--	
Remove floating trash and debris	Once per week to once per month	Increase frequency, if needed	
Remove vegetation from dam top and faces, if applicable	Once per year	Increase frequency, if needed	

Table 13: Maintenance Recommendations: Wet Ponds

Action	Typical Frequency	Notes	Reference
Remove all sediment from forebay and deep pool (dredging)	Variable (Once every 5 to 10 years is typical in stable watersheds)	In unstable watersheds (i.e. those with active construction), the frequency is typically once a year.	
Monitor sediment depth in forebay and deep pools	Once per year	Can be performed with capacity testing	
Maintain outlet structures	Once per month and after every storm over 2 inches	Follow visual inspection guidelines	
Remove floating trash and debris	Once per week to once per month	Increase frequency, if needed	Hunt and Lord (2006)

Remove vegetation from dam top and faces, if applicable	Once per year	Increase frequency, if needed	
Mow wet pond perimeter	From every week to once per year	--	
Remove muskrats and beavers, if present	Inspect at least monthly	Destroy muskrat holes whenever present. Contact a professional trapper to remove beavers	

Table 14: Maintenance Recommendations: Constructed Wetlands

Action	Typical Frequency	Notes	Reference
Remove all sediment from forebay and deep pool (dredging)	Variable (Once every 5 to 10 years is typical in stable watersheds)	In unstable watersheds (i.e. those with active construction), the frequency is typically once a year.	Hunt and Lord (2006)
Monitor sediment depth in forebay and deep pools	Once per year	Can be performed with capacity testing.	
Maintain outlet structures	Once per month and after every storm over 2 inches	Follow visual inspection guidelines.	
Remove floating trash and debris	Once per week to once per month	Increase frequency, if needed.	
Remove vegetation from dam top and faces, if applicable	Once per year	Increase frequency, if needed.	
Remove invasive species (particularly cattails)	Twice per year for the first two years. Annually afterward.	Large cattail colonies should be removed with a backhoe. Chemical application may be used for small or new cattail growth.	
Remove muskrats and beavers, if present	Inspect at least monthly	Destroy muskrat holes whenever present. Contact a professional trapper to remove beavers.	

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7.2: Infiltration Systems

Infiltration systems are systems that capture and infiltrate industrial stormwater runoff and include all manmade and natural infiltration areas to which runoff is diverted. Infiltration systems reduce runoff volume, recharge groundwater, and reduce pollutant loads to surface waters.

Effectiveness

The effectiveness of infiltration systems depends on the size of the practice compared to the size of the drainage area and the subsurface soils. Larger infiltration systems can store more stormwater runoff and allow it to infiltrate into the soil. Infiltration is limited by the subsurface soils and can only be installed at facilities in which stormwater runoff will completely infiltrate in 48 hours or less.

Design and Installation Considerations

There are several different types of infiltration systems including infiltration trenches, infiltration basins, and bioretention systems, and underground infiltration tanks.

An infiltration trench is a shallow excavated trench, usually 2 to 10 feet wide and 2 to 4 feet deep, filled with a coarse stone aggregate. The coarse stone allows temporary storage of stormwater runoff in the space between stones which then infiltrates into the subsurface soil.

An infiltration basin captures and temporarily stores stormwater runoff while allowing it to infiltrate into subsurface soils. The function is similar to an infiltration trench with the exception that stormwater is stored in the basin as opposed to within the coarse aggregate stone.

Bioretention practices are similar to infiltration basins, but typically smaller, shallower, and sometimes include soil specifically chosen to promote infiltration and support vegetation growth.

Underground infiltration tanks capture stormwater underground in pipes or tanks and allow stormwater to infiltrate into subsurface soils through open bottoms or perforations.
Underground infiltration practices are typically installed at facilities where surface space is limited.

Placeholder for photo

All infiltration systems should have pretreatment to capture large sediment and debris. Pretreatment will extend the life of infiltration systems and reduce maintenance.

Restrictions/Limitations

Class 5 injection wells

Class 5 injection wells as an infiltration system is strictly prohibited without federal approval**.** Under federal law, class 5 injection wells, which are essentially any stormwater infiltration device that is deeper than it is wide, are required to be inventoried by reporting to the EPA. There are no other regulations at the present time, but future regulation is anticipated.

Minn. Rule chapter 7060

Minnesota State laws prohibit the direct discharge of untreated stormwater to the saturated zone if the discharge threatens groundwater from potential pollutants. There could be liability if it is determined that a discharge has introduced contaminants into groundwater in violation of state law. Treatment before infiltration is a suggested means to discourage the possible introduction of pollutants into the groundwater.

Wellhead Protection Plans

For stormwater systems located in defined wellhead-protection areas, the local unit of government must develop a "Wellhead Protection Plan" in accordance with state laws and requirements. Special attention should be given to injection wells or infiltration basins and trenches which may pose a high risk to the wellhead, especially for drinking water wells classified by the Minnesota Department of Health as vulnerable to contamination.

Maintenance Considerations

The material in this section is adapted from "Assessment and Maintenance of Stormwater Treatment Practices," published by the University of Minnesota (Gulliver et al., 2009), which includes information and details about assessment and maintenance of stormwater treatment practices. Maintenance of infiltration practices can range from the relatively simple task of trash removal to more complicated tasks such as controlling invasive vegetation and repairing and stabilizing eroded banks. Maintenance activities are given in Tables 4, 5, 7, and 8. Common reasons cited for failure of infiltration basins, trenches, and bioretention practices include:

- Poor site selection
- Improper soil textures
- Lack of pretreatment structures
- Clogging of the soil
- Compaction of soil
- Improper maintenance of appropriate surface vegetation

The most commonly cited reason for failure of infiltration structures is clogging due to sediment and organic debris (Kang, et al., 2008). Due to the high susceptibility of clogging, pretreatment of stormwater prior to its introduction to an infiltration basin or trench is recommended to remove sediments and debris. Like all stormwater treatment practices, infiltration practices need annual inspection and maintenance to ensure proper function and extend useable life.

Table 3: Quick Facts: Infiltration Trenches (adapted from Weiss et al., 2007)

Impervious Area (acres)	**0.5**	**1**	**2.5**
Estimated Construction Cost	$33,000	$59,000	$124,000
Estimated Annual Maintenance Cost	$1,683 - $41,580	$3,009 - $74,340	$6,324 - $156,240
Estimated Total Present Cost	$108,000	$190,000	$402,000

Estimated Total Suspended Solids Effectiveness (Annual lb reduction)	600	1,100	2,800
Estimated Land Required (acres)	< 0.015	< 0.03	< 0.075

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 4: Typical maintenance activities for infiltration basins and trenches (Adapted from Watershed Management Institute (WMI) 1997).

Activity	Schedule
• Remove sediment and oil/grease from pretreatment devices and overflow structures • Mow and remove litter and debris • Stabilize of eroded banks, repair undercut and eroded areas at inflow and outflow structure	Standard Maintenance (As Needed)
• Inspect pretreatment devices and diversion structures for signs of sediment buildup and structural damage • If dead or dying grass is evident at the bottom or the basin/trench, check to ensure water percolates within 2-3 days following significant rain events	Semi-Annual Inspection
• Disc or otherwise aerate bottom • De-thatch basin bottom	Annual Maintenance
• If bypass capability is available, it may be possible to regain or increase the infiltration rate in the short term by providing an extended dry period.	5-year Maintenance
• Total rehabilitation of the trench to maintain storage capacity within 2/3 of the design treatment volume and 72-hour exfiltration rate • Excavate trench walls to expose clean soil	Upon Failure

If there is any indication that the infiltration practice is not draining or will not drain the design runoff volume within the required time (typically 48 hours), the following steps can be taken to address the problem:

1. Remove and replace any mulch or surface layer material (including accumulated sediment), and reestablish any vegetation according to design.

2. Remove and replace the top four to six inches of sand or soil media, and reestablish any vegetation according to design.

3. Remove and replace the entire media bed and reestablish any vegetation according to design.

Typical maintenance frequencies may vary from multiple times per year to every 5 years or more. It is recommended, however, that inspection of infiltration practices occurs at least once per year. Most maintenance for infiltration basins is minimal or simple and addresses buildup of sediment, litter, and debris. Additional maintenance may be needed for bioretention practices to manage vegetation.

Annual maintenance costs for infiltration practices can be significant, ranging from approximately 1% to 100% or more of the total construction cost per year (U.S. EPA, 1999; Weiss et al., 2007). Most maintenance for infiltration practices will cost between 1% and 20% of total construction cost annually. The extreme maximum cost (>100%) is likely due to poor site design or lack of pretreatment such that the infiltration practice requires significant maintenance every year to maintain performance. This emphasizes the importance of proper design of infiltration practices. Additional information on construction, maintenance, and total present cost is provided in Tables 3 and 6.

Table 5: Maintenance Recommendations: Infiltration Trenches

Action	Typical Frequency	Notes	Reference
Remove sediment and oil/grease from pretreatment and overflow structures	As needed	--	Adapted from Watershed Management Institute (WMI) (1997)
Mow and remove litter and debris			
Stabilize eroded banks, repair undercut and eroded areas at inflow and outflow locations			
Inspect pretreatment devices and diversion structures for damage and sediment buildup	Semi-annual	--	
Inspect to make sure all water infiltrates within 2 days of rainfall event			
Roto tilling surface	Annually	--	
De-thatch bottom of basin			
If there is a bypass mechanism, keep the system dry for an extended period as it may increase infiltration capacity	5 years	--	
Excavate walls to expose clean soil	Upon failure	--	
Total rehabilitation			

Table 6: Quick Facts: Bioretention (adapted from Weiss et al., 2007)

Impervious Area (acres)	**0.5**	**1**	**2.5**
Estimated Construction Cost	$34,000	$69,000	$175,000
Estimated Annual Maintenance Cost	$238 - $3,434	$483 - $6,969	$1,225 - $17,675
Estimated Total Present Cost	$61,000	$105,000	$214,000
Estimated Total Suspended Solids Effectiveness (Annual lb reduction)	500	1,000	2,500
Estimated Land Required (acres)	< 0.025	< 0.05	< 0.125

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 7: Maintenance Requirements and Frequencies for bioretention practices (Hunt and Lord, 2006).

Task	Frequency	Notes
Inspection and maintenance of pretreatment unit(s)	Variable	Frequency and tasks depend on the pre-treatment unit (s).
Pruning	1-2 times/year	Nutrients in runoff often cause bioretention vegetation to flourish
Mowing	2-12 times/year	Frequency is dependent on location and desired aesthetics
Mulching	1-2 times/year	--
Mulch and top layer of soil removal	1 time every 2-3 years	Mulch accumulation reduces available water storage and decreases infiltration rates. The top layer usually is the cause of clogging and entire rain gardens rarely need to be replaced.
Watering	1 time every 2-3 days for first 1-2 months. As needed afterward	--
Fertilization	1 time initially	One time spot fertilization
Replace and remove dead plants	Annually	Within first year, 10% of plants may die. Survival rates increase with time
Miscellaneous upkeep	1 time/month	Weeding, trash collection, clearing overflow structures, etc.

Table 8: Maintenance Recommendations: Bioretention

Action	Typical Frequency	Notes	Reference
Inspection and maintenance of pretreatment unit(s)	Variable	Frequency and tasks depend on the pre-treatment unit(s).	Hunt and Lord (2006)
Inspection for sediment accumulation and removal, if necessary	Once a year or more	As needed	
Pruning	1-2 times/year	Nutrients in runoff often cause bioretention vegetation to flourish	Hunt and Lord (2006)
Mowing	2-12 times/year	Frequency is dependent on location and desired aesthetics	
Mulching	1-2 times/year	--	
Mulch and top layer of soil removal	1 time every 2-3 years	Mulch accumulation reduces available water storage and decreases infiltration rates. The top layer usually is the cause of clogging and entire rain gardens rarely need to be replaced.	
Watering	1 time every 2-3 days for first 1-2 months. As needed afterward	--	
Fertilization	1 time initially	One time spot fertilization	

Replace and remove dead plants	Annually	Within first year, 10% of plants may die. Survival rates increase with time	
Miscellaneous upkeep	1 time/month	Weeding, trash collection, clearing overflow structures, etc.	

References

Gulliver, J.S., Erickson, A.J., and P.T. Weiss, editors. 2009. Assessment and Maintenance of Stormwater Treatment Practices. University of Minnesota, Minneapolis, MN.

Hunt, W. F., and W.G. Lord. 2006. Urban Waterways: Bioretention Performance, Design, Construction, and Maintenance. North Carolina Cooperative Extension Service.

Kang, J.H., P.T. Weiss, C.B. Wilson and J.S. Gulliver, "Maintenance of Stormwater BMPs: Frequency, Effort and Cost," Stormwater, 9(8), pp. 18-28, November/December 2008.

Watershed Management Institute (WMI). 1997. Operation, Maintenance, and Management of Stormwater Management Systems. Prepared for: US EPA Office of Water, Washington, DC.

Weiss, P.T., A.J. Erickson and J.S. Gulliver. 2007. Cost and pollutant removal of storm-water treatment practices. Journal of Water Resources Planning and Management. 133(3):218-229.

7.3: Filtration Systems

Stormwater-filtering systems are a diverse group of techniques for treating the quality of stormwater runoff. The commonality is that each type utilizes some kind of filtering media, such as sand, soil, gravel, peat or compost, to filter pollutants from stormwater runoff. In addition, most filtering systems are typically used for small (five acres or less) drainage areas. The information in this section is based on the Center for Watershed Protection's "Design of Stormwater Filtering Systems" (Claytor *et al.,* 1996).

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Effectiveness

The effectiveness of filtration systems depends on the size of the system compared to the area draining to the system and the size of sediment in the stormwater runoff. Larger filtration practices will store more stormwater runoff and allow it to filter through the filter media. Also, larger sediment are captured more readily in filtration practices than finer sediment, although on average sand filters in the United States retain 82% of total suspended solids (TSS) (Weiss et al. 2005).

Design and Installation Considerations

Pretreatment is recommended for all filtration systems to capture coarse sediments. Without pretreatment, the filter will quickly clog, and lose its pollutant-removal capability. The most common technique of pretreatment is a wet or dry settling chamber.

Filtering systems use one or more forms of media, such as sand, gravel, peat, grass, soil or compost, to filter pollutants from stormwater. The selection of the right media is important, as each has different hydraulic, pollutant-removal and clogging characteristics. An example of an organic media filter can be found at: http://www.fhwa.dot.gov/environment/ultraurb/3fs9.htm. Filter media may also incorporate materials such as iron for phosphorus removal or activated carbon for organic materials.

The depth of most filtering systems ranges from 18 inches to 4 feet. Biofiltration systems are filtration systems that also use vegetation to capture pollutants; an example can be found at: http://www.fhwa.dot.gov/environment/ultraurb/uubmp3p9.htm.

Filtered runoff is typically collected in perforated pipes underneath the filter media which are connected to downstream storm sewer or receiving water bodies..

Maintenance Considerations

The material in this section is adapted from "Assessment and Maintenance of Stormwater Treatment Practices," published by the University of Minnesota (Gulliver et al., 2009) and contains information and details about assessment and maintenance of stormwater treatment practices.

Maintenance of filtration practices can range from trash removal to complete removal and replacement of the filter media and underlying system. Maintenance recommendations are given in Table 2. The primary failure mechanism for filtration practices is clogging due to buildup of sediment, litter, and debris (Kang, et al., 2008). Clogging can result in long periods of standing water, flooding of surrounding areas, bypassing of the filter by untreated stormwater, lack of measurable effluent, or any combination thereof. Like all stormwater treatment practices, filters need annual inspection and maintenance to ensure proper function and extend useable life.
If there is any indication that the filter is not draining or will not drain the design runoff volume within the required time (typically 48 hours), the following steps can be taken to address the problem, in increasing order of expense:

1. Inspect the outlet structures and underdrain system and remove any objects obstructing flow and replace or repair any damaged structural components.
2. Roto-till the top six inches of filter media to break up any consolidation.
3. Remove and replace the top four to six inches of filter media.
4. Remove and replace the entire media bed.

Maintenance recommendations include removing and replacing the top layer (4 – 6 inches) of filter media as often as once per year (Wossink and Hunt, 2003) but at least once every five years (Landphair et al., 2000), depending on watershed and filter size, land use, rainfall amounts and intensities. Annual maintenance costs for filtration practices can be significant, ranging from approximately 1% to 13% of the total construction cost per year (U.S. EPA, 1999; Weiss et al., 2007). Additional information on construction, maintenance, and total present cost is provided in Table 1. Most maintenance for filtration practices is minimal or simple and addresses buildup of sediment, litter, and debris.

- Organic Media Filters? http://www.fhwa.dot.gov/environment/ultraurb/3fs9.htm (filtration system section)
- Biofilters? http://www.fhwa.dot.gov/environment/ultraurb/uubmp3p9.htm (filtration)
(both pulled from the "alternative management/reuse" chapter)

Table 1: Quick Facts for filtering systems (adapted from Weiss et al., 2007)

Impervious Area (acres)	**1**	**2.5**	**5**
Estimated MN Construction Cost	$89,000	$154,000	$233,000
Estimated MN Annual Maintenance Cost	$801 - $8,455	$1,386 - $14,630	$2,097 - $22,135
Estimated Total Present Cost	$159,000	$275,000	$415,000
Estimated Total Suspended Solids Effectiveness (Annual lb reduction)	1,000	2,400	4,800
Estimated Land Required (acres)	< 0.03	< 0.075	< 0.15

NOTE: All cost data in 2009 dollars for Minnesota. Assumes WQV designed for two inches of runoff from impervious area, and 1.095 increase from 2005 to 2009 dollars (http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Table 2: Maintenance Recommendations

Action	Typical Frequency	Notes	Reference
Roto tilling surface	as needed	If infiltration rates are low, roto tilling may restore infiltration capacity	Landphair et al., (2000)
Remove & replace sediment layer	1-3 years	--	
Replace entire media bed	3-5 years	--	

References

Gulliver, J.S., Erickson, A.J., and P.T. Weiss, editors. 2009. Assessment and Maintenance of Stormwater Treatment Practices. University of Minnesota, Minneapolis, MN.

Kang, J.H., P.T. Weiss, C.B. Wilson and J.S. Gulliver, "Maintenance of Stormwater BMPs: Frequency, Effort and Cost," Stormwater, 9(8), pp. 18-28, November/December 2008.

Landphair, H.C. , McFalls, J.A., and D. Thompson. 2000. Design Methods, Selection, and Cost-Effectiveness of Stormwater Quality Structures. Texas Transportation Institute, Report 1837-1.

U.S. EPA. 1999. Preliminary data summary of urban stormwater best management practices. 821-R-99-012. U.S. Environmental Protection Agency. Washington, D.C. http://www.epa.gov/waterscience/guide/stormwater/

Weiss, P.T., A.J. Erickson and J.S. Gulliver. 2007. Cost and pollutant removal of storm-water treatment practices. Journal of Water Resources Planning and Management. 133 (3):218-229.

Wossink, A., and B. Hunt. 2003. The Economics of Structural Stormwater BMPs in North Carolina. University of North Carolina Water Resources Research Institute, Report 2003-344

7.4 Proprietary Structural Controls

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Proprietary Structural Controls are commercially available stormwater treatment systems designed to remove target pollutants from stormwater runoff. There are many types and configurations of these systems but they generally fall into one of the following categories:

- Hydrodynamic systems that utilize gravity or vortex separators
- Catch basin media inserts
- Filtration systems
- Chemical treatment systems
- Prefabricated Detention structures

Most proprietary stormwater treatment systems are best used at small facilities and areas where there is limited available land for other surface structural controls. In many ultra-urban setting a small underground proprietary device may be the only option. One of the biggest difficulties in selecting a proprietary treatment system is the lack of adequate independent performance data, particularly for use in Minnesota conditions. However the rise in popularity of these devices is spurring many studies across the country and better data is becoming available.

Hydrodynamic Systems (?)
Catch Basin Inserts (?)

Filtration Systems
Proprietary stormwater treatment devices which use a filter media may be of particular interest if a facility's sector requires monitoring for a particular pollutant. Manufactures of filter type stormwater treatment systems can supply different filter media which target different pollutants. Filter media can be selected to remove TSS, phosphorus, hydrocarbons, metals or other constituents.

Design and Installation Considerations
One limiting aspect of these systems that is common is the devices dependence on flow rate for performance. Nearly all of these systems require a stormwater bypass channel in order to function as claimed by the manufacture. For example, a filtration unit can only pass stormwater through the media at a particular rate. Devices that rely on gravity need to limit flow rates in order to allow sediments to settle out within the system. For this reason the performance of the systems will drop dramatically during high intensity rain events. Although the water traveling through the system will receive the desired treatment, once it combines with the untreated bypass water the overall removal rates will be lower.

Application within a New Facility
Any new facility being constructed that disturbs more than one acre of land will be required to apply for the construction stormwater permit and will be subject to the stormwater treatment requirements of than permit. In general, these types of devices will not satisfy the requirements as a stand alone device. The construction stormwater permit requires the use of a surface wet sedimentation basin or an infiltration system that will capture and hold a specific volume of water. These systems are preferred because there is no stormwater bypass. There are exceptions to this. Proprietary stormwater treatment devices can be used to serve new construction when;

- a site has physical limitations that preclude the installation of other systems
- used as pretreatment before discharging into another system (treatment train approach)
- the project is not creating more than one acre of new impervious surfaces (i.e. reconstruction)

It is possible that a proprietary treatment system will meet the requirements of the construction stormwater permit. For example, an underground detention chamber that will infiltrate stormwater through the bottom can meet the requirements if designed properly. Contact the Construction Stormwater Technical Assistance Unit if unsure if a certain system will meet the requirements. Contact information and additional information can be found on the construction stormwater web page.

Maintenance

The maintenance considerations for these devices are too varied to discuss in detail within this manual. Each manufacturer has recommended maintenance activities and schedules and they may need to be adjusted given each site's characteristics and use. In general maintenance is required more often than more traditional surface stormwater treatment systems but it is often a fairly simple task. For example, a filtration device may need the filter cartridge to be replaced often but it may be as simply as lifting it from a sump and replacing it with a new cartridge. Because these devices are often underground, it can be easy for maintenance activity to be overlooked. Because of the stormwater bypass channel previously discussed untreated runoff will continue to pass through the device unobstructed long after it has completely failed. It is very important that facilities have staff that are aware of the presence of these devices and are knowledgeable about the required maintenance.

Guidelines for selecting Proprietary Systems

Because there is limited data on the performance of these systems, selecting the proper type for a facility can be difficult. A proprietary system must have demonstrated the capability of meeting the stormwater management goals in which it was intended. This means the system must have independent third-party scientific verification of performance. Proven longevity of performance in the field is one of the best indications that it will perform at a Permittee's facility. Consideration of location should be given when investigating monitoring results. Information from the Midwest may be more accurate than information collected from an area with a different climate type.

Vendor Information:

The Stormwater Equipment Manufacturers Association (http://www.stormwaterassociation.com/) consists of organizations involved in the manufacture of stormwater quality solutions. Several of the vendors listed below are members of the Association. The listing of vendors of proprietary treatment control BMP systems does not constitute a complete list or recommendation/endorsement by the State of Minnesota. The list of vendors and their website addresses are provided for reference only:

- AquaShield, Inc. www.aquashieldinc.com
- BaySaver, Inc. www.BaySaver.com
- Bio Clean Environmental Services Inc™ www.biocleanenviornmental.net
- CDS Technologies, Inc www.cdstech.com
- United Stormwater, Inc www.unitedstormwater.com
- Enviro-Drain®, Inc www.enviro-drain.com
- P2 Filter www.p2filter.com
- KriStar Enterprises, Inc www.kristar.com
- Altech Technology Systems, Inc www.altech-group.com
- Interlocking Concrete Pavement Institute www.icpi.org

- Americast, Inc www.americastusa.com
- Jensen® Precast www.jensenprecast.com
- Practical Technology® www.practology.com
- Kistner Concrete Products, Inc www.env21.com
- Roberts Design, Inc www.stormdrains.com
- Stormceptor ® Corporation www.stormceptor.com
- Stormwater Management, Inc www.stormwaterinc.com
- StormTreat Systems, Inc www.stormtreat.com
- Stormwater Management Products™ www.stormwater-products.com
- Stormwater Systems ® www.stormfilters.com
- The Sea Life Saver™ www.sealifesaver.com
- Abtech Industries, Inc www.abtechindustries.com
- Vortechnics, Inc www.vortechnics.com
- Hydro International, Inc. www.hydro-international.biz
- Contech www.contech-cpi.com

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http://www.dauphincd.org/swm/BMPfactsheets/Inlet%20Protection%20fact%20sheet.pdf

7.5: Mechanical treatment systems

Mechanical treatment systems include many manufactured devices such as grit chamber oil grit separators, swirl separators and numerous other devices. Most systems include an enlarged chamber designed to settle out grit (sand, gravel and silt) in order to clean some of the stormwater before it drains into lakes and streams. A mechanical treatment system with an oil removal mechanism, such as a skimmer, is often called an “oil grit separator.” Mechanical treatment systems are often made out of large box culverts or enlarged pipes. Some are small tanks with innovative swirl, filter or plate removal mechanisms.

These devices are often buried underground or otherwise located so that the stormwater will drain through them on its way to lakes and streams. Because of the size of the chamber, the water slows as it passes through and the grit settles out. The grit collects in the bottom of the chamber and a maintenance crew periodically cleans it out. With oil separators, skimmers and other oil-removal devices may be used to remove the oil separately from the sediments.

Effectiveness

Mechanical treatment systems are effective, but they have to be cleaned regularly. Full grit chambers are ineffective. Mechanical treatment systems typically have to be cleaned every one to six months. Storm sewer maintenance crews should keep track of how much material they remove from each of the chambers so they know how often to clean them. Sediment build-up and dredging destroy and disrupt to the natural habitat of the animal and plant species in the waterway.

Removed grit should be handled in accordance with applicable MPCA requirements.
The material is often contaminated well beyond levels associated with the raw stormwater itself with a

wide array of inorganic and organic pollutants. Disposal without proper precautions would not be recommended regardless of the source of the residue.

Grit chambers are relatively expensive and are usually used where the cost of land would be prohibitive or where the resources are sensitive or valuable.

Chapter 8: Information about cold climate & extreme weather, related to BMPs

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Due to Minnesota's extremely variable climate, Permittees with outside operations have to manage facility conditions and stormwater runoff over the spectrum of weather conditions, ranging from hot summer droughts (dry durations and intensities) to intense spring/summer/fall storms (storm intensities and durations) and to extreme cold-climate conditions. The dry intensities and durations may suggest consideration of:

1. periodic sweeping/cleaning operations of impervious surface to avoid build-up of contaminants
2. capture/storage and reuse options

Higher storm intensities may speak to the need for volume and rate controls (such as slowing stormwater down and treating it onsite). Higher intensity storms with corresponding increases in runoff volumes can also be increase flooding potential from both up-gradient run-on and backwater effects of downstream areas. Multiple winter snow accumulations are also subject to more winter thaws (usually two or more days greater than 32 degrees Fahrenheit), hence the need for avoiding contaminating snow/ice in outdoor storage areas. Facility operators need to consider the effects of variable weather from flooding to drought, and blizzards to tornadoes, when planning site management and stormwater BMPs.

8.1: Winter Considerations

There are a variety of onsite management considerations potentially of consequence during winter/ice periods. For additional cold climate runoff management, see Chapter 9 of the Minnesota Stormwater Manual. Ice and snow accumulations can mask pollutant loss/build up periods in outdoor handing areas. Safe storage techniques and periodic checks of outdoor storage and handling operations are suggested. Up-gradient snow storage areas may also influence winter thaw runoff volumes and flow patterns.

Weather

Knowing existing and potential weather conditions is very important for a successful snow and ice control operation. Monitor the weather closely in order to be prepared to act early in storm situations. Check the National Weather Service (website http://www.noaa.gov) local TV station, or website weather.

Drainage

Take time to inspect drainage ways and, remove obstructions to prepare for the spring melt. Never open frozen storm drains with high doses of salt. This is toxic to aquatic life in the receiving waters. Use other methods such as heat to open drains. Look for ways to capture any solids before they enter the storm drain system. Make sure parking lots do not drain through salt storage areas.

Storage

Storage areas often cause groundwater or surface water contamination. Store snow piles in an area where solids can be recovered after the snow melts. Locate snow down-slope from salt and sand storage. Prevent snow melt from flowing through salt or sand storage area. Avoid pushing snow into lakes, ponds, wetlands, rivers or other natural areas. This will increase the amount of solids that can be

recovered after the melt. Windrows of snow can be used to guide motorists in parking when they cannot see the parking lines. Store salt piles where it is protected from rain, snow and melt water. Store on an impervious surface. Cover all piles, ideally indoors. Sweep loading areas back into the pile to reduce leaching. Contoured pads (bowl-like) for pretreated salts, reduces runoff from the pile. Store away from lakes, rivers, ditches, storm drains and wetland edges. Store salt bags away from rain or snow. Dispose of bags properly. Seal open bags. Winter sand is typically mixed with some deicer to prevent freeze-up of the pile. Therefore, sand pile storage should be the same as salt pile storage. Do not use leftover winter sand for other uses. Save it under cover for the next season. Cover salt and salt/sand piles and place them on an impervious pad to limit runoff and infiltration of chlorides.
A common mistake is storing a snow pile uphill of a salt pile.

Sidewalk Tips
Always remove snow prior to applying deicers. If plowing first, the chances of refreeze diminish and slush build-up is minimized. Sidewalks are often the most over-salted of all areas in winter maintenance. Sidewalks are the area of highest tracking into the building. Extra salt and sand contribute to slippery entryways inside the building. Use drop spreaders, not rotary spreaders, for sidewalks. If using a rotary spreader, adjust the opening to limit dispersion of deicers to the sidewalk or install shields to restrict the spread pattern. This minimizes application rates and protects the vegetation. Many slip and fall incidents occur within ten feet of the curb lines. Adjust practices to include proactive measures like anti-icing. If the Permittee is not responsible for sidewalk maintenance, consider providing this information to the building occupants to educate them on these best practices for winter maintenance. Look for opportunities to close extra entrances during the winter to reduce the need to use chemicals on all sidewalks and steps. Focus on aggressive mechanical removal of snow. The less snow, the less deicer required. This will lend to a safer walking surface.

Parking Lot Tips
Sand/salt mix isn't advised however it may help in freezing rain situations. Always plow before applying chemical. Permittees may be able to use a lower rate in high traffic areas. Traffic tends to help mix and melt. Store snow downhill from any salt storage areas. Avoid water running through salt storage.

Anti-icing
Anti-icing—a proactive approach—should be first in a series of strategies for each winter storm. By applying a small and strategic amount of liquid or pre-wet deicer before a storm, it helps to prevent snow and ice from bonding to the pavement. Anti-icing requires about ¼ the material and 1/10 the overall cost of deicing. It can increase safety at the lowest cost, and is effective and cost-efficient when correctly used and approached with realistic expectations. Anti-icing prevents formation of ice from frost. It can be effective for up to several days depending on the weather conditions.

http://www.pca.state.mn.us/publications/parkinglotmanual.pdf

8.2: Planning for Extreme Events
An extreme event is one that occurs on a rare interval. This is not easily defined and it depends on the situation and condition of the facility. An extreme event can be a one year storm (e.g. 2.2 to 2.4 inches in the metro area) to a 100 year storm (e.g. 6 inches in the metro area). It is recommended to consider

being prepared to have a ten year storm without significant property damage, and be prepared for a 100 year storm event where life threatening health and safety are concerned. But extreme events can also be extreme drought or many days in a row of normal rain (cumulative rainfall effects from erosion or flooding). Dried out (drying out of ponds) or saturated soils (on steep slopes) may behave quite differently than normal soils. When unusual events occur Permittees should inspect their facility to see if there are adverse effects and be ready to address any problems.

Planning for extreme events includes routing surface and roof drainage such that interactions with significant materials or stockpiles is eliminated or minimized. Roof drainage during extreme events can quickly become significant and poorly routed roof drainage can quickly wash off significant materials and stockpiles into downstream receiving waters. Surface and roof drainage can also exceed the conveyance capacity of storm sewer systems during extreme events, which can result in flooding and flow of runoff through unforeseen pathways. Flooding and flow through unforeseen pathways can also interact with significant materials and result in contaminated stormwater runoff that may not pass through onsite stormwater BMPs before discharging to receiving waters. Careful site planning and inspection are required to eliminate or minimize these effects during extreme events.

8.3: Structural Design and Construction of BMPs

Any embankment, principal spillway or emergency spillway constructed in conjunction with a detention basin should meet the criteria of accepted engineering manuals such as NRCS Standard 378, Ponds, (NRCS, February 1995). Wherever applicable, MDNR Dam safety program requirements and local flood control ordinances must be complied with.

8.4: Dam Safety Requirements (how is this connected to ISW?)

In accordance with state rules, a permit from the Minnesota Department of Natural Resources (MDNR) is required for the construction of any dam or artificial barrier that is over 6 feet high and has a maximum storage capacity over 15 acre feet. The height is measured from the top of the dike or overflow (not the spillway structure) to the downstream toe (?) of the dike. Structures up to 25 feet high and with a storage capacity up to 50 acre-feet (2,178,000 cubic feet) may be exempt from the DNR dam safety permit requirement if it is demonstrated that there is no potential for loss of life due to failure or faulty operation.

8.5: Emergency Spillways

Larger structures may require a dam safety permit, but all structures should be designed with safety in mind since they can create downstream hazards because of the impounded water. This is especially important in a densely populated urban area.

An emergency spillway is needed for all temporary and permanent stormwater control basins for ponds and infiltration basins. At a minimum, the emergency spillway capacity should meet the requirements in accepted engineering design manuals. Emergency spillways can be pipes or culverts but often are vegetated channels which can have a bottom width of 10 feet or more and a level section of 30 feet or more. Emergency spillways channels should be excavated in undisturbed soil rather than fill material. Use accepted engineering practices to determine the appropriate spillway width and depth of flow. After determining the depth of flow, the freeboard must be added to determine the elevation of the top of dam. Freeboard is the difference in elevation between the water surface in the spillway during the passage of the emergency-spillway-design storm and the top of settled fill. The minimum freeboard should be at least 1 foot. (? don't understand any of this, especially in context of ISW) **(can we combine 8.3-8.5 together? Lou and Andy discuss)**

8.6: Local Controls

In many areas, flood control is subject to regulation of the local watershed district or water-management organization. Local needs for flood control can vary widely, depending upon drainage conditions. In many cases detention at the lowest point of facilities are most effective for overall flood control and is also the most economical form of detention for stormwater treatment. To minimize the amount of unprotected area, the drainage area of some facilities can be quite large. Larger structures may require a dam safety permit, but all structures should be designed with safety in mind since they can create downstream hazards because of the impounded water. This is especially important in a densely populated urban area.

8.7: Local Criteria for two-year through 100-year precipitation events

Many watersheds require that post development runoff must equal the 10- and 100-year, 24-hour predevelopment events. In addition, low floor elevations (?) of structures are typically required to be at least 0.5 to 3.0 feet above the 100-year flood elevation. These rates and elevations may need to be considered in the design of the system. (?)

8.8: Monitoring

Monitoring during extreme events is not recommended. Safety is the first consideration, and monitoring should not be conducted if there is any question about safety of the personnel or the equipment. Be prepared with proper equipment and safety devices but also have clear instructions about when monitoring should be postponed. For more information about safety during stormwater monitoring, see the MPCA's Stormwater Manual.

8.8: Inspections and Maintenance

Inspections should be conducted after each extreme event. Check washing away of materials and equipment, erosion of channels, and undercutting of dams, dikes, or structures. Notify the MN Duty Officer regarding any significant materials that have discharged off of the facility boundary. Be prepared to do preventative maintenance on the significant structures such as dams and dikes and erosion of channels, immediately. Flooded basements, equipment rooms and "significant materials" storage areas may be a major concern at some facilities. Address other problems which may be considered to be less significant or that can be adequately addressed by interim measures, on a final schedule created, in an appropriate time frame. The maintenance schedule must be kept with the SWPPP and should explain the decision making process.

Appendix A: Technical information for structural BMPs

Appendix A for Chapter 7: Cost and Effectiveness of Stormwater Treatment Practices
The material in this appendix is adapted from "Cost and Pollutant Removal of Stormwater Treatment Practices," (Weiss et al., 2007) and "The Cost and Effectiveness of Stormwater Management Practices," (Weiss et al., 2005). For more information and details please refer to these documents.

Introduction
This appendix explains a cost comparison tool and an effectiveness comparison tool for common stormwater Best Management Practices (BMPs). The method is based on published, reliable information of construction cost, annual maintenance cost, and capture of TSS and total P for six existing stormwater BMP types. It is assumed that all stormwater BMPs receive regular and sufficient maintenance such that they perform as designed.

Cost estimation
Costs were adjusted to year 2005 dollars; relative comparisons between practices are independent of the year in which the proposed stormwater BMP will be constructed. To estimate actual costs, however, cost data should be adjusted to the year in which the proposed STORMWATER BMP will be constructed using an appropriate adjustment factor (e.g., http://oregonstate.edu/cla/polisci/faculty-research/sahr/infcf17742008.pdf).

Total Construction Costs
Values of total construction costs of stormwater BMPs throughout the United States were collected from published literature. Although data were collected on many stormwater BMPs, sufficient data to perform a cost analysis could be found for only dry extended detention basins, wet/retention basins, constructed wetlands, infiltration trenches, bioretention filters, and sand filters. By means of "regional cost adjustment factors" as reported by the United States Environmental Protection Agency, all data were adjusted to reflect costs in Rainfall Zone 1 of the United States (USEPA, 1999). Rainfall Zone 1 covers the northeast and north-central United States and includes Maine, New Jersey, Pennsylvania, Michigan, Wisconsin, Iowa, Minnesota, and the northern portions of Indiana, Illinois, and Ohio.
The unit construction cost (EPA Rainfall Zone 1, 2005 dollars) as a function of design water quality volume (m^3) for six stormwater BMP types is shown in Figure 1. The unit construction cost is defined as the total construction cost per cubic meter of water quality volume (WQV). The water quality volume is a design parameter typically defined as the runoff volume which a stormwater BMP is designed to capture and treatment before overflow occurs. Also shown in Figure 1 is the dashed, best-fit line representing the average (or mean) of the data and the solid lines representing the 67% confidence interval of the mean. Assuming a normal probability distribution of uncertainty about the mean, 2/3 of the data will be within the 67% confidence interval of the data shown in Figure 1. This uncertainty observed for all stormwater BMPs is most likely due to several factors such as design parameters, regulation requirements, soil conditions, site specifics, etc. For example, variable design parameters that would affect the total construction cost include pond side slopes, depth and free board on ponds, total wet pond volume, outlet structures, and retaining walls, among others. Site-specific variables include clearing and grubbing costs, fencing around the stormwater BMP, among others. It is therefore important to consider the confidence intervals shown in Figure 1 when estimating construction costs.

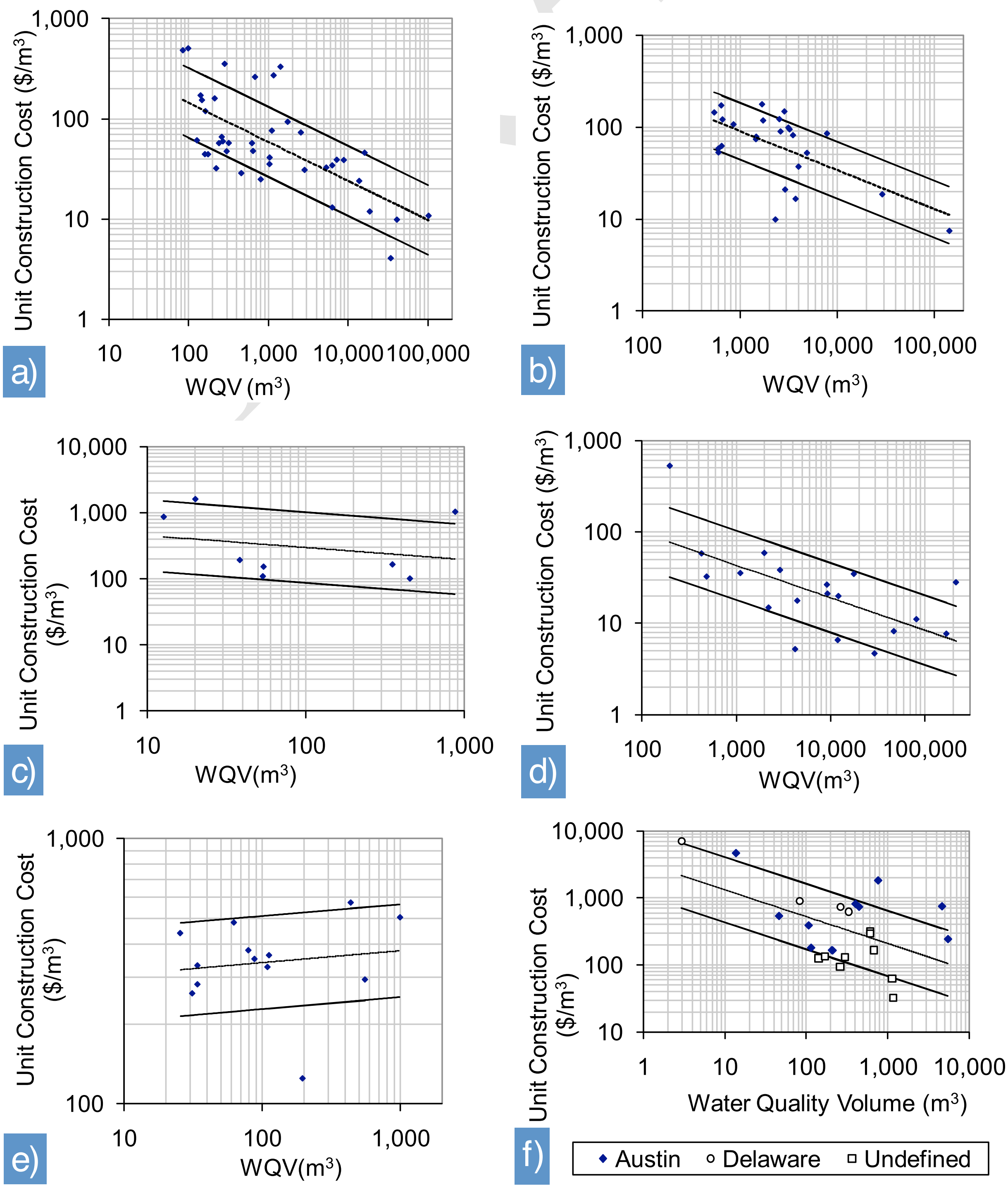

Figure 1: Unit construction costs ($/m³ of WQV) as a function of water quality volume in 2005 EPA rainfall zone 1 dollars (Weiss et al., 2005, 2007). (a) dry ponds, (b) wet ponds, (c) infiltration trenches, (d) constructed wetlands, (e) bioretention, and (f) sand filters. Land costs are not included.

For a given WQV (typically determined from historical rainfall amounts, contributing watershed characteristics, and regulatory requirements), Figure 1 can be used to estimate the unit construction cost. For example, with a WQV of 1,000 m^3, the average unit construction cost from Figure 1 is approximately \$60/m^3 for dry ponds, \$90/m^3 for wet ponds, \$200/m^3 for infiltration trenches, \$40/m^3 for wetlands, \$440/m^3 for bioretention, and \$200/m^3 for sand filters. It is important to consider the uncertainty in these values, as represented by the solid confidence interval lines shown in Figure 1. For a given WQV of 1,000 m^3, the average unit construction cost from Figure 1 is approximately \$60/m^3 for dry ponds but varies from \$25/m^3 to \$150/m^3 within the 67% confidence interval. Similarly, the 67% confidence interval of unit construction costs for a WQV of 1,000 m^3 is \$45/m^3 to \$200/m^3 for wet ponds, \$60/m^3 to \$600/m^3 for infiltration trenches, \$20/m^3 to \$100/m^3 for wetlands, \$250/m^3 to \$600/m^3 for bioretention, and \$70/m^3 to \$700/m^3 for sand filters.

The total construction cost can then be estimated as the product of the unit construction cost and the WQV (e.g., average = \$60/m^3 for dry ponds X 1,000 m^3 = \$60,000). Again, it is important to consider the uncertainty of the average cost by computing the range of total construction cost (e.g., 67% confidence interval = \$25/m^3 to \$150/m^3 for dry ponds X 1,000 m^3 = \$25,000 to \$150,000).

With the exception of bioretention practices, all stormwater BMPs exhibit an 'economy of scale' such that practices designed to capture larger volumes of water is cheaper, per volume, than smaller practices. For example, the average construction cost of a dry pond that will treat a WQV of 300 m^3 is approximately \$100/ m^3, but the cost of a dry pond that will capture a WQV of 3,000 m^3 is approximately \$40/ m^3 (Figure 1a). In this example, the dry pond treats ten times as much water (300 m^3 vs. 3,000 m^3), but only costs four times as much (\$30,000 vs. \$120, 000).

Of the data collected for sand filters, some contained information on the type of sand filter (e.g., Austin or Delaware) while other data included no such description. The data suggest that sand filter unit construction costs are independent of the type of filter, and therefore the average and confidence interval calculations are computed for all available data as shown in Figure 1f.

Land Area Requirements

Land area requirements and the associated land costs can vary dramatically for each stormwater BMP. In many cases, land costs can be approximately the same as construction costs for some stormwater BMPs which will have a significant impact on the total cost of a project. Because land costs vary significantly within a small area and therefore land costs must be estimated on a facility-by-facility basis. Typical stormwater BMP land area requirements are presented in Table 1.

Table 1: Reported Best Management Practices Land Area Requirements for Effective Treatment.

Best Management Practices	Land Area Requirement (% of impervious watershed) (USEPA, 1999)	Land Area Requirement (% of watershed) (Claytor and Schueler, 1996)
Bioretention	5	-
Wetland	3 – 5	3 – 5
Wet ponds (retention basins)	2 – 3	2 – 3
Sand filter	0 – 3	2 – 7
Infiltration trench	2 – 3	-
Filter Strips	100	-
Swales	10 – 20	-
Infiltration (basin)	-	2 – 3

Maintenance Cost

Over the lifetime of a stormwater BMP the cost of maintenance can be a significant expense that must be considered during selection. Expected annual maintenance cost is shown in Table 2 and estimated annual maintenance cost for typical maintenance schedules for all stormwater BMPs except infiltration trenches is shown in Figure 2. Similar to Figure 1, the dashed, best-fit line representing the average (or mean) of the data and the solid lines representing the 67% confidence interval of the mean are also shown.

Table 2: Typical Annual Maintenance Cost of Best Management Practices.

Best Management Practices	Summary of typical annual maintenance costs (% of construction cost) (USEPA, 1999)	Collected cost data: estimated annual maintenance costs (% of construction cost) (Weiss, et al., 2005, 2007)
Wet ponds (retention basins)	3 – 6%	1.9 – 10.2%
Dry ponds (detention basins)	<1%	1.8 – 2.7%
Constructed wetlands	2%	4 – 14.1%
Infiltration trench	5 – 20%	5.1 – 126%
Infiltration basin	1 – 3%, 5 – 10%	2.8 – 4.9%
Sand filters	11 – 13%	0.9 – 9.5%
Swales	5 – 7%	4.0 – 178%
Bioretention	5 – 7%	0.7 – 10.9%
Filter strips	$320/acre (maintained)	-

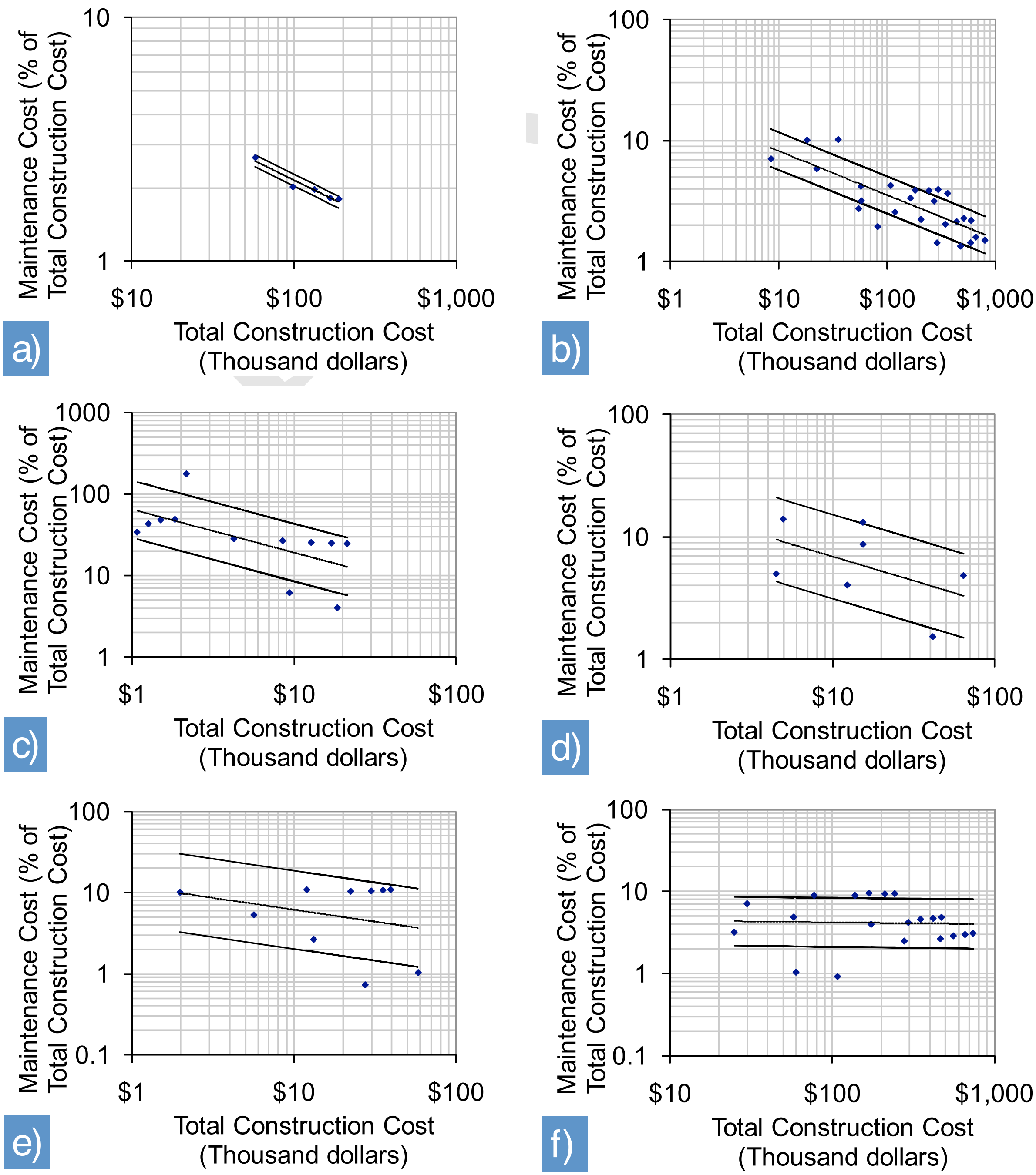

Figure 2: Maintenance cost (percent of total construction cost) as a function of total construction cost in 2005 EPA rainfall zone 1 dollars (Weiss et al., 2005, 2007). (a) dry ponds, (b) wet ponds, (c) swales, (d) constructed wetlands, (e) bioretention, and (f) sand filters.

Total Present Cost

Total present cost is defined as the present worth of a project including the total construction cost (not including land acquisition costs) and the present worth of 20 years of annual maintenance. The values reported do not include costs of pretreatment units (which may be required), design or engineering fees, permit fees, land costs, contingencies, etc. Annual maintenance costs are converted to an equivalent present cost using the time value of money and historical values of interest and inflation rates (Collier and Ledbetter, 1988). Total present cost (with 67% confidence interval), excluding land costs, of each stormwater BMP can be described (fit) with an equation:

$$TPC = \beta_0 (WQV)^{\beta_1} \quad \text{equation (1)}$$

where: TPC = total present cost (2005 U.S. Rainfall Zone 1 dollars), land costs not included; WQV = water quality volume (m3); and β_0 and β_1 are constants.

For each stormwater BMP the values of β_0 and β_1 for the average TPC, the values of β_0 and β_1 for the upper and lower 67% confidence intervals, and the range of WQV for which data are given in Table 3. A comparison of the average total present cost for six stormwater BMPs is shown in Figure 3.

Table 3: Constants for Total Present Cost (TPC) equation and valid WQV range.

Best Management Practice	Average total present cost		Upper 67% confidence interval		Lower 67% confidence interval		Water quality volume range (m^3)
	β_0	β_1	β_0	β_1	β_0	β_1	
Dry ponds	1,281	0.634	2,024	0.671	1,055	0.585	85 – 101,000
Wet ponds	4,398	0.512	6,119	0.536	3,592	0.484	410 – 215,000
Sand filters	6,153	0.594	13,618	0.596	3,495	0.592	3 – 5,500
Bioretention practices	1,542	0.776	3,838	0.723	897	0.802	26 – 990
Constructed wetlands	1,515	0.565	2,579	0.585	1,076	0.537	200 – 215,000
Infiltration trenches	2,237	0.817	4,039	0.817	1,418	0.817	13 – 870

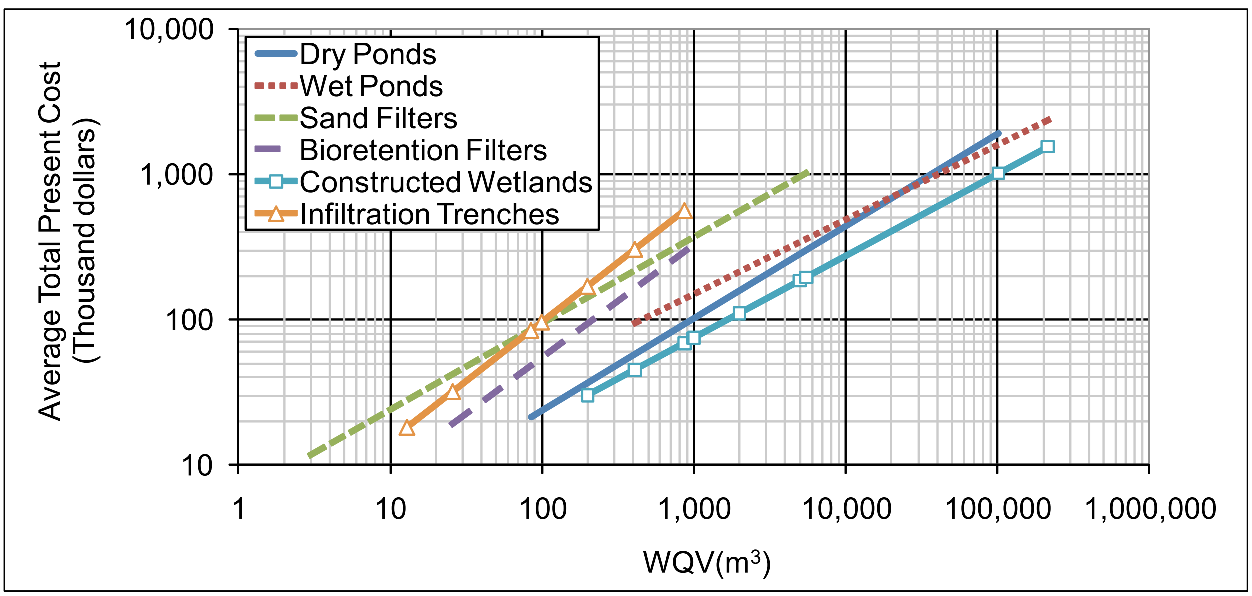

Figure 3: Average total present cost (2005 EPA rainfall zone 1 dollars) of six best management practices as a function of water quality volume (m^3) (Weiss et al., 2005, 2007).

Pollutant Removal Effectiveness

The pollutant removal effectiveness of six stormwater BMP types is summarized in Table 4 (Weiss et al., 2007). In addition to these removal rates, a method has been developed to estimate the load of total suspended solids (TSS) captured by six stormwater BMP types over a 20-year span as a function of water quality volume. To estimate the load captured, multiple the WQV of the chosen stormwater

BMP by the load factors provided in Table 5 (lower confidence interval, average, and upper confidence interval) for the stormwater BMP type (e.g., dry ponds).

Table 4: Average Percent Removal Rates of Best Management Practice with Corresponding Confidence Interval.

Best Management Practices	Total Suspended Solids Removal (%)	67% Confidence Interval
Dry pond	53	+/- 28
Wet pond	65	+/- 32
Constructed wetlands	68	+/- 25
Bioretention practice	85*	+/- 10*
Sand filter	82	+/- 14
Infiltration trench	95*	+/- 5*

* = Assumed Value

Table 5: Load Factors for Total Suspended Solids Removal as a Function of Water Quality Volume.

Best Management Practice	Load Factors (kg/WQV)		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	9.55	27.49	45.43
Wet ponds	12.73	33.67	54.61
Sand filters	24.85	42.4	59.96
Bioretention practices	26.78	44.19	61.59
Constructed wetlands	16.79	35.27	53.74
Infiltration trenches	30.64	49.39	68.13

Example Application #1

Several stormwater BMPs are being considered to treat runoff from a facility on a five acre facility with approximately 100% impervious in the Minneapolis/St. Paul metropolitan area. The chosen stormwater BMP will be designed to capture all runoff from a rainfall depth of 3.7 cm. Comparison of different stormwater BMP options can be made using the previously discussed tools by following these steps:

1. Determine the water quality volume (WQV). One method to estimate the WQV is by the following equation:

   WQV (m^3) = 100*precipitation depth (cm)*(0.05+0.009*(percent impervious))*watershed area
   For this example, the water quality volume:
   WQV (m^3) = 100*(3.7 cm)*(0.05+0.009*(100% Impervious))*(5 acres ÷ 2.471 acre/hectare)
   WQV (m^3) = 720 m^3 (approximately)

2. Using the equation constants from Table 3, the average total present cost can be estimated for a dry pond:

   $TPC_{average} = \beta_0(WQV)^{\beta_1} = (1,281)*(710)^{(0.634)}$ = $83,000 (approximately)

Similarly, the upper and lower confidence intervals can be estimated:
$TPC_{lower} = \beta_0(WQV)^{\beta_1} = (1{,}055)*(710)^{(0.585)} = \$49{,}500$ (approximately)
$TPC_{upper} = \beta_0(WQV)^{\beta_1} = (2{,}024)*(710)^{(0.671)} = \$167{,}300$ (approximately)
Similarly, the average +/- 67% confidence interval total present cost for the five other stormwater BMPs can be calculated:

Best Management Practice	Total Present Cost (2005 EPA Rainfall Zone 1 dollars)		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	$49,500	$83,000	$167,300
Wet ponds	$86,800	$127,700	$208,100
Sand filters	$171,800	$306,400	$687,200
Bioretention practices	$175,500	$254,300	$446,600
Constructed wetlands	$36,800	$62,300	$121,100
Infiltration trenches	$306,300	$483,200	$872,400

3. Using the percentages from Table 1 and a local property value, the cost of land used by the stormwater BMP can be estimated. Minimal land costs can be estimated using the smallest percentages from Table 1 and a lower ($20,000 per acre) assumed land value. Conservatively large land costs can be estimated using the largest percentages from Table 1 and a larger ($200,000 per acre) assumed land value:

Best Management Practice	Approximate Cost of land lost to stormwater BMP ($)	
	Lower ($20,000 per acre, Minimum Table 1 values)	Upper ($200,000 per acre, Maximum Table 1 values)
Dry ponds	$2,000*	$50,000*
Wet ponds	$2,000	$30,000
Sand filters	$2,000	$70,000
Bioretention practices	$2,000	$50,000
Constructed wetlands	$3,000	$50,000
Infiltration trenches	$2,000	$30,000

* = Assumed between 2% and 5% of impervious watershed for dry ponds.

4. Using the load factors from Table 5, the total TSS load captured by a dry pond over a 20-year span can be estimated:

$\text{Total Load}_{average}$ (kg) = Load factor X WQV
$\text{Total Load}_{average}$ (kg) = (27.49 kg/WQV) X (720 m^3) = 19,800 kg (approximately)
Similarly, the upper and lower confidence intervals can be estimated:
$\text{Total Load}_{lower}$ (kg) = (9.55 kg/WQV) X (720 m^3) = 6,900 kg (approximately)

Total $Load_{upper}$ (kg) = (45.43 kg/WQV) X (720 m^3) = 32,700 kg (approximately)
Similarly, the average +/- 67% confidence interval total captured load for 20 years for the five other stormwater BMPs can be calculated:

Best Management Practice	Total TSS Load Captured over 20-years (kg)		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	6,900	19,800	32,700
Wet ponds	9,200	24,200	39,300
Sand filters	17,900	30,500	43,200
Bioretention practices	19,300	31,800	44,300
Constructed wetlands	12,100	25,400	38,700
Infiltration trenches	22,100	35,600	49,100

5. Choose the best option. From the data calculated in steps 2, 3, and 4 the best option can be determined:

    - From total present cost (step 2), the three best (least expensive) choices are constructed wetlands, dry ponds, and wet ponds, respectively.

    - From land costs (step 3), the four best (least expensive) choices are wet ponds, infiltration trenches, dry ponds, and bioretention practices, respectively, due to a tie. Note that land costs for this example are small compared to total present costs and similar among all practices; therefore land costs may be disregarded as a comparison criteria.

    - From total TSS load capture (step 4), the three best (greatest load) choices are infiltration trenches, bioretention practices, and sand filters.

6. **(Optional)** Because none of the best choices for cost coincide with the best choices for total load capture, another comparison criterion may be helpful in choosing the best option. One such criterion is the ratio of total TSS load captured to total cost. To estimate this value, divide the total TSS load captured by the sum of the total present cost and the total land cost. For example, the dry pond will capture approx. 19,800 kg of TSS over 20 years and will cost approx. $83,000 + $50,000 (land costs, worst case), which is $133,000. Therefore the ratio is 19,800 kg / $133,000 = 0.149 kg per dollar. Similarly, the ratio for the other five stormwater BMPs is:

Best Management Practice	Total TSS Load Captured (kg) per dollar spent		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	0.069	0.149	0.150
Wet ponds	0.079	0.153	0.165

Sand filters	0.074	0.081	0.057
Bioretention practices	0.086	0.105	0.089
Constructed wetlands	0.139	0.226	0.226
Infiltration trenches	0.066	0.069	0.054

It is apparent that the most efficient stormwater BMP will capture the greatest TSS load at the least expense, and therefore will have the largest ratio of TSS load captured per dollar spent. Using this criterion, the three best (largest ratio) choices are constructed wetlands, wet ponds, and dry ponds, respectively.

Example Application #2

Several stormwater BMPs are being considered to treat runoff from a facility on a twenty acre facility with approximately 100% impervious in the Minneapolis/St. Paul metropolitan area. The chosen stormwater BMP will be designed to capture all runoff from a rainfall depth of 3.7 cm. Comparison of different stormwater BMP options can be made using the previously discussed tools by following these steps:

1. Determine the water quality volume (WQV). Similar to the previous example:

   WQV (m^3) = 100*(3.7 cm)*(0.05+0.009*(100% Impervious))*(20 acres ÷ 2.471 acre/hectare)
   WQV (m^3) = 2,850 m^3 (approximately)
2. Using the equation constants from Table 3, the average total present cost can be estimated:

Best Management Practice	Total Present Cost (2005 EPA Rainfall Zone 1 dollars)		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	$110,700	$198,600	$421,100
Wet ponds	$168,800	$258,300	$435,000
Sand filters	$387,900	$693,800	$1,560,000
Bioretention practices	WQV TOO LARGE		
Constructed wetlands	$77,100	$135,600	$270,700
Infiltration trenches	WQV TOO LARGE		

   Note that the water quality volume for this site is greater than the applicable range for bioretention practices and infiltration trenches, as shown in Table 3. Therefore it is not appropriate to estimate the total present cost of these practices using the values from Table 3. These practices may, however, be the more cost-effective than other options and should not be excluded from the selection process. More information is needed to determine if these practices are the best choice for facilities.

3. Using the percentages from Table 1 and similar assumptions as the previous example, the cost of land used by the stormwater BMP can be estimated:

	Approximate Cost of land lost to stormwater BMP ($)

Best Management Practice	Lower ($20,000 per acre, Minimum Table 1 values)	Upper ($200,000 per acre, Maximum Table 1 values)
Dry ponds	$8,000*	$200,000*
Wet ponds	$8,000	$120,000
Sand filters	$8,000	$280,000
Bioretention practices	$8,000	$200,000
Constructed wetlands	$12,000	$200,000
Infiltration trenches	$8,000	$120,000

* = Assumed between 2% and 5% of impervious watershed for dry ponds.

4. Using the load factors from Table 5, the total TSS load captured by a dry pond over a 20-year span can be estimated:

Best Management Practice	Total TSS Load Captured over 20-years (kg)		
	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	27,200	78,300	129,500
Wet ponds	36,300	96,000	155,600
Sand filters	70,800	120,800	170,900
Bioretention practices	76,300	125,900	175,500
Constructed wetlands	47,900	100,500	153,200
Infiltration trenches	87,300	140,800	194,200

5. Choose the best option. From the data calculated in steps 2, 3, and 4 the best option can be determined:

   - From total present cost (step 2), the three best (least expensive) choices are constructed wetlands, dry ponds, and wet ponds, respectively.
   - From land costs (step 3), the four best (least expensive) choices are wet ponds, infiltration trenches, dry ponds, and bioretention practices, respectively, due to a tie.
   - From total TSS load capture (step 4), the three best (greatest load) choices are infiltration trenches, bioretention practices, and sand filters.

6. **(Optional)** Because none of the best choices for cost coincide with the best choices for total load capture, another comparison criterion may be helpful in choosing the best option. Similar to the previous example, one such criterion is the ratio of total TSS load captured to total cost:

	Total TSS Load Captured (kg) per dollar spent

Best Management Practice	Lower 67% Confidence Interval	Average	Upper 67% Confidence Interval
Dry ponds	0.088	0.196	0.209
Wet ponds	0.126	0.254	0.280
Sand filters	0.106	0.124	0.093
Bioretention practices	WQV TOO LARGE		
Constructed wetlands	0.173	0.299	0.325
Infiltration trenches	WQV TOO LARGE		

It is apparent that the most efficient stormwater BMP will capture the greatest TSS load at the least expense, and therefore will have the largest ratio of TSS load captured per dollar spent. Using this criterion, the best (greatest ratio) choices are constructed wetlands, wet ponds, and dry ponds, respectively.

Acknowledgements

The material in this appendix is adapted from “Cost and Pollutant Removal of Stormwater Treatment Practices,” (Weiss et al., 2007) and “The Cost and Effectiveness of Stormwater Management Practices,” (Weiss et al., 2005). For more information and details please refer to these documents.

References

Claytor, R. A., and Schueler, T. R. 1996. “Design of stormwater filtering systems.” Center for Watershed Protection, Silver Spring, Md.

U.S. Environmental Protection Agency (USEPA). 1999. “Preliminary data summary of urban stormwater best management practices.” EPA-821-R-99-012, Washington, D.C.

Weiss, P.T., A.J. Erickson and J.S. Gulliver. 2007. “Cost and pollutant removal of stormwater treatment practices.” Journal of Water Resources Planning and Management. 133(3):218-229.

Weiss, P. T., J. S. Gulliver, and A. J. Erickson. 2005. “The Cost and Effectiveness of Stormwater Management Practices.” Project Report No. Mn/DOT 2005-23, St. Anthony Falls Laboratory #470., University of Minnesota, Minneapolis, MN. http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1023.

Appendix B: Acronyms and Definitions

B1: Acronyms

- BMP: Best Management Practice
- TSS: Total Suspended Solids

B2: Definitions

“Best Management Practices” or “BMPs” means practices to prevent or reduce the pollution of waters of the state, including schedules of activities, prohibitions of practices, and other management practices, and also includes treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge, or waste disposal or drainage from raw material storage (Minn. R. 7001.1020, subp.5).

Industrial activities

Significant Materials includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA); fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have the potential to be released with stormwater discharges. When determining whether a material is significant, the physical and chemical characteristics of the material should be considered (e.g., the material's solubility, transportability, and toxicity characteristics) to determine the material's pollution potential. (40 CFR 122.26(b)(12).)

Appendix C: Resources, Bibliography, etc

We could consider breaking up this section by 2 categories:

Should we have a "web references" section?

1. **References/bibliography**
2. **Other resources**

Should we consider breaking up resources by chapter? Is that done? Or should I merge chapter references to this section?

- National Pollutant Removal Performance Database http://www.stormwaterok.net/CWP%20Documents/CWP-07%20Natl%20Pollutant%20Removal%20Perform%20Database.pdf
- Preliminary Data Summary of Urban Stormwater Best Management Practices (August 1999) http://www.epa.gov/waterscience/guide/stormwater
- Stormwater Management for Industrial Activities (SWPPP and BMPs) http://www.stormwaterauthority.org/assets/EPA%20%20Developing%20Pollution%20Prevention%20Plans%20and%20BMPs.pdf
- Stormwater BMP case studies http://programs.iowadnr.gov/stormwaterbmp/Default.aspx
- State Stormwater BMP Manuals http://yosemite.epa.gov/R10/WATER.NSF/0/17090627a929f2a488256bdc007d8dee?OpenDocument
- National Menu of Stormwater Best Management Practices http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm
- International Stormwater BMP Database http://www.bmpdatabase.org/
- Stormwater Design Manual, Volumes I & II http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp
- Urban Small Sites Best Management Practice Manual http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm
- Commercial/Industrial/Manufacturing BMPs http://www.mrsc.org/Subjects/Environment/water/SW-BMP.aspx#Commercial
- Cost and Effectiveness of Stormwater Treatment Technologies http://stormh2o.com/web-articles/cost-effectiveness-bmps.aspx
- Maintenance of Stormwater BMPs Frequency, effort, and cost http://www.stormh2o.com/november-december-2008/bmp-maintenance-cost.aspx

- Stormwater Center 2007 Annual Report http://ciceet.unh.edu/unh_stormwater_report_2007/SC_Report_2007.pdf
- North Carolina Division of Water Quality Stormwater Best Management Practices Manual http://h2o.enr.state.nc.us/su/documents/BMPManual_WholeDocument_CoverRevisedDec2007.pdf
- Recommended Best Management Practices for Stormwater Discharges: Guidance for Eliminating or Reducing Pollutants in Stormwater Discharges Associated With Industrial Activity http://www.cleanwaterservices.org/content/documents/Business%20and%20Industry/DEQ%20Stormwater%20BMP%20Guidance.pdf
- Best Management Practices for Stormwater Discharges Associated with Industrial Activities http://www.deq.state.or.us/wq/stormwater/docs/nwr/indbmps.pdf
- BMP guidance for various Industrial Activities http://www.portlandonline.com/bes/index.cfm?c=43858
- Best Management Practices For Industrial Stormwater Pollution Control: Sacramento Stormwater Management Program http://www.emd.saccounty.net/Documents/Info/Sacramento%20Industrial%20BMP%20Manual%20Nov.pdf
- Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring http://www.fhwa.dot.gov/environment/ultraurb/
- Virginia Stormwater BMP Clearinghouse http://www.vwrrc.vt.edu/swc/BMPSelection.html
- Suggested Practices to Reduce Zinc Concentrations in Industrial Stormwater Discharges http://www.ecy.wa.gov/pubs/0810025.pdf
- Compliant/Non-compliant photos http://www.pneac.org/stormwater/PhotoGallery.cfm
- Assessment of Stormwater Best Management Practices http://wrc.umn.edu/outreach/stormwater/bmpassessment/assessmentmanual/index.html
- http://www.pca.state.mn.us/publications/wq-wwtp5-64.pdf (Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment System)
- Managing dry cell batteries, MPCA: http://www.pca.state.mn.us/publications/w-hw4-05.pdf

filtration: (GeoSyntec Consultants, Wright Water Engineers, Inc., **Prepared for:**
Water Environment Research Foundation American Society of Civil Engineers (Environmental and Water Resources Institute/Urban Water Resources Research Council) U.S. Environmental Protection Agency Federal Highway Administration American Public Works Association **February 2006)**