DRAINAGE DETENTION SYSTEMS GUIDEBOOK

A basin owner's guidebook for general observation and inspection of stormwater detention systems

SOUTHERN INDIANA STORMWATER ADVISORY COMMITTEE

SWAC

General observation, inspection, and maintenance reference materials for stormwater basin and detention system owners

Developed: November 2011

Revised: July 2019

by the Southern Indiana Stormwater Advisory Committee

Also available online at:

www.SISWAC.org

Acknowledgments

This document, developed through the Southern Indiana Stormwater Advisory Committee partnership, serves as a reference to assist home owners associations and businesses with general procedures for inspection and maintenance of common drainage detention systems. This document would not have been possible without the dedication and commitment of the Southern Indiana Stormwater Advisory Committee (SWAC) communities including, the City of Jeffersonville, the City of New Albany, the City of Madison, the Town of Clarksville, the Town of Sellersburg, the Oak Park Conservancy District, Floyd County, and the Town of Georgetown. Through this robust partnership, the SWAC strives to safely, efficiently, and professionally enhance the quality of life for citizens by guiding the community on stormwater issues and protecting the environment for future generations.

Our Mission

The Southern Indiana Stormwater Advisory Committee is a regional partnership whose core function is to guide stormwater quality programs in a cost-effective, consistent, and efficient manner, striving through collaborative efforts to educate all constituents, encourage involvement, and implant new planning approaches to improve the quality of life for the region, and thus society, now and into the future.

Executive Summary

As new construction and development takes place, numerous land improvements are necessary in order to serve these homes and businesses, while also protecting existing properties downstream and adjoining the new development. Drainage system improvements are a necessary part of these land improvements, of which many contain drainage detention systems. As drainage detention systems impact both the quantity and quality of stormwater runoff, it is crucial for these facilities to receive regular inspection and maintenance in order to help protect the health and safety for residents, businesses, and the community. Failure to properly maintain these systems can have numerous implications that can be dangerous and sometimes even catastrophic. Though drainage systems are sometimes "out of sight, out of mind," every involved party, including municipalities, commercial properties, and home owners associations, has a responsibility to do their part.

When it comes to the drainage system, it is important to realize several key elements. Foremost, the drainage system is extensively connected, therefore every action, be it positive or negative, has an impact on properties and the environment downstream of you. Of course, everyone uses the drainage system, thus everyone has an impact on it; therefore, everyone is responsible for doing their part to protect the health and safety of the environment for the benefit of residents and the community. Secondly, drainage systems are not solely the responsibility of local governments to manage and maintain. If you are part of a subdivision home owners association (HOA) or responsible for grounds maintenance on a commercial property, chances are there is stormwater infrastructure that you are responsible for maintaining. As these private drainage facilities are owned and operated by home owners associations and businesses, failure to properly maintain these features can result in serious consequences. It is important that each entity understands the measures they must implement. The responsibilities should be clearly delineated in documents associated with the development. These documents may include property covenants, long-term operation and maintenance agreements, original construction plans, and other reference materials that outline the necessary inspection and routine maintenance that should take place for drainage detention systems. Additionally, every party should know their roles and responsibilities when it comes to maintaining drainage detention facilities. As the drainage system owner, it is your responsibility to fully understand your obligations. If roles or responsibilities are unclear, please contact the local Stormwater Coordinator in your community to assist you.

Finally, it is imperative that experienced and properly trained individuals perform inspections and develop recommendations for successful long-term operation of these facilities. Inspectors should be familiar with the design, analysis, construction, inspection procedures, and maintenance requirements for detention systems. This document,

intended for small, local drainage systems, seeks to capture the core procedures that should be implemented for the routine inspection and maintenance of detention systems. This Guidebook is not intended to be a holistic reference to cover every unique aspect for the inspection and maintenance of each detention system. It is essential that inspectors thoroughly review and fully understand the design and implementation of the basin. Each drainage system has its own specific requirements that must be evaluated for performance and improved when necessary. It is also necessary for responsible parties to fully understand all applicable local, state, and federal regulations and permits that may be required when performing maintenance activities of drainage facilities. As always, appropriate understanding, systematic observation, sound judgment, and common sense must all be employed to maximize the sustainability of these drainage systems. As this document is a guide outlining general procedures, no liability is inferred, implied or accepted by any communities of the Southern Indiana Stormwater Advisory Committee.

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Table of Revisions

The following table summarizes revisions, additions, deletions, etc. to the Drainage Detention Systems – Guidebook for Inspection:

Date	Affected Sections	Summary of Change
10/30/14	Multiple sections	Minor wording changes throughout for clarity.
10/15/15	Contacts	Contacts updated to reflect changes in SWAC personnel.
5/7/19	Contacts	Contacts updated to reflect changes in SWAC personnel.

1.0 Introduction

Stormwater detention systems are an essential component of successful drainage and stormwater management. Drainage detention systems are often called Best Management Practices (BMPs), as they frequently serve to reduce flooding and improve water quality. By doing so, these drainage facilities seek to help protect the health and safety of the community. When properly designed, installed, and maintained, these systems can reduce flooding, limit pollution, beautify areas, and improve property values.

There are numerous types, sizes, and configurations of drainage detention systems. These systems are highly configurable, and they must be in order to meet the unique requirements of each new development.

When dealing with detention systems, it is important to understand the basics of how they work and why they are necessary. For starters, natural drainage conveyances have evolved for thousands of years, and they are unique with their own size, alignment, geometry, drainage capacity, habitat, etc. When a change takes place in that watershed, such as new residential homes or a commercial development, it affects how the natural drainage system operates. Impervious surfaces such as buildings and roads prevent rain from naturally infiltrating or seeping into the ground, which results in more drainage flow from the site. Increases in runoff can cause flooding and lead to erosion among other problems. Drainage detention facilities seek to decrease those high flows by collecting and storing rainwater and releasing it at a slower rate. This decreased rate of drainage runoff is also beneficial to the environment and aquatic habitat through the capture and treatment of pollutants, which regularly accumulate on impervious surfaces.

This Guidebook offers basic information as to why detention basins are necessary, common problems that exist, and general procedures for inspection and maintenance. Each community assisting with the development of this document has designated representatives to assist basin owners and inspectors with understanding the roles and responsibilities for proper basin inspection and maintenance. Contact information is included in **Appendix E**.

1.1 BASIC TERMINOLOGY

It is necessary to have a basic understanding of some of the terms used throughout this document. A more comprehensive list of definitions is included in **Appendix A**.

- Best Management Practice (BMP): Drainage structures and practices that store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities.

- Drainage Detention: Temporary drainage storage for flood reduction purposes.
- Embankment: A raised area typically constructed of clay soils with the purpose of creating a barrier to contain drainage runoff.
- Erosion: The weathering process and transport of solids, such as soils and rock from water, wind, or ice.
- Impervious Surface: Hard surfaces like buildings, streets, sidewalks, etc, that prevent the natural infiltration of drainage into soils.
- Infiltration: The process of water on the ground entering and flowing through ground soil.
- Intake Structure: The location where stormwater flow enters a drainage structure.
- Municipality: A City, Town, County or Conservancy District with the authority to monitor stormwater and drainage systems for the purposes of ensuring overall system safety and compliance with necessary water quality statutes.
- Outlet / Spillway: The location where drainage flow leaves the basin.
- Private Owner: A person, home owners association, business or other entity that is responsible for the inspection, maintenance, upkeep, and successful operation of specific elements of the detention system.
- Runoff: Rainfall which flows on top of the ground surface (does not infiltrate).
- Sediment: Solid material that is in suspension, is being transported, or has been moved from its origin by air, water or ice.

1.2 DETENTION SYSTEMS OVERVIEW

For the purposes of this document, detention systems will be categorized into four groups: dry detention basins, wet detention basins, infiltration basins, and underground storage systems. These systems are primarily installed to collect stormwater runoff and detain drainage for a period of time to minimize flooding downstream. Numerous secondary benefits exist for detention systems, some of which are mentioned above.

1.2.1 Dry Detention Basins

Figure 1: Example of a dry detention basin

Dry detention basins, sometimes also called "dry ponds" or "holding ponds", are used to hold excess runoff from rain events in order to prevent flooding. When it rains, these basins collect runoff and slow the rate of drainage flow leaving the site. These basins are typically covered by vegetation or sometimes lined with concrete or riprap and remain empty once the excess runoff is slowly introduced back into surface water. Dry detention basins may provide some groundwater recharge through infiltration, but they release the majority of accumulated runoff on the surface. Therefore, dry basins do not significantly reduce the total volume of runoff. When full, it typically takes eight to 24 hours to drain. Some dry basins use pumps to remove water from the holding area in flatter regions.

1.2.2 Wet Detention Basins

Wet detention basins, sometimes also called "wet ponds", are also used to detain excess rainfall to reduce downstream flooding. However, wet detention basins hold a certain amount of water at all times. When compared to dry detention systems, wet detention basins generally have more water quality benefits by diluting and actively treating pollutants through diverse vegetation. Because wet basins store a permanent pool of water, additional inspection and maintenance is necessary to ensure the embankment remains stable from the resulting water pressure of the permanent pool. When properly incorporated into developments, wet basins can benefit aesthetics and improve property values. Many types of wet detention basins in urban areas have permanent water features, such as fountains, which also help increase oxygen levels in the basin and improve species habitat.

Figure 2: Example of a wet detention basin

1.2.3 Infiltration / Retention Basins

Infiltration basins are shallow impoundments designed to infiltrate stormwater into soil, thus replenishing groundwater aquifers and limiting excess stormwater to streams, creeks, or rivers. These drainage features are sometimes called retention systems or retention basins as they "retain" excess runoff on the site and manage this runoff through infiltration and evaporation. These systems typically have an overflow to divert flow downstream only for very large storm events. Additionally, the soil is a highly effective tool in removing and even treating many pollutants before the stormwater is introduced into the groundwater. However, only soils with high infiltration rates are acceptable for infiltration basins. Many native soils in southern Indiana have high clay content, making them less suitable for infiltration practices.

Figure 3: Example of an infiltration basin

1.2.4 Underground Storage Systems

Underground storage systems are another tool used to retain excess runoff and slowly introduce it into the groundwater system. This storage system consists of underground pipes or storage tanks which collect and discharge water at a slower rate to lessen the chances of flooding. Some of these systems have infiltration practices built into them to encourage groundwater recharge and limit the overall volume of runoff. These systems are more typical in highly developed areas where space is at a premium and conventional surface storage is not as practical, cost-effective, or feasible, due to the high cost of land and/or limitation of available development space. Because underground storage is very unique and has specific requirements, this manual does not focus heavily on the management of these systems.

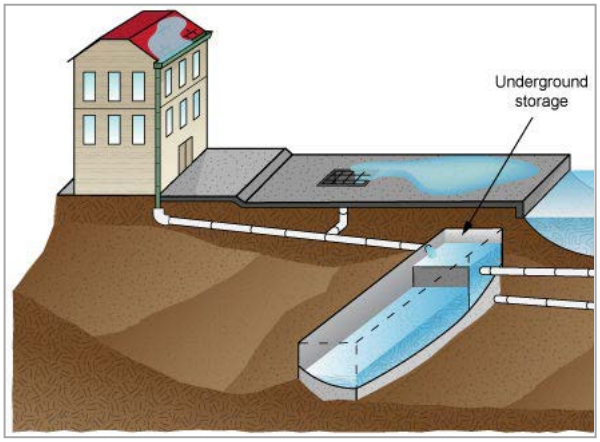

Figure 4: Example of an underground

1.3 BASIN INSPECTION, MAINTENANCE PLAN, & DOCUMENTATION

A detention system is designed to hold a certain amount of stormwater based on a specific rainfall event. When it is first built, the detention system should work to its optimum expectancy. But like every other system, it will need to be inspected and maintained in order to keep it in good working condition. Regular inspections in combination with a detailed, proactive maintenance plan are the best way to maintain the detention system.

These maintenance plans should be developed by a professional engineer and must be customized for each detention system. At a minimum, maintenance plans should include inspection schedules and forms, planting details and vegetation maintenance schedules, embankment and outlet stabilization, debris and litter control, and sediment and pollutant removal features.

The maintenance plan serves as the minimum that should be implemented. However, situations may arise that require additional upkeep. Maintenance needs are influenced by many details, including original design parameters, frequency and intensity of rain events, drainage area conditions, changes in upstream development, etc. If recurring problems exist despite implementing the basin operational plan, it may be necessary to modify the plan in order to sustainably manage the basin. If the basin maintenance plan cannot be located or has not been developed, a detailed inspection schedule and maintenance plans should be created.

1.3.1 Long-Term Operation & Maintenance Agreement

Every private detention system should have a long-term operation and maintenance agreement (LTOMA) associated with it. This LTOMA is typically between the property owners and the municipality in which the detention system is located. The LTOMA should be recorded with the development plat to serve as the legally binding document for outlining the inspection and maintenance responsibilities.

1.3.2 Documentation of Maintenance & Improvement Activities

It is important to document all activities associated with detention basin systems, including inspection reports, operational problems, maintenance activities, and system improvements. This information should be stored with engineering and construction drawings, LTOMAs, and other information relevant to the basin.

Basin owners should understand that federal, state, and local governments have a responsibility to periodically audit basin maintenance. All documentation should be kept in a central location in order to facilitate the timely and efficient review of basin inspection, maintenance, and operational procedures performed by the private owner. Should an audit determine insufficient inspection and maintenance activities

are taking place, significant penalties and fines exist, on top of the considerable liability assumed for lack of proper operation by the owner. Penalties are subject to local regulation for each jurisdiction.

2.0 Common Problems

Many factors can influence the performance of a detention system, and some factors can affect certain detention systems more than others. Listed below are common problems that can lead to water quality issues, infrastructure damage and failure of the detention system.

2.1 VEGETATION

Vegetation is an essential component to the long-term sustainability, performance, and functionality of the drainage system. When these systems are designed, the type of vegetation used to cover the basin and remove sediment from stormwater is a key component to the successful operation of the basin. Inadequate vegetation can compromise stability and lead to erosion and reduction in storage volume, potentially compromising public safety and contributing to water quality issues. Unmanaged and excess vegetation can disrupt the performance of stormwater features and contribute to blockages in the drainage system, which can cause flooding. Similarly, unmanaged tree growth on dams and dikes can disrupt the soil stability causing seepage or "piping," which is the movement of soil particles by water through pathways such as along the roots of trees and excess vegetation.

2.1.1 Excessive Woody Vegetation on Slopes/ Dams/ Embankments

Excessive woody vegetation can cause damage to detention systems. The root systems associated with woody vegetation is typically deep and can lead to seepage through the detention structure which, in return, leads to soil stability issues within earthen structures. When water flows through these embankments, it can pull soils with the flow along the tree roots, removing the very material that comprises the structure. As soil is washed away, voids become larger

Figure 5: Excessive woody vegetation on dam embankment

increasing the flow of water and accelerating the erosion process. This process is known as piping.

Tree growth on an embankment should be addressed, but only under the direct supervision of a geotechnical engineer with experience in embankments and drainage systems. The zone where the trees are located will dictate the treatment practice. Smaller trees may be cut flush with the ground and treated with a herbicide to prevent suckers or new tree growth. Removal of larger diameter trees requires equipment to properly excavate the root-ball and backfill with sufficiently compacted clay soil material to re-stabilize the embankment.

2.1.2 Improper Maintenance of Vegetation

Many basins are stabilized with vegetation, which can be effective at preventing erosion when maintained properly. Improper mowing techniques can lead to less dense vegetation which in turn minimizes natural "armoring" or erosion protection. Mowing grass too short can result in poor vegetation root structure, which can expose the soil and accelerate erosion. Unmanaged areas that receive little or no mowing can result in excessively tall vegetation, which can lead to sparse vegetation near the soil surface. This condition can result in bare soils, accelerating erosion. Taller and unmanaged vegetation on embankments can present challenges to routine inspections, limiting the inspector's ability to identify small problems before they become large problems. As mentioned above, trees have deep roots which can compromise the stability of embankments for drainage basins.

Embankments to basins should typically have vegetation maintained to a height of approximately six (6) to twelve (12) inches to maximize root structure, vegetation density, and natural armoring in the event drainage flows occur in these areas. Keep in mind, some native species may have specific maintenance requirements that allow for taller growth.

2.1.3 Inadequate Vegetation on Slopes

Adequate vegetation is important to detention basin slopes. It will naturally armor the slope and protect it from erosion. To keep from disturbing vegetation, excessive traffic or use of the slopes should not occur.

In the event slopes do not contain vegetation, the area should be reseeded immediately and monitored until completely vegetated. In cases where excess traffic from pedestrians or vehicles is contributing to vegetation disturbance, informational signage may be used to inform residents, deter improper use, and prevent future damage to vegetation. It may be necessary to place topsoil on the disturbed area to encourage rapid reestablishment of vegetation.

2.1.4 Sparse Vegetation in Bottom Areas of a Dry Basin

Adequate amounts of native vegetation in the bottom areas are essential to the performance of a dry basin. The vegetation promotes infiltration into the subsurface soils, intercepts sediment and other pollutants in runoff, and provides for the stability of the basin. After some time, dry basins may accumulate sediment that can disrupt the natural flow of water to the outlet. This can cause standing water that can kill vegetation.

If areas of standing water occur in a vegetated detention basin for more than 24 hours, or for longer than the basin was designed for, it may be necessary to grade the bottom of the basin in order to promote drainage flow to the outlet of the basin.

2.2 EROSION

Erosion is the breaking down or weathering of soil and rock through wind, rain, and other processes. In the case of detention basins, structures such as dams, embankments, slopes, and soil around inlets and outlets are all subjected to erosive forces. Erosion can be prevented or reduced through appropriate vegetation management and routine inspections. Often when a small eroded area is not immediately addressed and stabilized, the eroded areas can rapidly spread resulting in more significant and expensive repairs. Many types of erosion can occur in detention basins as summarized below.

2.2.1 Shoreline Erosion

Wet detention basins are exposed to the possibility of shoreline erosion. Especially in large basins, the existing water surface can lap against the edge of the basin, eroding the shoreline. Also, when water surface elevations rapidly increase and decrease due to rain storm events, the soil can be eroded at an accelerated rate if not protected by vegetation, riprap or other erosion control measures. If left unchecked, eroded areas can spread up the bank and compromise the stability of the basin and embankment. The simplest approach to inspecting for

Figure 6: Shoreline erosion

shoreline erosion is to walk the entire shoreline of the wet detention basin.

Re-vegetation, riprap and erosion control blankets are typical solutions to prevent and control shoreline erosion.

2.2.2 Sheet and Rill Erosion on Slopes

Many factors can influence erosion of slopes. Continuous rainfall, resulting in saturated soils, can cause sheet and rill erosion on slopes, just as inadequate vegetation maintenance can contribute. Commonly walked or used areas can decrease vegetative cover, resulting in an increased likelihood of erosion. Sparse vegetation can also be a result of poor or inadequate topsoil. Topsoil is essential in providing vegetation the necessary nutrients for dense growth. Sheet erosion is when an area has a large "sheet" of water flowing over it at a very shallow depth. This erosion is most likely to occur on bare soils. Rill erosion is when water begins to collect and concentrate in an area, which eventually cuts paths in the slope allowing deeper channels to form. The paths weaken the underlying slope structure while increasing runoff flow. Both sheet and rill erosion are more inclined to happen on steeper slopes.

Figure 7: Rill erosion along basin slopes

2.2.3 Outlet, Outfall & Spillway Scouring

Scouring is a condition where accelerated erosion occurs in a channel or area subject to high velocity, concentrated drainage flow. Scouring associated with detention basins is most likely to occur at the discharge or downstream end of the basin, or at locations where drainage pipes and channels flow into the basin area. Because outlet scour essentially "digs" at the channel bottom, it is important to stabilize scouring outlets and spillways. Failure to address scouring problems can result in compromised embankment stability and water quality problems from suspended soils and sediment. Regularly scheduled inspections should take place at all pipes discharging into the basin, as well as at the downstream end of the basin's outfall and spillway structures.

Outfall scouring can be addressed using several approaches, including through the use of riprap, turf-reinforcement mats, permanent transition mats, sod and other methods designed specifically for the site conditions by a professional engineer.

2.3 SEDIMENT ACCUMULATIONS

Large amounts of sediment accumulation may be detrimental to a detention system. In dry basins, the sediment can build in areas disrupting drainage to the outlet structure and covering vegetation. If left unaddressed over time, these accumulations lower the amount of runoff storage available, decreasing the performance and effectiveness of the detention basin. Additionally, dry basins are typically designed to drain naturally using the flow of gravity. When excessive sediment accumulates it can impede the flow of water to the outlet structure, which can result in standing water, poor vegetation, and a habitat for mosquito breeding. Additionally, when sediment accumulates, there is the potential for soils to re-suspend in subsequent storm events, potentially contributing to water quality problems.

Figure 8: Sediment / debris accumulation in pipe

Wet detention basins can also collect sediment which periodically needs to be removed in order for the basin to continue functioning as intended. Sediment in wet basins can cause water quality and habitat problems. Some basins may have a forebay installed, which is designed to collect sediment and simplify maintenances activities. A professional surveyor should be utilized according to the maintenance plans and no less than once every five years to survey both wet and dry detention basins to determine overall sediment buildup and storage capacity.

In the event sediment accumulations have occurred that effect the basin's operation and efficiency, maintenance should be performed to remove the accumulated material and restore the basin to the original designed configuration.

2.4 BLOCKAGES AT OUTLETS/ SPILLWAY STRUCTURES

As drainage flows through the conveyance system, it can pick up materials that can accumulate in critical areas and lead to blockages in the system. Blockages disrupt the flow of the water causing a backup of water in the detention system itself. If the system cannot hold the excess amount of water, it may lead to drainage flowing to areas not intended for runoff, which can lead to problems like structure and roadway flooding, erosion, etc. Rocks, sediment, debris, limbs, leaves, and garbage are all types of materials which can cause blockages and lead to flooding. Regular vegetation maintenance and litter collection can prevent excess amounts of debris accumulations.

If materials have accumulated near the basin spillway structure(s), it is essential that these blockages are immediately removed. Inspections for blockages should take place regularly and after large storm events that are likely to have resulted in debris accumulations.

2.5 ANIMAL BURROWING & NUISANCE WILDLIFE

Animal burrowing and nuisance wildlife can cause extensive damage to a detention system. In southern Indiana animals most likely to affect basins may include beavers, groundhogs, muskrats, gophers, coyotes, foxes, and other creatures. If unnoticed or ignored, some animals can burrow connecting passages beneath basin embankments or on the sides of the slopes. These passages can collapse, allowing water to leave the basin in an uncontrolled and undesired manner. When performing inspections, it is important to look for evidence of animal activity. Evidence may include holes in the embankment, accumulations of brush, dens, animal tracks, embankment collapses, and other indicators. In wet ponds, it is important to inspect below the waterline for den entrances. The muskrat and beaver, most likely to be found in southern Indiana, typically burrow six inches to four feet below the water surface. For small slopes, follow a zigzag pattern along the basin embankment. For longer and taller embankments, walk parallel along the embankment in a straight line at multiple locations.

Figure 9: Den entrance below the water surface

If nuisance wildlife is found on the dam, animal relocation may be necessary prior to restoration measures. Preventative measures, such as barriers and repellents, may also be justified in order to decrease the likelihood of future nuisance wildlife.

2.6 VANDALISM

Vandalism can be a recurring problem for some basin owners. Common problems may include destruction of drainage infrastructure and disturbance of vegetation from regular, unauthorized traffic. Especially frequent in rural areas, off-road vehicles like dirt bikes and all-terrain vehicles can cause serious disturbance to vegetation, compromising the stability of the drainage structure.

Reasonable precautions, such as “No Trespassing” signs and other deterrents, should be used to discourage or restrict access. Additionally, it may be beneficial to coordinate

with property owners neighboring the basin so they know who to contact if vandalism and unauthorized property access is taking place.

2.7 OUTLET STRUCTURE FATIGUE / FAILURE

As with all infrastructure, drainage structures have a finite lifespan and must be replaced periodically. Concrete pipes are commonly used for the primary outlet structure of detention systems, but some older basins may use corrugated metal pipe. Often, emergency spillways may be constructed from concrete chutes or concrete lined channels.

It is important for inspectors to carefully inspect drainage structures for signs of distress and failure. The inspection should include a close examination of the upstream and downstream ends of the primary outlet structure. Along the alignment of the pipe, the inspector should look for voids, holes, or subsidence, which can indicate pipe joint cracks or failures. When possible, the inspector should observe the inside of the pipe, both upstream and downstream ends, as far as possible with a flashlight or other means (video recording equipment). Emergency spillways that use concrete or other hard armoring practices should be inspected for voids beneath and surrounding areas of the structure.

2.8 WATER QUALITY PROBLEMS

Water quality is an essential component to the successful operation of the stormwater system. As we are all users of the stormwater system, we all influence the quality of water flowing to our streams, creeks, rivers, and lakes. Additionally, water quality is an unavoidable requirement, mandated through the Clean Water Act, which must be implemented by each southern Indiana community. Failure to implement measures to improve water quality can result in serious penalties and fines for individuals and the community through this federal program.

Figure 10: Example of eutrophication

2.8.1 Eutrophication, Hypoxia, & Stagnation

Eutrophication most commonly occurs when a water body accumulates an excess of nutrients, such as nitrates and phosphorus, which can rapidly increase aquatic

vegetation and algae growth in the water body. Algae growth may take place on the bottom, middle or top of the water column. Algae color is typically a shade of green, though yellow, brown, and red algae growths are possible. Algae blooms, especially on the surface, can drastically reduce sunlight penetration below the water surface, which can adversely affect other species. Furthermore, when algae rapidly grow, they consume dissolved oxygen in the water. With this rapid consumption of oxygen, hypoxia can occur. Hypoxia is the lack of dissolved oxygen in the water which causes suffocation for many aquatic species. Stagnation, when water is not flowing, allows the water to be a breeding ground for mosquitos, bacteria, and diseases. These problems are far less likely to exist in a balanced ecosystem; therefore excess algae or mosquitos can be an indicator of water quality issues.

Fountains in wet detention ponds help fight against stagnation by promoting increased dissolved oxygen. Educational information can be provided to properties draining to the basin to remind them of proper fertilizer applications practices.

2.8.2 Sediment Laden Discharges

Sediment laden discharges can cause turbidity surges which are harmful to aquatic wildlife in the drainage system. Some sediment will settle out of the runoff when flows reach the detention basin and water velocity decreases. When this sediment drops out of suspension, it can cover the ecosystem on the floor of the pond. It is important to understand that imbalances in the ecosystem in one region can affect numerous other aspects of the system. Regular water quality problems can also detract from aesthetics, potentially affecting property values. Excess sediment also can lead to blockages and decrease of storage volume in the detention basin.

2.8.3 Oil/ Hydrocarbon Discharges

Oil and hydrocarbon accumulations in water bodies are often attributed to increases in impervious surfaces, which can accumulate oil from leaking automobiles and equipment. When it rains, these accumulations are washed into drainage conveyances that ultimately discharge to our creeks and rivers. Oils most likely to enter our stormwater system may be through illegal dumping or improper disposal of automotive oils and waste vegetable oils used by the restaurant industry. Adverse effects may include damage to plants, harm to animals, and overall

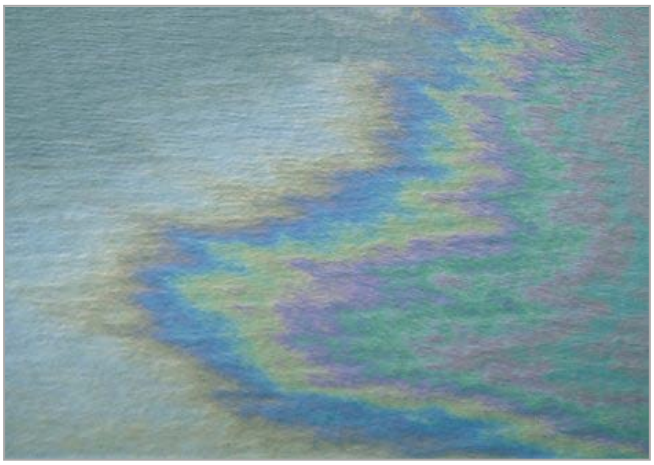

Figure 11: Oily sheen on water surface from spill

decrease in water quality.

2.8.4 Trash and Garbage Accumulations & Illegal Dumping

Trash and garbage are common maintenance problems for detention basins, especially in commercial and high traffic areas. Not only do trash and garbage create an eyesore, they also can cause operational problems in the drainage system, such as clogging and partial blockages. Significant accumulations can cause a total blockage at the outlet spillway, contributing to water backups. Garbage can also cause pollution problems for waterbodies. Illegal dumping can also be a maintenance issue for the property owner.

Recurring dumping can be addressed through a combination of public education, "No Dumping" signs, site surveillance, and coordination with your local municipality. Whenever dumping of a liquid substance takes place, basin operators should contact their local stormwater coordinator or municipal representative.

2.8.5 Pesticides, Herbicides, Fertilizers, & Other Chemicals

Figure 12: Fish kill from improper pesticide

Various chemicals that are commonly used by grounds maintenance staff can cause serious water quality problems. Herbicides are frequently used to manage noxious or unwanted vegetation. However, if not applied properly, they can kill surrounding vegetation, which provides necessary cover for ground stability and erosion prevention. Herbicides can also cause fish-kills if applications are spilled or washed into nearby waterbodies.

Fertilizers must also be applied with great caution due to similar water quality problems. Applications of both herbicides and fertilizers should be performed by a Certified Applicator and should be done when no rain is projected. All chemicals should follow the manufacturer's specifications and should be applied as minimally as possible around or near detention basins and water bodies.

3.0 Indicators of Significant Problems

Figure 13: Example soil failure along embankment

In order to efficiently and effectively inspect and document basin problems, inspectors need to have knowledge of what to look for when completing an inspection. Developing the skills to thoroughly inspect these drainage systems requires a combination of technical training, field experience, and thoroughness. It should go without saying that you must first identify the problem before you can develop and implement a solution to fix it. Listed below are indicators of potentially significant problems. If these or similar problems are identified during a basin inspection, you should immediately contact your local municipal representative (**Appendix E**). These representatives are also available for general assistance to confirm basin owners are property inspecting, documenting, and maintaining their detention systems.

3.1 STRIPPED OR DEVOID VEGETATION

When dead vegetation or voids are found in the detention basin, the system is highly vulnerable to erosion, which can lead to numerous problems including dam and embankment failure. There can be multiple causes for devoid vegetation, as mentioned in **Section 2**. Bare areas can also increase sediment deposits in waterbodies, which can cause problems for the environment. When bare soils are found, the area must be stabilized and re-vegetated immediately to avoid system degradation and to prevent water quality problems.

3.2 SEEPAGE & BOILS

Seepage is the uncontrolled flow of water through the dam or embankment via cracks, voids, animal burrows, tree root channels, or other inadequacies in the soils. If seepage is not addressed, it can lead to a basin failure, potentially causing serious consequences downstream.

Seepage is typically easiest to observe on the downstream side of the embankment. Indicators of seepage may include water-saturated ground on the downstream side of

the embankment or boils or bubbling water flowing from or near the embankment. It can also be indicated by excessively green vegetation during dry periods.

3.3 CRACKS IN EMBANKMENTS

Cracks in the embankments are a sign of instability of the internal soil structure. The cracks can be caused by animal burrowing, woody vegetation, internal soil erosion, improper embankment construction, and even extensive periods of dry weather in dry basins. These cracks can allow flow through the embankment in unintended locations.

Figure 14: Longitudinal crack along top of embankment

Cracks are easiest to observe by making numerous passes along recently mowed embankments. In the event cracks are observed, a geotechnical engineer should be immediately consulted to determine the cause, depth, and severity of the deficiencies.

3.4 VOIDS, UNEVEN SETTLEMENT, & SIGNS OF STRESS

Figure 15: Voids on the surface from failing pipe joint

Other problems may exist that are more subtle than cracks but are just as important to look for. Voids below the surface may be observed via low or sunken areas along the embankment. Settlement, or the consolidation and compaction of soils, can also help identify problems. Settlement should be minor and take place in a relatively uniform manner along the embankment. Subsided or low areas along the embankment can be an indicator of seepage through the embankment causing soil loss. Subsurface voids typically have an abrupt change on the surface, where settlement is generally more gradual and sometimes more difficult to perceive visually. Other signs of embankment stress

may include soil sloughing or slumping, which is the sliding and relatively abrupt failure of a portion of an embankment down the slope. This problem is more common on steep slopes, and is identified by a sunken area upslope and a higher area downslope where the material which moved has accumulated.

When performing site observations on embankments, it is important to realize that most embankments are intended to be uniform along the slope. Therefore, low areas, either abrupt or gradual, can indicate problems below the surface. When investigating for these problems, inspectors should walk along all areas of the embankment. Because voids may be more common along and near basin outlet pipes and outfall structures, particular attention should be paid in these areas. Based on the inspection schedule for the basin and at least once every five years, the basin embankment should be surveyed by a professional licensed surveyor to verify elevations so a professional engineer can check for embankment stability.

3.5 OUTLET STRUCTURE OBSTRUCTIONS & SIGNS OF FAILURE

When observing for obstructions and blockages, both the upstream and downstream ends of the outlet structure need to be viewed during the site visit. If the basin contains a secondary or emergency spillway, this should also be observed. In the event a pipe is used to carry flow through the basin, efforts should be made to determine if sediment, rocks or other material have accumulated in the pipe. The pipes should also be inspected for signs of distress such as cracking, holes, or other signs of infrastructure fatigue. Flashlights, cameras and other equipment can aid with these investigations. (NOTE: In order to thoroughly inspect some structures, confined space entry may be necessary, which requires special training as prescribed by the Occupational Safety and Health Administration and other appropriate agencies.)

3.6 WATER QUALITY

Figure 16: Blockage caused by inadequate maintenance

As stated previously, water quality is a necessary component of successful basin operation. Because basins are part of the drainage system, they influence the ecosystem and environment. Thus, plants and animals rely on the entire system to function properly. When the aquatic ecosystem is healthy, we can infer that water quality is good. On the other hand, when the ecosystem is not healthy from excess pollutants or improper maintenance, water quality problems likely exist. When the

ecosystem is not operating properly, issues like mosquitoes, odors, and other problems can occur. Some indicators of water quality problems are listed below. If the owner or inspector suspects signs of a water quality problem, he or she should contact your local municipal representative, specified in **Appendix E**.

3.6.1 Excessive Algae Growth

As mentioned in **Section 2**, abnormally high algae growth can be caused by excessive or improper application of fertilizers. Excessive algae growth from fertilizers is more common and easier to recognize when on the surface. However, growth can occur below the surface as well.

When inspecting wet detention basins, look for large areas of algae growth, especially near the shorelines and near pipes discharging into the basin.

Figure 17: Surface algae from excessive nutrient loading

3.6.2 Fish Kills

Fish kills can be used as a common indicator for toxins or an unbalanced aquatic ecosystem. Toxins can originate from dumping or the improper application of chemicals, such as pesticides and herbicides. Fish kills can also result from excessive algae growth and natural droughts, which can deplete dissolved oxygen and cause hypoxia in aquatic species.

Fish kills are most likely to be reported by adjoining property owners, as opposed to them being discovered during a routine inspection. However, inspectors should be aware of using fish kills as an indicator for water quality. In the event that a fish kill is reported or discovered, laboratory water quality analysis will likely be necessary in determining the cause and developing a solution. You should also contact your local municipal representative, specified in **Appendix E**.

3.6.3 Surface Sheen

Surface sheen is an indicator of oil and hydrocarbon wastes which have been introduced to the basin from surrounding areas or from illegal dumping. Oil and

hydrocarbons are harmful substances to the aquatic ecosystem. Surface sheens can also indicate the presence of other toxins and pollutant discharges.

Wet detention basins should be inspected for a surface sheen. In the event of a spill, surface sheens can be used to determine if oil has reached the water body. Surrounding property owners should be made aware of surface sheens as indicators so that they understand who to contact if such an occurrence is observed.

4.0 Field Investigation Overview & Typical Process

When routine inspections are performed by trained personnel, most common problems that occur with the functionality of basin systems can be relatively easy to spot. Routine and thorough inspections are the best defense in avoiding extensive, costly repairs, as well as reducing serious threat to life and property of surrounding residents. It is important for inspectors to be familiar with the systems that are being inspected in order to develop an effective strategy for these essential activities.

4.1 DEVELOPING A STRATEGY

Before any basin field inspections take place, it is important to develop a strategy to ensure a comprehensive review is performed. It is necessary to be familiar with the site and understand the system you will be inspecting, which means collecting, reviewing, and understanding historic data associated with the site. The inspector must gather necessary field and safety equipment for the inspection, and should notify surrounding property owners of the inspection whenever possible.

4.1.1 Data Collection

The inspector should review and fully understand the basin system prior to performing any field visits. It may be necessary to contact previous inspectors, design engineers, etc. if any discrepancies or concerns exist. Regular photographs should be taken from consistent locations to that show critical areas of the basin, including embankments, outfalls, spillways, and other essential facilities. Photographs taken from the same location and perspective over time can help identify potential basin issues, such as vegetation encroachment or embankment settlement. Contained below is information that should be available for the inspector prior to and during the inspection.

- Detailed as-built construction plans of the basin and surrounding areas.
- Long-term operation and maintenance agreements outlining the basin maintenance and upkeep procedures and responsibilities.

- History of basin inspections, including field forms, inspection checklists, and site photographs.
- History of maintenance activities, both minor and major.
- History of problems identified and solutions developed.
- Site modifications and upstream changes that have occurred since the last inspection.
- Other information relevant to basin operation, maintenance, and repair.

4.1.2 Safety Planning & Field Equipment Preparation

It is preferable to perform inspections in teams, for both the purposes of safety as well as thoroughness. Teams should operate as one and routinely call out problems and discuss observations. Team members should also cover the same ground and follow the "check and re-check" approach to these inspections. Whenever possible, it is ideal to notify surrounding property owners prior to performing inspections. For safety purposes, teams should notify a third-party contact of their location and periodically check in. Appropriate personal protective equipment (PPE) should be worn during these inspections. Inspectors should be familiar with hazards associated with the site (i.e. steep terrain, flowing water, confined spaces, snakes, etc).

Figure 18: Soil slump failure of embankment

To effectively collect and document useful information during the inspection, crews should also use field equipment. Field equipment may include:

- Measuring instruments including, box tape, 300-foot open reel tape, rigid measuring stick such as a survey rod or folding carpenter's tape, etc;
- Digital camera with flash, cell phone, two-way radios, metal detector;
- Flashlight, high-visibility vest, gloves, walking stick, field boots, etc.

4.2 IMPLEMENTING A STRATEGY FOR INSPECTION

After reviewing site-specific information for the basin being inspected and collecting field and safety equipment, inspections may be performed. Though every basin is

unique and has its own requirements, contained herein are summarized approaches to assist with inspections. For reference, an example inspection form has been included in **Appendix D**. This form contains general information for inspection, but is not intended as a holistic approach to cover every unique aspect of all basins.

4.2.1 Dry Detention and Infiltration Basins

Contained below is a general overview for inspection of dry detention and infiltration systems.

- Inspect for bare soils or disturbed vegetation on the upstream and downstream sides of the embankment.
- Inspect for soil subsidence or settlement of the embankment.
- Check for any damage to the embankment and bare areas where there is no vegetation.
- Inspect for trees and woody growth on or near the embankment.
- Inspect the perimeter side-slopes for bare vegetation and erosion.
- Inspect the bottom of the basin for sediment accumulations, areas devoid of vegetation, or evidence of standing water.
- Inspect the pipes and channels discharging to the basin for erosion and scouring.
- Inspect the upstream end of the outfall and spillway structure(s) for debris accumulation.
- Inspect the downstream end of the outfall spillway structure(s) for erosion and scouring.
- Inspect entire basin for large areas of dead vegetation or other evidence of a spill.
- Observe for any signs of vandalism or trespassing that could affect the basin operation and site stability.
- If applicable, review pump operation and maintenance procedures.
- See **Appendix B** and **Appendix C**, for pre-inspection considerations and quick-reference fact sheet on dry detention and infiltration basins.

4.2.2 Wet Detention Basins

- Inspect for bare soils or disturbed vegetation on the upstream and downstream sides of the embankment.
- Inspect for soil subsidence or settlement of the embankment.

- Inspect for evidence of animal burrows and animal activity along the embankment, including below the water surface.
- Check for any damage to the embankment and bare areas where there is no vegetation.
- Inspect for trees and woody growth on or near the embankment.
- Inspect the downstream side of the embankment for boils or saturated areas, which indicated seepage. Specially focus at the bottom of the embankment, in areas that once contained woody vegetation, in areas that appear disturbed, and in areas where there is a significant change in vegetation species.
- Inspect the pipes and channels discharging to the basin for erosion and scouring.
- Inspect the water surface perimeter and basin side-slopes for bare soils and erosion.
- Inspect the upstream end of the outfall and spillway structure(s) for debris accumulation.
- Inspect the downstream end of the outfall and spillway structure(s) for erosion and scouring.
- Monitor the sediment accumulation in the basin forebay, if installed.
- Observe for any signs of vandalism, trespassing, or authorized access that could affect the basin operation and site stability.
- Check water surface for spills and dumping (oil sheen, dead fish, dead vegetation, etc).
- Inspect water for excessive algae growth.
- See **Appendix B** and **Appendix C**, for pre-inspection considerations and quick-reference fact sheet on wet detention systems.

4.2.3 Underground Storage Systems

Underground storage systems will need to be inspected by someone with the qualifications and specialization skills required for such a system. Additional challenges and techniques must be employed with underground systems.

- Inspect the inlets and outlet(s) for trash accumulation, clogging, etc.
- Monitor the sediment accumulation in the facility silt trap or system forebay.
- Monitor sediment accumulations in the system; may require video recording equipment or confined space entry (OSHA).

- Inspect the outlet of the basin for scouring or erosion at the discharge.
- Walk the site inspecting for surface subsidence and other indicators of unstable underground conditions.
- See **Appendix B** and **Appendix C**, for pre-inspection considerations and quick-reference fact sheet on underground storage systems.

5.0 General Maintenance

When a problem is identified during an inspection, appropriate action needs to be taken to correct the issue. Depending on the problem, solutions can be short, simple, and cheap. However, some problems may need more time, money, and effort to correct. This can be especially true when small deficiencies turn into large problems, either from failure to perform routine inspections or neglecting to address problems promptly once discovered.

In all situations, significant maintenance activities and basin improvements should be designed and constructed under the supervision of a professional engineer experienced with such systems. Some typical solutions to common problems are listed below.

5.1 VEGETATION

As specified above, appropriate vegetation plays an essential role in the stability and performance of most detention systems. Areas stripped of vegetation are subject to rapid erosion when dealing with detention basins. Additionally, trees and woody debris can seriously compromise the stability of these structures.

- Vegetation should be managed based on the construction plans and with native vegetation where feasible. Periodic mowing should take place on embankments and surrounding areas.
- Trees should not be allowed on the basin embankment. Removal of large trees from an embankment requires the supervision of a professional engineer.

Figure 19: Armoring of pipe outlet to prevent scour

5.2 EROSION

Erosion corrections can be very simple or a large effort depending on the types, as identified in **Section 2**. However, failure to promptly and sufficiently respond to eroded areas can result in rapid deterioration and instability of the basin.

- Bare areas should be reseeded and stabilized immediately.
- Locations where large amounts of flow enter or leave the basin, such as pipe discharges and spillways, are more susceptible to erosion. These areas will likely require riprap, turf-reinforced matting, or other armoring practices.
- For wet detention basins suffering from shoreline erosions, erosion control material should be selected by a professional engineer and installed promptly.
- Always perform follow-up inspections after the first storm event following completion of erosion repair to ensure eroded areas have been stabilized sufficiently.

5.3 SEDIMENT ACCUMULATIONS

Sediment accumulations are more likely to occur in flatter areas, such as at the bottom of dry detention basins and wet ponds where flows slow down and sediment drops out of suspension. Some facilities may have forebays installed, which are designed to capture and store sediment. Sediment accumulations are especially important to monitor and track in underground detention systems.

- A professional surveyor should be utilized to collect elevations and determine sediment buildup. Special measures will be necessary to collect bottom elevations in wet detention ponds.
- Every drainage detention system has its own sediment capacity, so it is essential that periodic inspections take place to determine when accumulations should be removed.
- Permits may be needed to remove sediment accumulations from wet detention systems.

5.4 BLOCKAGES AT OUTLETS/ SPILLWAY STRUCTURES

Blockages and debris accumulations at outfalls and spillways are typically easy to identify and address. However, failure to address debris buildup prevents the basin for releasing flows at the intended rates. Most outlets and spillways should have proper trash racks installed to allow for minor debris collections, while still allowing drainage into the outlet structure. Trash racks can also decrease the frequency of debris cleaning at the outlet. If your basin does not have a trash-rack installed, it is advisable to review the original design plans and have appropriate changes designed and incorporated into the basin. It may likely be of additional assistance to contact a professional engineer to assess the need of such an installation.

- Clean trash and woody debris regularly from outlet structures.
- If regular clogging takes place, a routine inspection and maintenance plan should be implemented.
- Contact a professional for the removal of large debris and heavy limbs.
- After debris cleaning, inspect the structure and surrounding areas for damage; repair and stabilize disturbed areas as needed.
- **Do not** attempt to clear debris from spillways during high flows.

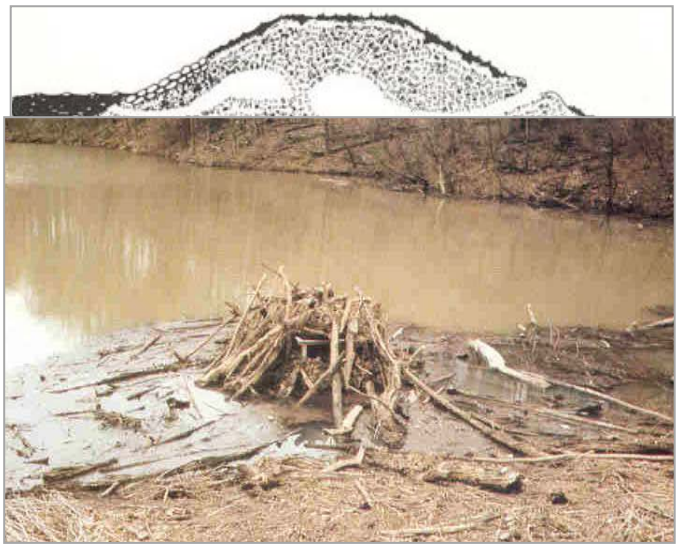

Figure 20: Woody debris accumulations at basin outlet

5.5 ANIMAL BURROWING AND NUISANCE WILDLIFE

Animal burrowing, similar to excessive woody vegetation, will leave voids in dams or embankments which will weaken the structures over time.

- The burrows need to be filled with properly compacted material placed under the supervision of a professional engineer.
- Deterrents, such as wire mesh and matting placed above and below the shoreline may be selected to prevent animal burrowing activity.
- Immediately contact your local community representative, found in **Appendix E**, if large voids are discovered that could compromise the stability of the basin and basin embankment.

- If animal burrowing problems continue to occur, local and state animal control authorities should be contacted to remove the animals from the basin area.

5.6 VANDALISM AND PUBLIC ACCESS

As mentioned above, some basins may have occasional and sometimes recurring problems with vandalism. Vandalism can often be addressed with informational signage such as "No Trespassing" or similar signage. If vandalism continues, it may be necessary to implement more significant and aggressive deterrents, such as fencing and surveillance equipment. Your municipal representative may be able to assist you with measures to minimize basin damage from the public.

- Use signage to inform and warn.
- Distribute pamphlets and fliers to inform surrounding residents about restricted access areas.
- Utilize exclusion fencing to limit access.

5.7 WATER QUALITY

As mentioned in **Section 2**, water quality is a necessary component to the successful operation of any basin. Water quality enhancements are a requirement for development, and though basin owners may not fully understand all regulations, they must understand that these laws exist. Contained below are some basic measures that can be implemented to help detention systems operate as intended and maximize the improvements to water quality.

Figure 22: Regular pedestrian traffic

- Follow all construction plans and long-term operation and maintenance agreements when performing maintenance and making repairs to basin system.
- Post "No Dumping" signs in areas near the basin, and especially where regular dumping takes place.
- Do not allow surrounding property owners to dump woody debris, yard waste, and other material in or near the basin.
- Post "No Littering" signs and encourage surrounding property owners to pick up trash to minimize accumulations in basins.

- Inform surrounding property owners about water quality issues such as fertilizer and pesticide use via mailers, fliers, posters, discussions at home owners association meetings, etc.
- Coordinate with your municipality and Stormwater Coordinator on additional ways to inform property owners as to how they can help water improve water quality.
- Encourage surrounding property owners to notify the municipality or the owner/ operator of the detention basin when dumping is observed, or when a problem is perceived with the basin's operation.

5.8 MAINTENANCE RESPONSIBILITY

The long-term operation and maintenance agreement (LTOMA) should include who is responsible for inspections and maintenance. Clearly establishing responsibility for each specific task will allow for better planning, maintenance, and overall basin operation. Concise LTOMAs may also help solve potential future disagreements among involved parties. If a basin LTOMA is vague or does not exist, it is strongly encourages that inspection and maintenance activities are clearly delineated for all parties. Listed below are typical responsibilities for basin owners.

5.8.1 Owner's Responsibility

Contained below is general information on responsibilities of the private owner.

- It is the owner's ultimate responsibility to perform routine and non-routine maintenance to ensure a properly functioning and safe detention system.
- The owner is responsible for all documentation associated with inspection, maintenance, and improvements.
- In the event of maintenance or repair work performed by the municipality due to inadequate operation or an emergency situation, it is the owner's responsibility to repay the municipality for all work rendered and all fines assessed, as governed by federal, state, and local regulations.
- The basin owner is ultimately responsible for the performance of the basin, both for water quantity and water quality.
- Owners should make available any and all inspection forms and documentation of maintenance activities to the appropriate municipal representative. Owners should also forward inspection forms to their municipal stormwater representative upon completion.
- After each inspection, the basin owner should immediately submit a copy of the inspection report to the stormwater coordinator in your jurisdiction. Contact information is included in **Appendix E**.

5.8.2 Inspector's Responsibility

Contained below is general information on responsibilities of the inspector (if different from the owner).

- The inspector should be familiar with all construction drawings, plans, and other background information associated with the basin.
- The inspector should have a thorough background in and understanding of detention system operation and maintenance, field experience, water quality and environmental measures, and pertinent training that will assist during the inspection.
- The inspector shall perform a thorough, detailed, and extensive field inspection of the basin and appurtenant stormwater facilities.
- The inspector shall carefully document field conditions, through inspection forms, reports, photography, and other measures, and provide those reports to the basin owner.
- Upon satisfactory completion of all the recommended or required items, the inspector will update all files and databases.
- The inspector will immediately notify the basin owner and municipal representative in the event that a structural deficiency has been identified, such that imminent threat to property or public safety is perceived.
- The inspector will inform the basin owner and municipal representative of any and all potential situations that may result in any water quality problem, either confined to the basin or discharged downstream.
- The inspector will work cooperatively with the governing municipality, Soil and Water Conservation District, State Regulators, and other departments to initiate and follow-through with necessary repairs or improvements, and/or the assessment and enforcement process.

5.8.3 Municipality Coordination

Each municipality has a designated representative to assist private basin owners as well as perform audits and enforcement for basins that are not being inspected and maintained on a regular schedule. Every effort should be made by inspectors and basin owners to keep municipal representatives apprised of activities associated with the successful long-term operation of the basin. Each municipality reserves the right to perform inspection and maintenance audits of the basin. See **Appendix E** for contact information for each municipality.

- The municipality may provide assistance on inspection and maintenance, including procedures, forms, activities, and other measures that may benefit the sustainability of the basin operation.
- The municipality may issue penalties, fines, or other means to safeguard the environment and public from inattention from basin owners. Penalties, fines, and other means are subject to applicable federal, state, and local regulations.
- The municipality may elect to, but is not required to, implement corrective action in the event that danger is perceived to life, property, or the environment. Subject to local regulation, the repairs and corrective action will be at the basin owner's expense.

6.0 References & Additional Resources

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Appendix A

DEFINITIONS

Best Management Practice (BMP): A structural or non structural technique designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities.

Conveyance: A pipe, channel, spillway, or other drainage facility used to contain and convey the flow of drainage.

Drainage Detention: Temporary storage of drainage with the purpose of preventing flooding.

Ecosystem: A system formed by the interaction of a group of organisms within their environment.

Embankment: A raised area typically constructed of clay soils with the purpose of creating a barrier for collecting or holding back accumulated drainage runoff.

Emergency Spillway: A spillway, typically isolated from the primary spillway, that provides a stable channel to safely convey extra-large flows through the basin without overtopping the basin embankment in an uncontrolled fashion; Should only be active during extreme conditions; Typically are wide surface channels lined with concrete, riprap, dense vegetation, or other armoring methods.

Erosion: The weathering process and transport of solids, such as soils and rock from water, wind, or ice.

Eutrophication: The significant increase in plant biomass in a water body typically caused by the increase in nitrates and phosphates. Typically, eutrophication signifies an imbalance in the aquatic ecosystem and generally results in adverse environmental effects, including hypoxia, decreases in sunlight penetration, and other harms.

Forebay: A small pool or chamber designed to intercept and contain solids, such as sediment and trash, in an effort to minimize scale and scope of maintenance activities and to maximize overall efficiency and proper operation of all aspects of the stormwater system.

Hypoxia: The depletion of oxygen; A condition where the lack of dissolved oxygen in a water body causes suffocation for aquatic species.

Impervious Surface: Hard surfaces like buildings, streets, sidewalks, etc, that prevent the natural infiltration of drainage into soils.

Infiltration: The process of water on the ground entering and flowing through ground soil.

Intake Structure: The location where drainage flow enters a drainage structure.

Long-term Operation and Maintenance Agreement (LTOMA): A document between parties involved in the operation and maintenance of a specific detention system, usually the property owner and municipality. The document sets forth a plan of how the system should be operated and maintained and who is responsible for the actions.

Municipality: A City, Town, County or Conservancy District with the authority to monitor stormwater and drainage systems for the purposes of ensuring overall system safety and compliance with necessary water quality statutes.

Nuisance Wildlife: Wildlife that causes or has the potential to cause disruption in the designed operation of a detention system, either from a water quantity or water quality perspective

Outlet / Spillway: The location where drainage flow leaves the detention system.

Piping (erosion): The progressive flow of water along surfaces (tree roots, outside of pipes, etc) in an uncontrolled fashion that compromises the stability and structural integrity of the basin embankment.

Private Owner: A person, home owners association, business, or other entity responsible for the inspection, maintenance, upkeep, and successful operation of specific elements of the detention system.

Retention: The retaining of stormwater onsite and managing through infiltration, evaporation, transpiration, or other approach; Limits rate and volume of stormwater leaving the site.

Runoff: Rainfall which flows on top of the ground surface (does not infiltrate).

Scour: Water moving rapidly across the ground or structures that smoothes the surfaces.

Sediment: Solid material that is in suspension, is being transported, or has been moved from its origin by air, water or ice..

Sedimentation: The process of sediment falling out of suspension in stormwater; Typically should take place in basin forebay, designed to collect sediment.

Seepage: The movement of water through soils in an uncontrolled fashion; a concern for detention basins where water is moving through soil instead of at the designed outlet.

Settlement: The consolidation of soils and/or the reduction in soil volume over time.

Soil Sloughing or Slumping: The sliding or relatively abrupt failure of a portion of an embankment sliding down the slope.

Subsidence: A decrease in ground elevation caused by the settlement of soils or the loss of soils below the surface.

Stagnation: A situation where water flow through the drainage system is stopped, potentially resulting in water quality and public safety concerns.

Uneven Settlement (of Soils): The non-uniform consolidation of soils, which can be used as a problem indicator; often identifies improper practices during construction, unsuitable soils, sinkhole development (Karst), and/or seepage through a basin embankment.

Appendix B

Pre-Inspection Considerations:

- Utilize safe, prudent practices during all times while inspecting.
- Notify surrounding properties of inspection and maintenance activities in advance.
- Use appropriate personal protective equipment (PPE); i.e. gloves, two-way radios, boots, etc.
- Never enter a confined space without all appropriate equipment, training, and safety measures.
- Use the buddy system.
- Individuals familiar with the drainage system and similar facilities should be involved in site visit activities.
- Never perform inspections during storms, while the basin is in operation, or other risky conditions.
- Annual inspections may be easiest during late fall or early spring when vegetation growth and density are at a minimum.
- Review a copy of the construction plans, the long-term operation and maintenance agreement (LTOMA), and the inspection history.
- Review the history of maintenance activities performed on the basin.
- Review information on changes to the land use flowing to the basin and the surrounding areas.
- Make sure you have appropriate field supplies; i.e. inspection forms, camera, measuring tape, two-way radios, cell phone, etc.
- Develop a systematic strategy for inspecting all components of the detention system.
- Coordinate with your local governing authority when appropriate.
- Certain inspection measures may require specialized equipment or credentials (licensed professional surveyor, geotechnical engineer, professional geologist, hydrologist, etc).
- Some maintenance activities may require permit from state and federal agencies.

For additional information, see the Drainage Detention Systems Guidebook at www.SISWAC.org.

Appendix C

Dry Detention Basins

These detention systems are dry between storms. During a rainfall event the pond fills with runoff and detains drainage. An outlet structure releases stored water slowly to minimize downstream flooding. While water is detained, minor pollutant removal takes place. When properly designed and maintained, these systems effectively remove sediments and heavy metals, as well as a reduce nutrients (nitrogen, phosphorus, etc), toxic materials, floatable materials, oxygen demanding substances, and oil and grease. Most systems empty via gravity, but some systems, especially in flat areas, may rely on a pumping system.

General Operations & Maintenance Overview:

- ***Proper operation, inspection, and maintenance are the basin owner's responsibility, typically a private entity*** (i.e. Home Owners Association, commercial property, etc).
- At a minimum, annual inspection should be performed.
- Inspection should be performed after significant storm event.
- Owner shall document all inspections, problems, and maintenance activities.
- Owner shall contact local governing authority if danger of failure exists.
- Owner shall contact local governing authority if a spill occurs or pollutants are suspected in or near the detention system.

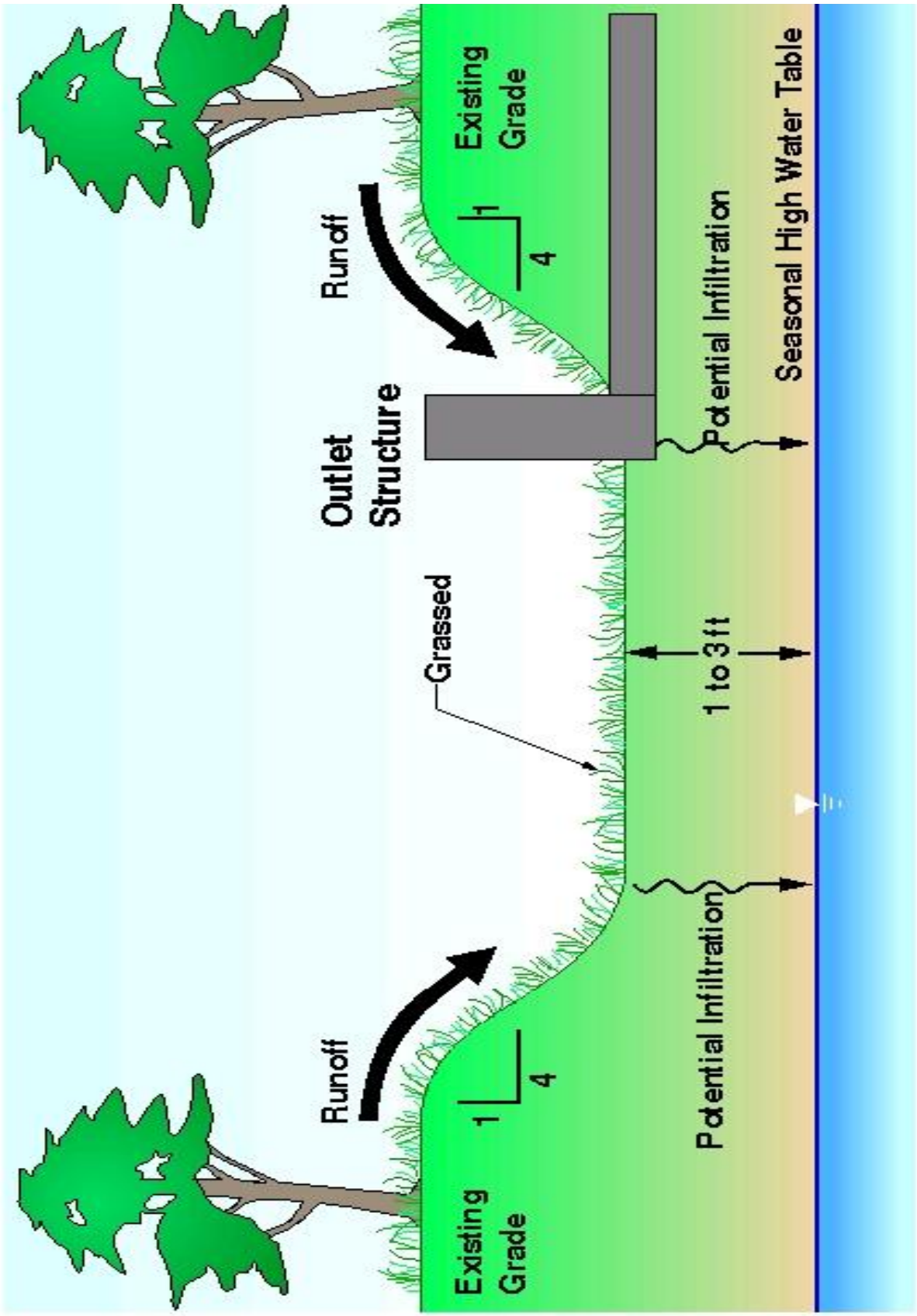
Details to Check For:

- ❑ Inspect for bare soils or disturbed vegetation in and surrounding the basin.
- ❑ Inspect for uneven settlement of the embankment.
- ❑ Inspect for trees and woody growth on or near the embankment.
- ❑ Inspect the basin for animal burrows or other animal activity that is harmful to the basin.
- ❑ Inspect the bottom of the basin for sediment accumulations and areas devoid of vegetation. Inspect for evidence of standing water and/or spills.
- ❑ Inspect the pipes and channels discharging into the basin for erosion and scouring.
- ❑ Inspect the upstream end of the outfall and spillway structure(s) for blockages and debris accumulation, such as trash, litter, leaves, limbs, trees, etc.
- ❑ Inspect the downstream end of the outfall spillway structure(s) for erosion and scouring.
- ❑ Inspect the entire spillway system for signs of deterioration or distress, such as breaks, settling, subsidence, or other problems with the system.
- ❑ Observe for any signs of vandalism or trespassing that could affect the basin operation and site stability.
- ❑ When applicable, check the area for appropriate warning signage, exclusion fencing, and other access deterrents.
- ❑ If installed, check the forebay for accumulations of sediment.
- ❑ If installed, review the pump operation and maintenance procedures.

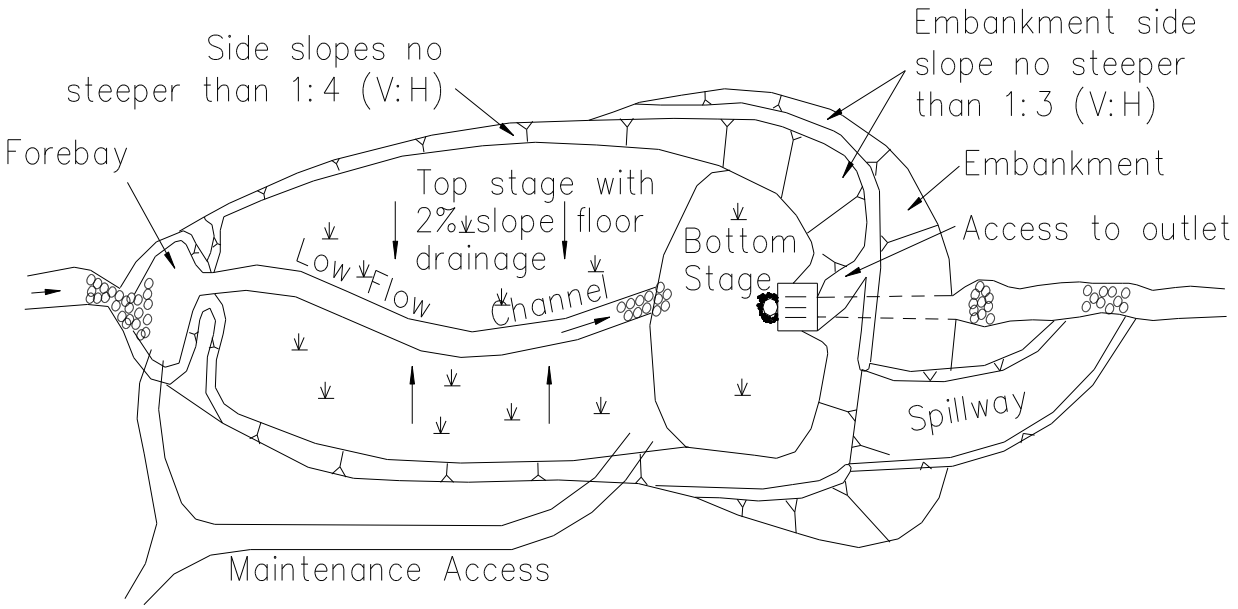
For additional information, please see the Drainage Detention Systems Guidebook at www.SISWAC.org.

Dry Detention Basins: Profile View

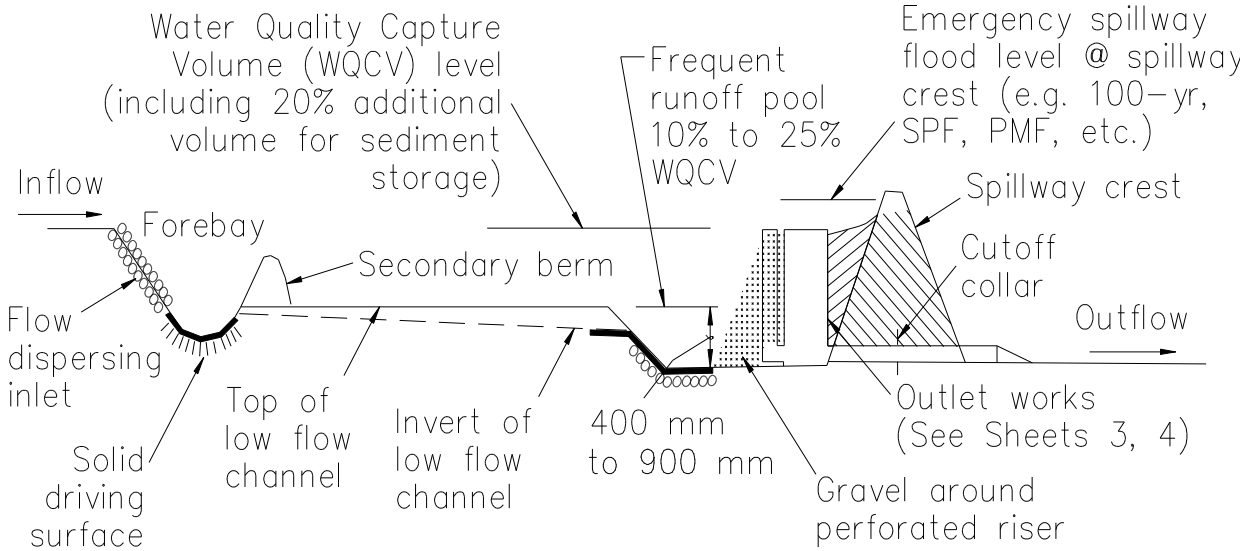
SWAC
SOUTHERN INDIANA



Dry Detention Basins: Example Plans



PLAN
NTS



SECTION
NTS

Adapted from: Urban Drainage, 1992

Wet Detention Basins

Wet detention basins maintain a permanent pool of water during dry weather. During storms, these basins collect excess runoff and release it at a slower rate. When properly maintained, wet detention systems benefit aesthetics, improving surrounding property value. These systems typically provide better wildlife habitat and more water quality benefits when compared to dry basins. These systems also provide better groundwater recharge. Additional inspection and maintenance expertise may be required when compared to a dry detention system. When functioning properly, mosquitos are addressed through natural wildlife.

General Operations & Maintenance Overview:

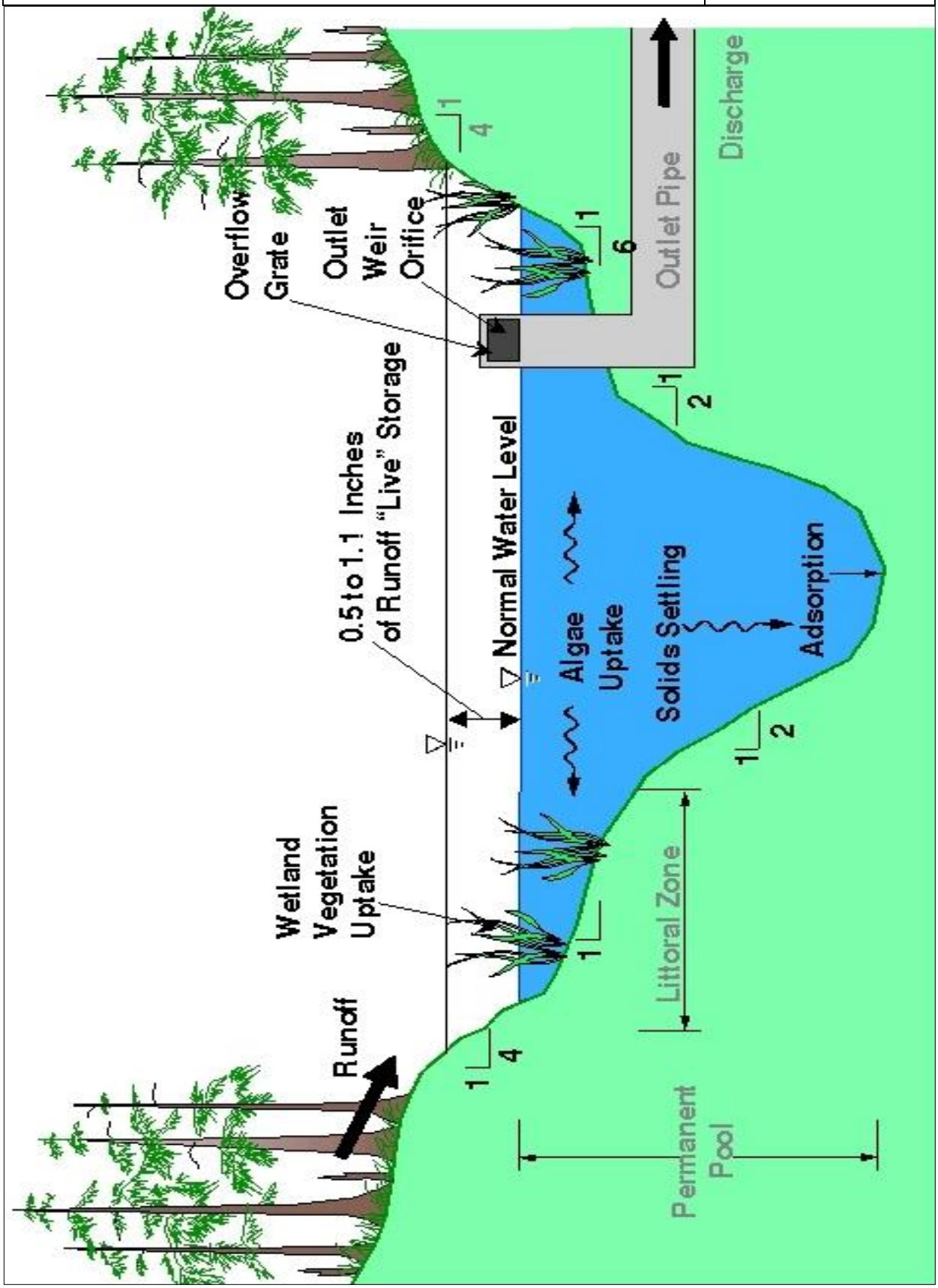
- ***Proper operation, inspection, and maintenance are the basin owner's responsibility, typically a private entity*** (i.e. Home Owners Association, commercial property, etc).
- At a minimum, annual inspection should be performed.
- Inspection should be performed after significant storm event.
- Owner shall document all inspections, problems, and maintenance activities.
- Owner shall contact local governing authority if danger of failure exists.
- Owner shall contact local governing authority if a spill occurs or pollutants are suspected in or near the detention system.

Details to Check For:

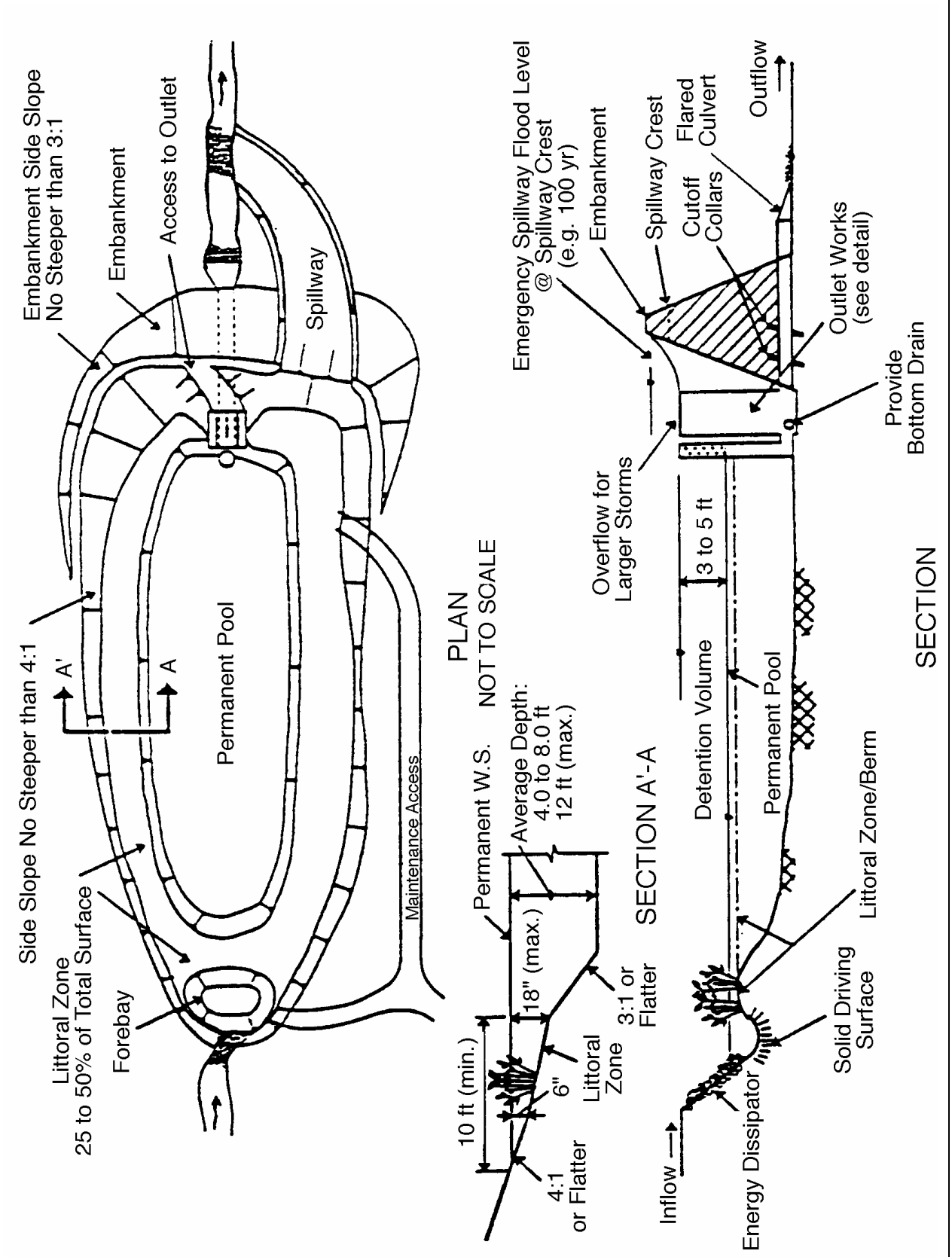
- ❑ Check for bare soils or disturbed areas surrounding the basin, with detailed focus on the embankment.
- ❑ Inspect for trees and woody growth on or near the embankment.
- ❑ Check for animal burrows or other animal activity that is harmful to the basin. Check below the waterline.
- ❑ Look for evidence of spills around the basin, at pipes discharging to the basin, and on the water surface.
- ❑ Inspect the pipes and channels discharging into and out of the basin for erosion and scouring.
- ❑ Inspect the upstream end of the outfall and spillway structure(s) for blockages and debris accumulation, such as trash, litter, leaves, limbs, trees, etc.
- ❑ Inspect the downstream end of the outfall spillway structure(s) for erosion and scouring.
- ❑ Visually inspect the crest of the embankment for signs of settling or internal erosion. Embankment crest should be uniform, flat, and well above the emergency spillway. Surveyor may be necessary.
- ❑ Inspect the entire spillway system for signs of deterioration or distress, such as breaks, settling, subsidence, or other problems with the system.
- ❑ Walk along the downstream face of the basin embankment to check for water seepage or boils, indicating water flowing through the embankment in an uncontrolled manner.
- ❑ Observe for any signs of vandalism or trespassing that could affect the basin operation and site stability.
- ❑ When applicable, check the area for appropriate warning signage, exclusion fencing, and other access deterrents.
- ❑ If installed, check the forebay for accumulations of sediment.
- ❑ Look for signs of water quality problems; i.e. excess algae, water clarity, oily sheen, dead fish, etc.

For additional information, please see the Drainage Detention Systems Guidebook at www.SISWAC.org.

Wet Detention Basins: Profile View



Wet Detention Basins: Example Plans



Infiltration & Retention Basins

Infiltration basins are often referred to as retention basins or retention systems, as they "retain" excess drainage on the site and infiltrate it into the ground. Infiltration basins do a better job of limiting the total runoff volume, and typically benefit water quality more when compared to dry and wet detention ponds. Infiltration basins pond water in a shallow, large area and require sandy soils to infiltrate excess runoff. These systems help with groundwater recharge. Over time, infiltration rates may decrease, indicating maintenance needs. The systems should have an overflow structure to safely divert the runoff downstream for large storms events.

General Operations & Maintenance Overview:

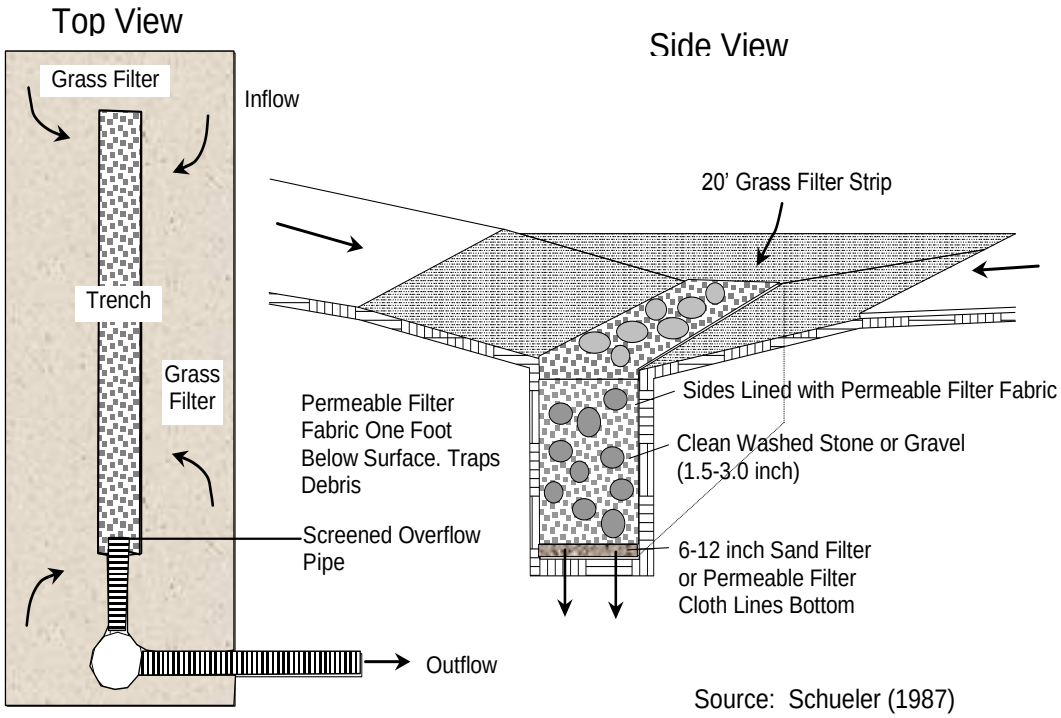
- ***Proper operation, inspection, and maintenance are the basin owner's responsibility, typically a private entity*** (i.e. Home Owners Association, commercial property, etc).
- At a minimum, annual inspection should be performed.
- Inspection should be performed after significant storm event.
- Owner shall document all inspections, problems, and maintenance activities.
- Owner shall contact local governing authority if danger of failure exists.
- Owner shall contact local governing authority if a spill occurs or pollutants are suspected in or near the detention system.

Details to Check For:

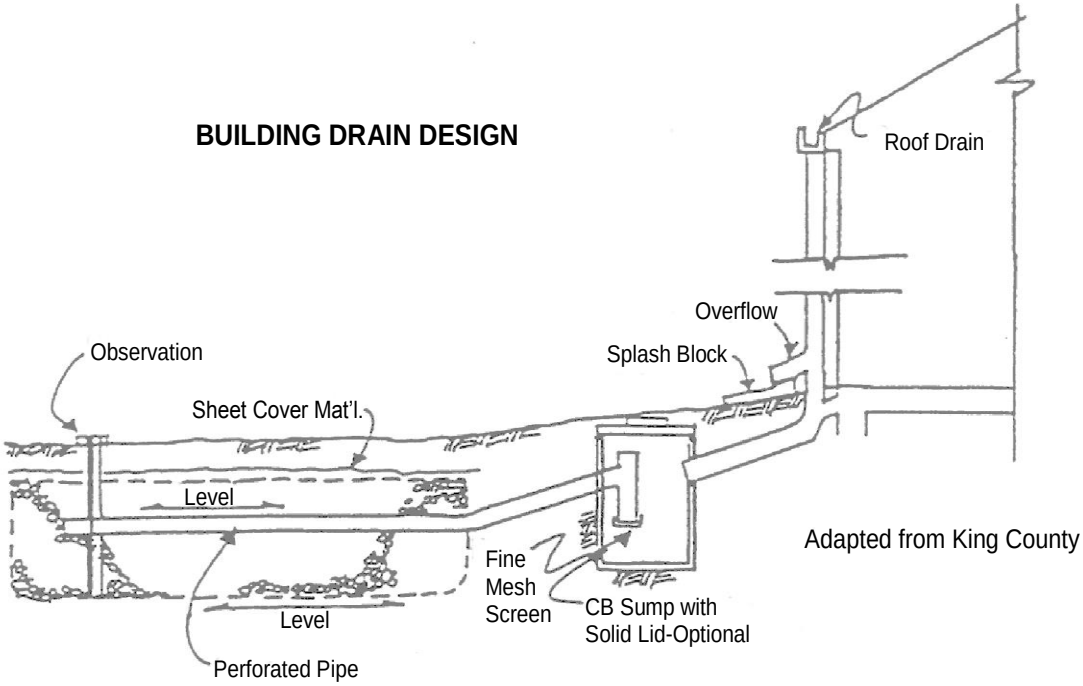
- ❑ Check for bare soils or disturbed areas surrounding the basin.
- ❑ Inspect for trees and woody growth on or near the embankment.
- ❑ Check the ponding area for excessive vegetation. No tall grasses, trees, or shrubbery should be in the ponding area unless specified on the plans.
- ❑ Check the ponding area for silting which can reduce the volume of the basin.
- ❑ Check for animal burrows or other animal activity that is harmful to the basin.
- ❑ Look for evidence of spills in and around the basin and at pipes and channels discharging to the basin.
- ❑ Inspect the pipes and channels discharging into the basin for erosion and scouring.
- ❑ Inspect the outlet pipes for erosion and scouring.
- ❑ Inspect the upstream end of the spillway structure for blockages and debris accumulation, such as trash, litter, leaves, limbs, trees, etc.
- ❑ Inspect the downstream end of the spillway structure for erosion and scouring.
- ❑ Inspect the entire spillway system for signs of deterioration or distress, such as breaks, settling, subsidence, or other problems with the system.
- ❑ Observe for any signs of vandalism or trespassing that could affect the basin operation and site stability.
- ❑ When applicable, check the area for appropriate warning signage, exclusion fencing, and other access deterrents.
- ❑ If installed, check the forebay for accumulations of sediment, trash, leaves, and other debris. If no forebay is installed, regular maintenance and clean-up should take place.

For additional information, please see the Drainage Detention Systems Guidebook at www.SISWAC.org.

Infiltration Basins: Examples

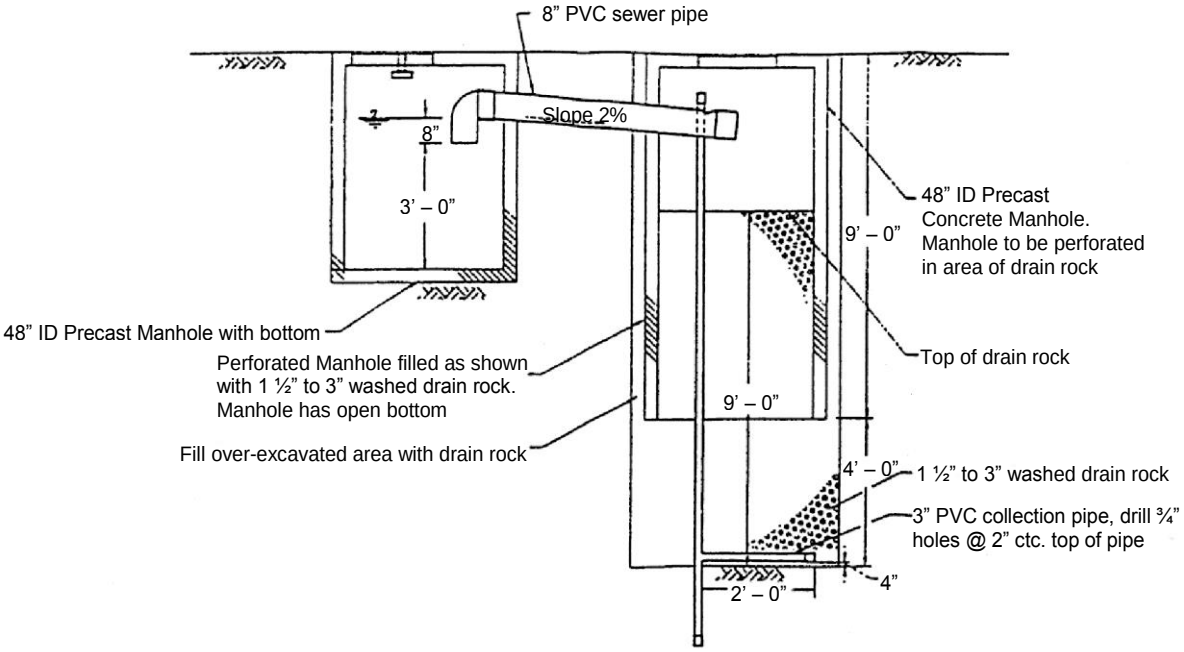


Source: Schueler (1987)

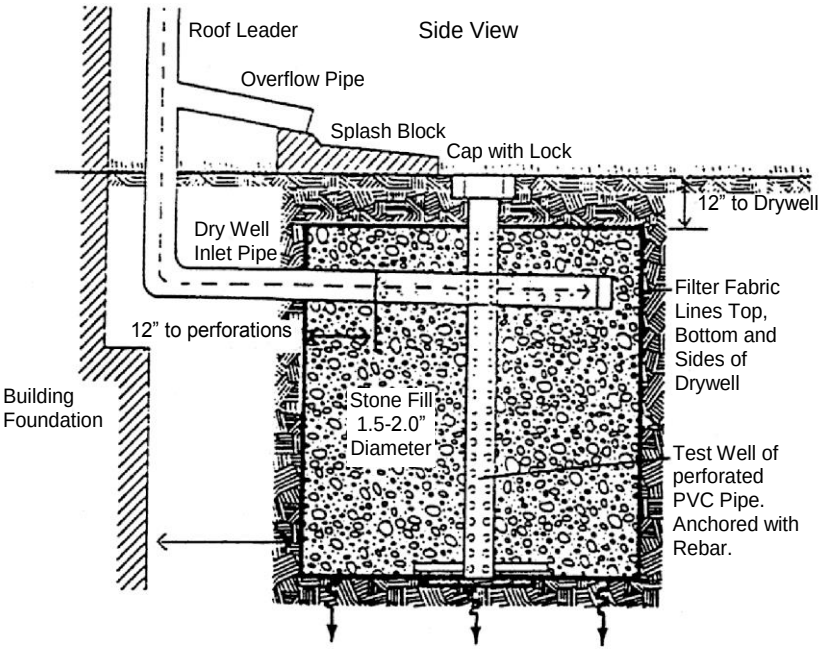


Adapted from King County

Infiltration Basins: Examples

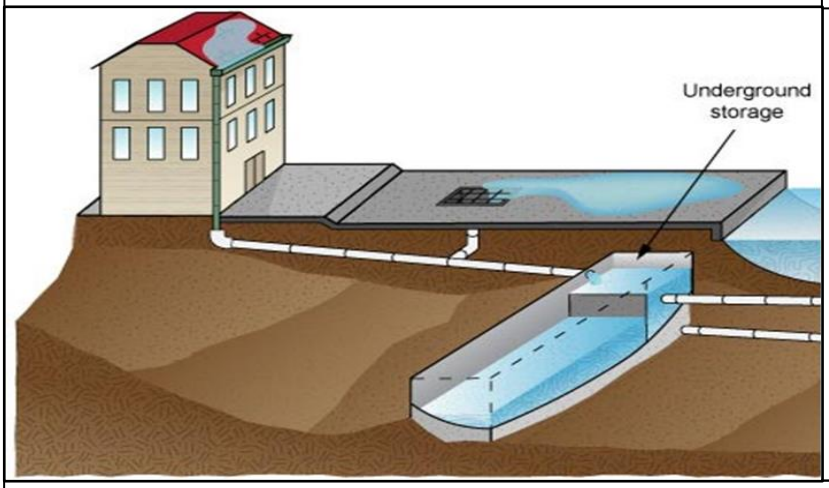


WITH PRETREATMENT



WITHOUT PRETREATMENT

Underground Storage Systems



Underground storage is generally used in dense urban areas where space it at a premium. Some underground systems use a series of pipes, where others utilize vaults for stormwater storage. These systems are more costly when compared to typical above-ground basin systems and they generally have fewer water quality benefits. In order to achieve water quality requirements, these systems may be fitted with trash racks, sediment forebays, hydrocarbon interceptors, and other means to help capture pollutants from the site. These systems typically have more routine maintenance requirements associated with them.

General Operations & Maintenance Overview:

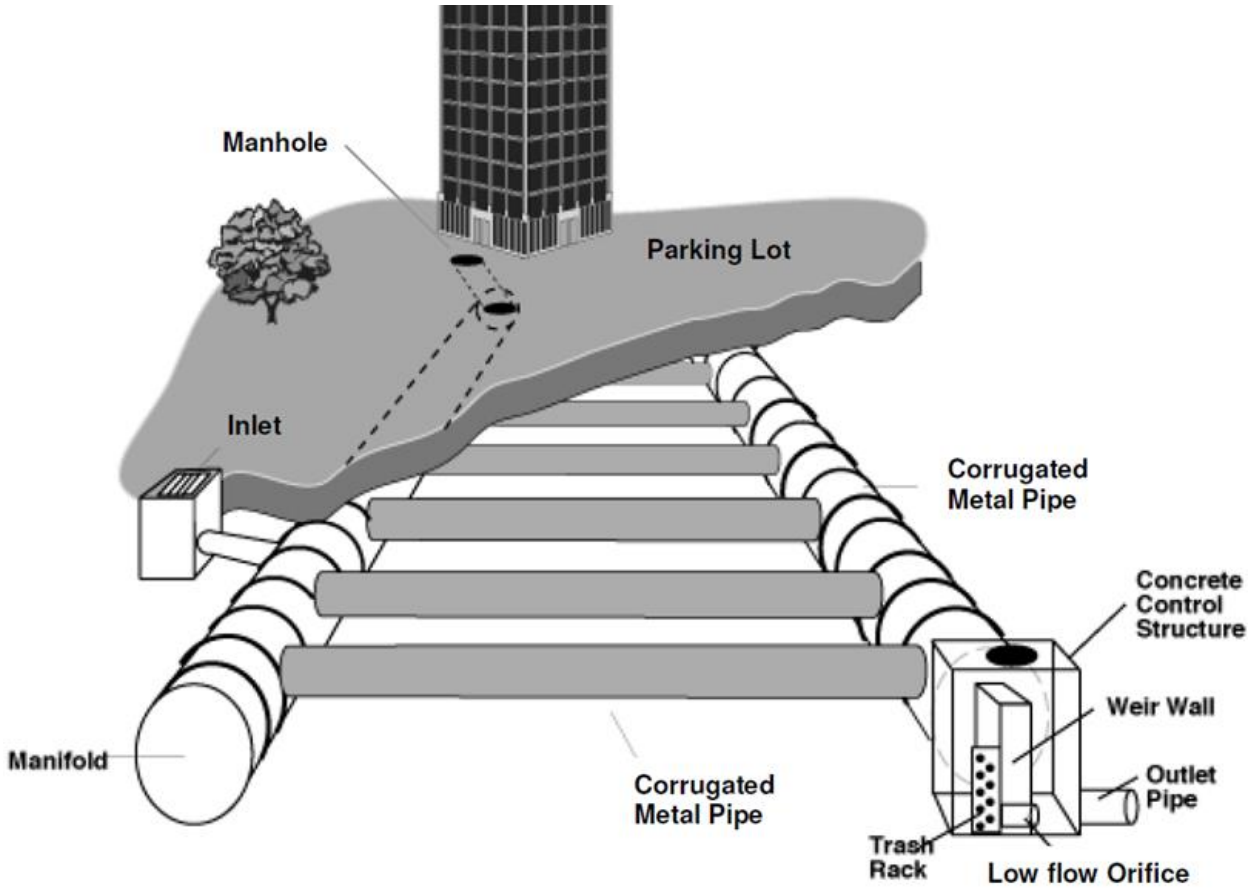
- ***Proper operation, inspection, and maintenance are the basin owner's responsibility, typically a private entity*** (i.e. Home Owners Association, commercial property, etc).
- At a minimum, annual inspection should be performed.
- Inspection should be performed after significant storm event.
- Owner shall document all inspections, problems, and maintenance activities.
- Owner shall contact local governing authority if danger of failure exists.
- Owner shall contact local governing authority if a spill occurs or pollutants are suspected in or near the detention system.

Details to Check For:

- ❑ Inspect for soil subsidence or settlement in the area above and surrounding the underground storage system; look for voids, holes or other indicators.
- ❑ Inspect the forebay (if installed) and the bottom of the system for sediment accumulations. Inspect for evidence of standing water. *Never enter a confined space without all appropriate safety training, provisions and equipment.*
- ❑ Inspect trash racks and throughout the system for accumulations of litter, trash, leaves, or other debris.
- ❑ Inspect the entire outfall system for signs of deterioration or distress, such as breaks, settling, subsidence, or other problems with the system.
- ❑ Inspect the storage chamber(s) (pipes, vault system or other) for signs of duress or structural fatigue or failure. *Never enter a confined space without all appropriate safety training, provisions and equipment.*
- ❑ Inspect the downstream end and outfall system for signs of scouring.
- ❑ When applicable, check the construction plans and detention area for appropriate warning signage, exclusion fencing, limited access grates, and other access deterrents.
- ❑ Check water quality treatment devices for maintenance or replacement needs.
- ❑ For advanced water quality treatment devices, it may be necessary to contact the device installer/manufacturer and/or a specialist with the cleaning, maintenance and upkeep of these structures.
- ❑ If applicable, review pump operation and maintenance procedures.
- ❑ Check the surrounding area to verify no new construction has occurred and impacted the system, such as by damaging pipes or the storage system.

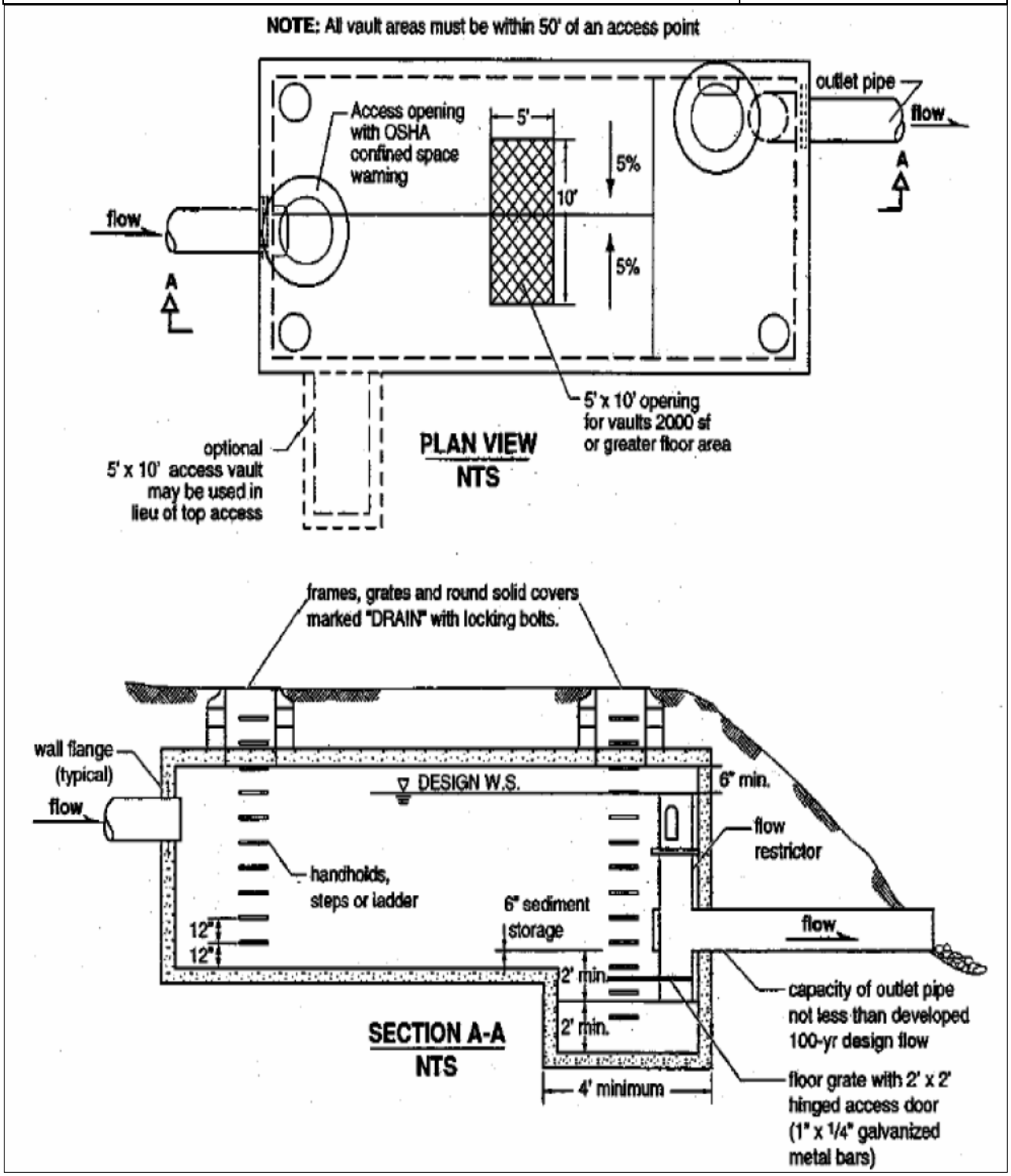
For additional information, please see the Drainage Detention Systems Guidebook at www.SISWAC.org.

Underground Detention: Pipe System



Underground Detention: Plan & Profile View

SWAC SOUTHERN INDIANA



Appendix D

Example Inspection Worksheet

Development & Address:_____

Date:_____ **Time:**_____ **Weather:**_____ **Last Rainfall:**_____

Present:_____

Completed by:_____ **Signature:**_____

Inspection Area and Activity	Yes/ No/ NA	Page #	Comments / Pictures Taken / Etc
Area 1: Embankment, Slopes, & Dams			
Is there excessively tall vegetation (greater than 12 inches) or trees on embankments?		**2.6**	
Are there spots with sparse vegetation or areas with dead vegetation?		**2.6** **2.7**	
Are there signs of erosion on the basin embankment or side slopes (sheet, rill, other)?		**2.7** **2.8**	
Are there any signs of animal burrowing (voids, paths, dens, burrows, etc)?		**2.10**	
Are there any cracks in the embankment or basin side-slopes?		**3.14**	
Are there any signs of seepage (piping, boils, etc) or other indication of uncontrolled flow through the embankment?		**3.14** **3.15**	
Are there any signs of settlement or distress in the embankment (uneven elevation along top of embankment, sunken areas, slumping, etc)?		**3.14** **3.15**	
Area 2: Inlets, Outlets, & Spillways			
Is there scouring or erosion at any pipes or channels discharging into the basin?		**2.8**	
Is there scouring, erosion, or disturbed areas at the basin outfall or emergency spillway?		**2.8**	
Is there sediment, rock, trash, or other accumulations inside or on outlet pipes or spillways?		**2.9**	
Are there signs of debris, trash, limbs, or other blockages in or around the basin outlet structures?		**2.9** **3.15**	
Are there signs of infrastructure fatigue or damage at the outlet structures (cracks, voids, holes in pipe, subsidence along pipe alignment, vandalism, etc)?		**2.11** **3.15**	
Other:			
Other:			

Area 3a: Dry Detention and Infiltration Basin Area (see 3b for Wet Detention Basins)			
Is there vegetation present which is not native or described in the basin design plans?		**2.6**	
Is the grass in the bottom of the basin or on the side slopes in need of mowing?		**2.6**	
Are there spots of dead or sparse vegetation in the bottom of the basin?		**2.7**	
Is there evidence of sediment accumulations in the bottom of the basin?		**2.9**	
Is there trash or debris in the basin area or near the outlet structures?		**2.9** **2.12**	
Area 3b: Wet Detention Basin			
Is there evidence of shoreline erosion or other erosion caused by the water pool (wave-action erosion, etc)?		**2.7**	
Are there any visible sediment accumulations at the bottom of the pool?		**2.9**	
Is there excessive vegetation or algae in, around, or on the surface of the pool?		**2.11**	
Is there floating debris and/or trash in the pond or an accumulation of trash along the shoreline?		**2.12**	
Are there signs of oil and hydrocarbon discharges or oil spills (i.e. sheen on the pool)?		**2.12** **3.17**	
Is the water murky, turbid or appear to have suspended particles in it?		**2.12** **3.16**	
Are there dead fish or other dead animals that may have been caused by a water quality problem?		**3.13** **3.16**	
Is there a significant presence of mosquitoes around the pond?		**3.16**	
Other:			
Area 4: Sediment Forebays			
If a sediment forebay is installed, is it more than 50% filled with sediment (review original plans)?		**2.9**	
Are there any signs of the forebay not functioning correctly?		**2.9**	

If yes, explain what actions need to be taken:_____

_____

_____

_____

_____

_____

Appendix E

LOCAL CONTACT INFORMATION

CLARKSVILLE:

Stormwater Department…….……... (812) 283-8233
Tom Clevidence, Stormwater Coordinator
125 East Harrison Avenue
Clarksville, IN 47129
Email: tclevidence@clarksvillesw.com

Street Department…… (812) 283-8233
Brad Cummings, Street Commissioner
107 Roy Cole Drive
Clarksville, IN 47129
Email: bcummings@townofclarksville.com

Clarksville Fire Department……...…… (812) 282-7619 or 911
Brandon Skaggs, Fire Chief
2249 Sam Gwin Drive
Clarksville, IN 47129
Email: bskaggs@cfdfire.com

FLOYD COUNTY:

Stormwater Department……..……...…..…….. (812) 949-5446
Chris Moore, Stormwater Coordinator
2524 Corydon Pike, Suite #201
New Albany, IN 47150
Email: cmoore@floydcounty.in.gov

Highway Department…….…….…….…… (812) 923-3041
Highway Superintendent
6412 Old Georgetown Road
Georgetown, IN 47122
Fax: (812) 923-9472
Email: fcroaddept@floydcounty.in.gov

Floyd County Volunteer Fire Department……..…….…….…….. 911

GEORGETOWN:

Public Works Department……..……...…….....(812) 951-3800
9111 State Road 64
P.O. Box 127
Georgetown, IN 47122

Fire Department…… (812) 951-2354 or 911
Richard Bader, Fire Chief
8910 State Road 64
Georgetown, IN 47122

JEFFERSONVILLE:

Stormwater Department…… (812) 285-6476
Matt Bell, MS4 Coordinator
500 Quartermaster Court
Jeffersonville, IN 47130
Email: MBell@CityofJeff.net

Streets and Sanitation…… (812) 285-6455
Clark Miles, Streets and Sanitation Commissioner
2003 Renfroe Way, Suite 100
Jeffersonville, IN 47130

Jeffersonville Fire Department…… (812) 285-6445 or 911
Eric Hedrick, Fire Chief
2204 East 10th Street
Jeffersonville, IN 47130
Fax: (812) 285-3032

MADISON:

Public Works Department…… (812) 265-8326
Brian Jackson, Utility Manager
101 W. Main St.
Madison, IN 47250
Email: utilitymanager@madison-in.gov

Stormwater Department…… (812) 265-8328
Jay Thompson, MS4 Stormwater Coordinator
1213 W. First Street
Madison, IN 47250
Email: ms4@madison-in.gov

Madison Fire Department…… (812) 265-8350 or 911
Steve Horton, Chief
101 W. Main St.
Madison, IN 47250
Email: firedept@madison-in.gov

NEW ALBANY:

Stormwater Department …….…….. (812) 945-1989
Christopher Gardner, Stormwater Coordinator
2113 Grant Line Road
New Albany, IN 47150
Email: cgardner@cityofnewalbany.com

Stormwater Department …….…….. (812) 945-1989
Brandon Sailings, MS4 Coordinator
2113 Grant Line Road
New Albany, IN 47150
Email: bsailings@cityofnewalbany.com

Street Department ……..……..…….. (812) 948-3586
Joe Ham, Street Commissioner
2113 Grant Line Road
New Albany, IN 47150
Email: jham@cityofnewalbany.com

New Albany Fire Department……..…….. (812) 948-5314 or 911
Matthew Juliot, Chief
316 East Spring Street
New Albany, IN 47150

OAK PARK CONSERVANCY DISTRICT:

Stormwater Operations …….…….. (812) 283-3960
Keith Ingram, Superintendent of Wastewater Treatment Operations
4230 Portage Place
Jeffersonville, IN 47130
Email: keithi@oakparkcd.us

Streets and Sanitation - Jeffersonville…….(812) 285-6455
Clark Miles, Streets and Sanitation Commissioner
2003 Renfroe Way, Suite 100
Jeffersonville, IN 47130

Fire Department – Jeffersonville…….(812) 285-6445 or 911
Eric Hedrick, Fire Chief
2204 East 10th Street
Jeffersonville, IN 47130
Fax: (812) 285-3032

SELLERSBURG:

Streets and Sanitation Department…….…….. (812) 246-3821, ext. 4
Bart Meyer, MS4/ADA Compliance Coordinator
316 E. Utica Street
Sellersburg, IN 47172
Email: ms4@sellersburg.org

Building Commissioner…….…….…….. (812) 246-3821, ext. 6
Building Commissioner
316 E. Utica Street
Sellersburg, IN 47172
Email: building@sellersburg.org

Fire Department……...……...…….(812) 246-2232 or 911
Sellersburg Volunteer Fire Department
426 E. Utica Street
Sellersburg, IN 47172

SOIL AND WATER CONSERVATION DISTRICTS

Clark County:

Clark County Soil and Water Conservation District…….…. (812) 256-2330, ext. 107
Tami Kruer, Education Coordinator
9608 Highway 62
Charlestown, IN 47111
Fax: (855) 391-1921
Email: tami.kruer@in.nacdnet.net

Floyd County:

Floyd County Soil and Water Conservation District…….……...…. (812) 945-9936
Angela Jackson
2524 Corydon Pike, Suite 103
New Albany, IN 47150
Fax: (812) 948-5255
Email: ajackson@floydcounty.in.gov

Jefferson County:

Jefferson County Soil and Water Conservation District…….....…. (812) 265-7609
Vicki Wehner, District Coordinator
3767 West State Road 256
Madison, IN 47250
Fax: (812) 873-6835
Email: vicki.wehner@jeffersoncounty.in.gov

STATE OF INDIANA CONTACT INFORMATION

Indiana Haz Mat (Hazardous Materials) Response Team……..… (800) 423-0765 (Office)
or (800) 669-7362 (Emergency)

Call the Indiana Haz Mat Response Team 24-hour hotline when there is a release or threatened release of a hazardous substance, pollutant or contaminant, petroleum or petroleum product.

Indianapolis – Central Office:
Office of Water Quality Stormwater Program ……..... (800) 451-6027
100 North Senate Avenue
MC 65-42, Room 1255
Indianapolis, Indiana 46204

IDEM Southeast Regional Office……..……..…..…… (812) 358-2027
Toll Free (within Indiana):……..…….. (877) 271-0074
820 West Sweet Street
Brownstown, Indiana 47220
Fax: (812) 358-2058

Illegal Dumping (24-hour hotline) ……...….. (800) 451-6027