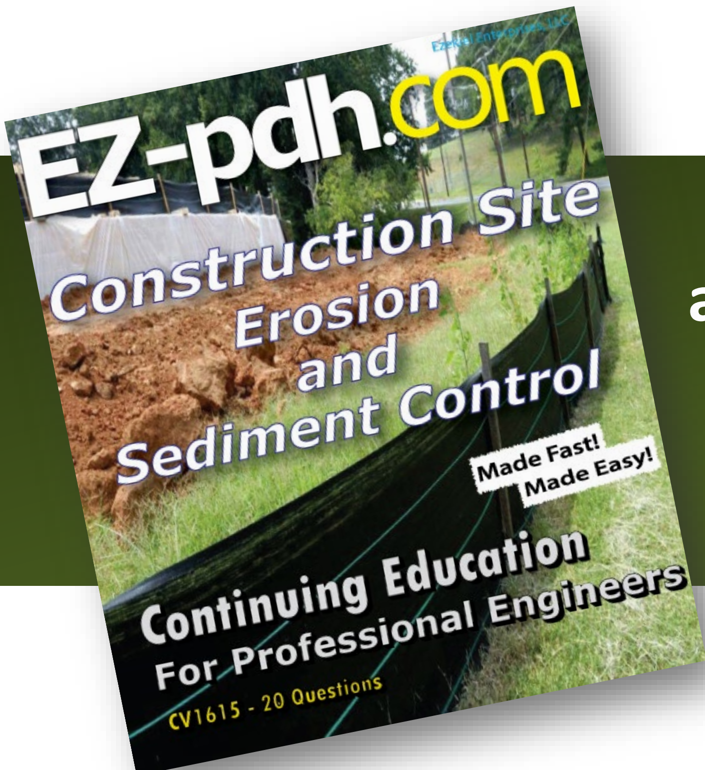


Construction Site – Erosion and Sediment Control: 5 PDH

Five (5) Continuing Education Hours
Course #CV1615

Approved Continuing Education for Licensed Professional Engineers

EZ-pdh.com
Ezekiel Enterprises, LLC
301 Mission Dr. Unit 571
New Smyrna Beach, FL 32170
800-433-1487
support@ez-pdh.com

Course Description:

The Construction Site – Erosion and Sediment Control course satisfies five (5) hours of professional development. The course is designed as a distance learning course that provides an in-depth exploration of stormwater runoff generation, its environmental impacts, and best practices for managing runoff through proper site assessment, planning, and construction-phase pollution prevention. It emphasizes both theoretical knowledge and practical application, preparing students to assess construction sites, plan sustainable developments, and implement effective stormwater quality controls.

Objectives:

The primary objective is to equip students with the knowledge and tools to analyze, plan, and implement environmentally responsible stormwater management systems in the context of urban development and construction activities, ensuring compliance with environmental regulations and promoting watershed health.

Grading:

Students must achieve a minimum score of 70% on the online quiz to pass this course. The quiz may be taken as many times as necessary to successfully pass and complete the course.

A copy of the quiz questions is attached to the last pages of this document.

Table of Contents

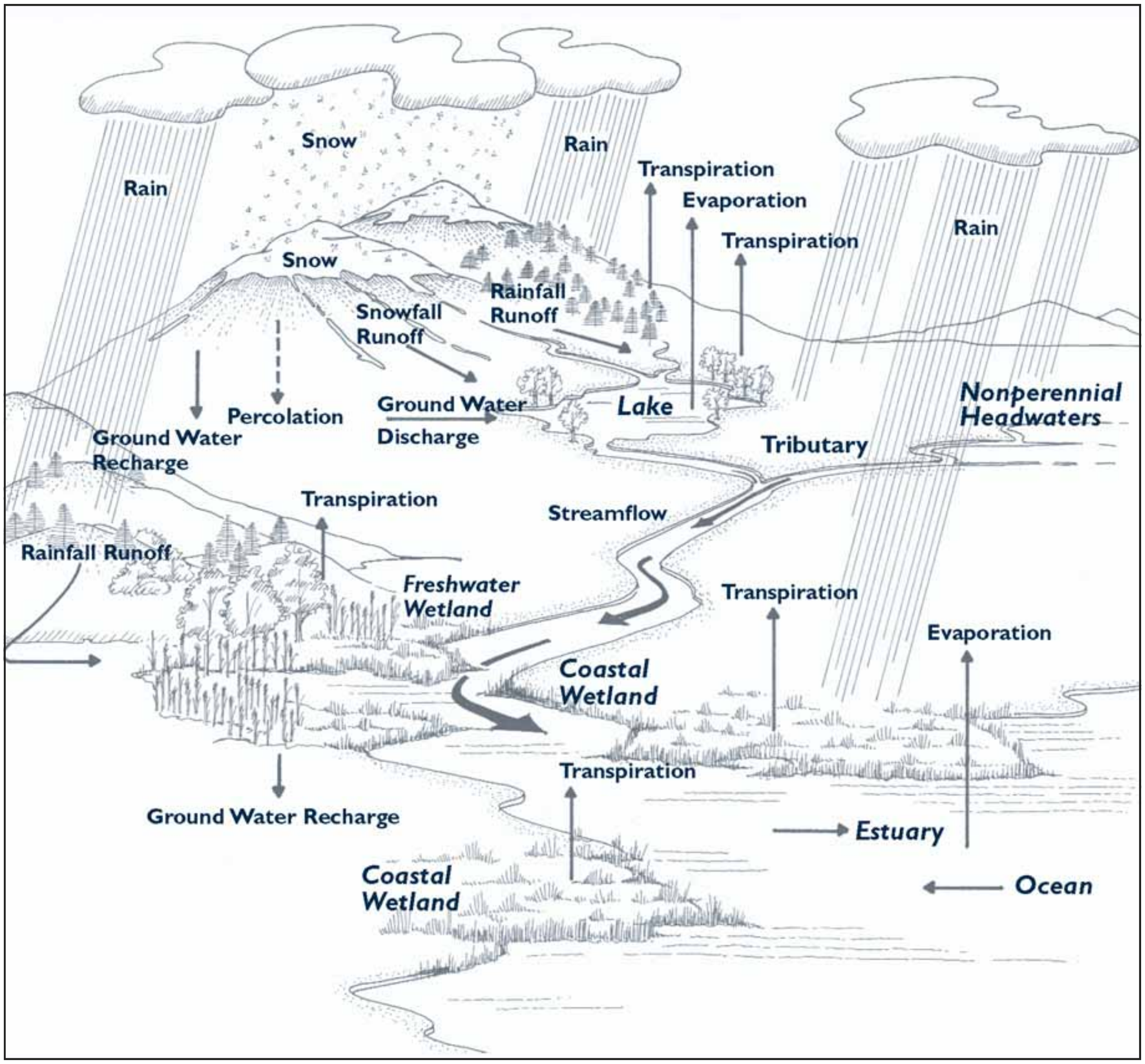
CHAPTER

1

Storm Water Runoff and Its Impact

INTRODUCTION TO STORM WATER RUNOFF

Storm water runoff is a part of the earth's hydrological cycle. The hydrological cycle is a conceptual model that describes the distribution and movement of water between the atmosphere, land, and water. The hydrologic cycle can be characterized by the diagram below.



Water that reaches the surface of the earth may:

- Percolate directly into the ground where it can be stored as groundwater or slowly migrate toward a waterbody.
- Flow into a creek, river, wetland, lake, or other natural features.
- Be taken up by roots of trees, grass, and other plants.
- Return to the atmosphere through evaporation, which is the transformation of water from a liquid into a gas.
- Return to the atmosphere through transpiration, which is the process whereby plants release water vapor back into the atmosphere through their leaves.

INTRODUCTION TO STORM WATER RUNOFF

Precipitation that reaches the surface of the earth is either absorbed by the soil through percolation or flows overland as runoff. Vegetative cover enhances absorption by intercepting the rainfall, slowing runoff, and providing root channels that promote infiltration.

Storm water runoff is the volume of water generated by a rainfall event, snowmelt, or other forms of precipitation that falls to the earth's surface and does not infiltrate into the ground. Runoff can be directly correlated with a specific land use. Runoff associated with a forested landscape will typically be less than runoff from an urbanized landscape.

Following rainfall events or snowmelt, runoff flows overland and picks up materials including but not limited to trash, debris, sediments, and pollutants. The runoff can often contain pollutants in quantities that will affect water quality. Runoff can carry a variety of pollutants that are associated with a specific land use. These materials can remain in solution or attach to sediment and will eventually be deposited in the lowest part of the landscape or discharged to creeks, rivers, lakes, and wetlands.

Storm water volume and runoff rates are directly related to the impervious surface area in a watershed. Land development and urbanization typically increase surfaces that are impervious. During construction an increase in runoff can often be attributed to compaction by heavy equipment. Typical urban landscapes have a high percentage of impervious surfaces due to parking lots, rooftops, roads, and highways.

The remainder of this chapter will focus on the pollutants associated with construction and urbanization and their impact to water quality.

IMPACTS OF URBANIZATION

A watershed's physical, chemical, and biological characteristics are generally altered when land undergoes some type of development. The watershed's storm water runoff quantity and quality can also be significantly affected. This is particularly true when undeveloped or agricultural land is converted to urban uses. For example, the hydrologic changes in an urban watershed are often magnified due to an increase in impervious surfaces such as rooftops, streets, sidewalks, and parking lots. This increase in impervious surface area usually decreases the amount of time it takes for storm water runoff to move from remote areas of the watershed to the receiving stream or waterbody. In addition, urban development usually requires the construction of storm water conveyance systems which are typically designed to convey storm water runoff in an efficient manner without regard for its impact. Therefore, not only is it quicker for storm water runoff to flow over paved surfaces versus a natural landscape, but these conveyance systems can expedite drainage into the nearest receiving waterbody. The overall result is a significant change to the predevelopment hydrologic conditions of the watershed. A drop of water that used to take hours or days to make its way through the watershed to a receiving waterbody now takes a matter of minutes or hours.

Another impact from altering a watershed's hydrology is an increase in peak runoff volumes. Increased peak runoff volumes can increase the frequency and severity of stream flooding during storm events. Conversely, during non-storm periods the flow in the channel or stream can be diminished greatly or in some instances there may be no flow in the channel or stream.

IMPACTS OF URBANIZATION

Peak runoff volumes are typically the result of an increase in impervious surface areas. An increase in peak runoff volumes generally results in the alteration of stream channels, natural drainageways, and riparian habitats. These alterations can have a significant impact on the reduction, and in some instances the elimination, of aquatic vegetation and organisms and can degrade water quality. Other potential effects include increased streambank erosion and streambed scouring, channel siltation, increased water temperatures, decreased dissolved oxygen levels, and changes to the morphology of the watercourse.

Increased pollutant loadings and discharges are still another impact of urban storm water runoff from impervious surface areas. Pollutants associated with urban areas are specific to the type and intensity of the land use. Some examples of pollutants associated with urban land uses include sediments, nutrients, oxygen demanding substances, road deicing agents, heavy metals, oils and grease, hydrocarbons, and bacteria. Runoff from commercial land uses such as shopping centers, business districts, office parks, and parking lots or garages may contain high hydrocarbon loadings and metal concentrations. Pollutant loadings from these types of land uses can be a significant pollutant source in storm water runoff and can be attributed to heavy traffic volumes and large impervious surface areas.

Gas stations are one type of land use that is often designated as a commercial land use and are subject to the same controls as shopping centers and office parks. However, gas stations may generate higher concentrations of heavy metals, hydrocarbons, and other automobile-related

IMPACTS OF URBANIZATION

pollutants. This is because of the type of day-to-day activities associated with the industry and the volume of clientele that use the facilities. There is also a higher probability for spills to occur at these facilities because of human error.

Protecting or improving water quality in existing urban areas is often difficult because of diverse pollutant loadings, large storm water runoff volumes, limited areas suitable for surface water runoff treatment systems, high costs associated with structural implementation of storm water measures, and the nonexistence of natural or manmade buffer zones. Most existing urban developments have typically been built without consideration for water quality protection. The objective during construction was more likely focused on using the land to its greatest potential for the planned land use. With this approach it is often difficult to address the reduction of pollutants after the fact due to space limitations and the inability to choose the most cost-effective and efficient measure to achieve pollutant removal. However, numerous opportunities exist to address storm water quality impacts and build storm water quality control and treatment measures into projects which propose to convert areas into urban landscapes.

The alteration of the soil probably has the greatest impact on water quality. Therefore, soil should be the first consideration for any proposed land use change. Soil is a subsystem, with a unique set of characteristics such as soil structure and permeability, within the earth's ecosystem. The primary function of soil is to support life. Therefore, there is a natural balance and interrelationship between soil, microorganisms, plants, and animals. This delicate balance can be significantly altered as a result of land use changes and construction activities. These human activities can affect the natural soil characteristics and health of the ecosystem in varying degrees. Changes to the soil ecosystem can be physical such as alteration or destruction of the soil structure while others may be biological or chemical. For example, construction and land disturbance can cause changes in the number and type of organisms that live in the soil. Loss of this soil biota leads to erosion, loss of humus (organic matter), loss of soil structure, and increased potential for soil compaction.

Soil erosion on construction sites has been said to have impacts that are more costly and severe than those of non-construction site impacts. More specifically, erosion causes the depletion of an important resource, nutrient rich topsoil, and often results in degradation of water quality. This is typically due to increased sediment loads and pollutants attached to the soil particles. Excessive sedi-

IMPACTS OF URBANIZATION

ment deposited on productive agricultural lands or forestlands can also make them sterile and unproductive.

Sediment is the most common pollutant associated with storm water runoff from construction sites. In fact, it has been shown that sediment is the number one pollutant, by volume, of surface waters of the United States. Sediment is also the primary pollutant that is addressed by state and local officials when they regulate construction projects. However, there are several other pollutants associated with construction activities. Some of these pollutants include, but are not limited to, solid wastes, nutrients, pesticides, petroleum products, and chemicals associated with construction activities.

The nature of the construction activity plays an important role in the types of pollutants that may be released from a construction site. For example, construction activities that result in massive earthmoving are likely to have a higher potential for off-site pollutant discharge. An alternative is to develop a project in phases and work with the natural landscape of the site which will result in minimal land disturbance and a reduction in the generation of pollutants. On projects where heavy equipment is utilized there is potential for the release of pollutants from vehicle refueling, fuel storage facilities, and equipment and maintenance areas.

The amount, intensity, and frequency of rainfall; soil type (infiltration rate, organic matter content, etc.); soil surface roughness; slope length and steepness; and ground cover (vegetated or unvegetated) are other factors that can have a significant impact on the amount of pollutants discharged to surface waters and ground water. In addition, the location of the construction site in relation to the receiving waters can have an overall impact on water quality.

The consequences of erosion and subsequent sedimentation can be far-reaching. It has been estimated that on average, one acre of land under construction contributes almost 30 tons of sediment to nearby lakes, rivers, and streams (Source: Wisconsin Department of Natural Resources). In fact, small streams show the most pronounced effects of sediment pollution because they are more easily clogged with sediment. This is primarily due to the stream's size. These small streams account for 86 percent of all stream and river miles in the continental United States (Source: "Protecting our Water," Delaware Nature Society). Therefore, sediment pollution is a major concern across the United States because of the high percentage of small streams and their susceptibility to clog with sediment.

IMPACTS OF URBANIZATION

In addition to clogging small stream channels, sediment accumulation is a concern because it decreases the channel's capacity to carry water. This increases the frequency of flooding and can lead to streambank erosion or scour. In fact, urbanization and associated construction activities can increase the occurrence of small floods by a factor of ten or more. High sediment loads and increased frequency of flooding also expedites the shifting or movement of a stream channel as the channel tries to compensate for its reduced capacity.

Another consequence of construction site erosion is that the resulting sediment is often deposited in low, depressional areas such as lakes, ponds, and wetlands that collect and retain surface water runoff. As sediment accumulates in the bottom of these areas, it slowly decreases the depth in which water can stand. As the water depth decreases in these enclosed ecosystems, the system loses its ability to support the plant, animal, and microorganism system it supported with the greater water depths. This issue is becoming a widely recognized problem, especially in natural wetland areas.

Wetland plants and microorganisms are very efficient at removing pollutants from surface water runoff, but as an ecosystem's capacity is diminished its filtration ability decreases. The end result is infilling of the wetland area and loss of habitat for the plants and microorganisms.

It is important to recognize that many depressional areas often serve as ground water recharge areas. As sediment accumulates in the bottom of these depressions it reduces the amount of water the depression can hold. In addition, the sediment seals over the bottom of the depression which then restricts or prevents ground water recharge.

Perhaps the most evident change to any landscape undergoing land-disturbing activities is removal or alteration of the vegetative cover. Vegetative cover plays a very important role in protecting soil resources and improving or maintaining water quality. Many plants have an inherent ability to cleanse water. They take up chemicals and heavy metals from the soil and/or water as they take up the nutrients they need to grow. Some plants are even able to alter the chemistry of the pollutants so that they can not be readily absorbed by animals and humans. The plants can then release the altered, benign pollutant(s) into the soil, water or air. Removal of vegetation can have a profound effect on soil and water quality because the ability to filter or cleanse runoff is lost with the loss of the vegetation.

IMPACTS OF URBANIZATION

Removal of vegetation from the soil surface has an immediate impact on the ecosystem. Almost immediately after vegetation is removed, the exposed soil begins to undergo erosion because plant roots are no longer available to grip the soil particles for plant stabilization and provide channels for air and water to circulate through the soil. The removal of plants also reduces the humus content, which binds the soil together in aggregates and gives the soil structure. Without plants, the structure of the soil begins to break down and the soil dries out. The soil then becomes susceptible to the erosive forces of wind and water and the negative impacts that construction equipment and machinery have on soil stability. Thus, the erosion process has begun.

Nutrients, pesticides, and heavy metals are easily absorbed onto exposed surfaces of the loosened soil particles once they have become detached and eroded. The eroded soil particles and attached contaminants are free to move throughout the environment. As these soil particles move, they can accumulate as polluted or contaminated sediments in the landscape or in waterbodies such as lakes or streams.

Vegetation has the ability to reduce storm water runoff because it slows storm water runoff velocities which in turn allows the runoff to infiltrate into the underlying soil. Grasses and larger plants such as trees often create an extensive, fibrous root system that helps bind the soil together and provides channels for the infiltration of water and air. In addition, leaf and needle

IMPACTS OF URBANIZATION

litter frequently acts as a sponge, reducing the flow of storm water runoff and increasing infiltration into the underlying soil. As these materials decay, they add humus to the soil. This helps loosen the soil and promotes the formation of soil structure which in turn promotes the infiltration of surface water.

In regard to erosion, vegetative canopies act like an umbrella to protect the soil from raindrop impact. Decaying plant stems and leaves and leaf and needle droppings provide a mulch cover over the soil surface which again protects the soil from raindrop impact.

Urban forestry management is another vegetative measure that can have an impact on soil and water quality. Trees can buffer the effects of climate extremes. For example, during summer months, they provide shade and can reduce home cooling costs. During winter months, they provide protection from the wind, reducing home heating costs and trapping snow which helps recharge soil moisture in the spring.

A forest's age is important in protecting soil and water quality and providing food and habitat for wildlife. Leaf litter and woody debris are important food and habitat sources for animals and organisms that live in and around the ecosystem, particularly in headwater reaches of a stream. Small aquatic organisms ingest and break down the decaying plant materials. Higher-order organisms feed on the smaller organisms and may transform some of the leaf litter and debris. Areas of newly planted trees usually lack this accumulation of leaf and needle litter and vegetative understory. Areas of newly planted trees are also less effective at preventing erosion verses a well-established forest that has a dense canopy and well-established root system. Therefore, protecting and preserving established forests should be a very important component of any land use change when forests are present. It is important to note that forest succession is a lengthy process. It typically requires several years to establish a diverse, complex mix of mature trees and saplings with well-developed root systems, a well-developed understory, and an adequate cover of downed trees, leaves, and leaf and needle litter.

Another impact of urbanization is the effect it can have on food and habitat for aquatic organisms, aquatic insects, fish, amphibians, freshwater mussels, wildlife, and so on. Water quality can affect the diversity and abundance of plant and animal species living in the ecosystem, feeding and mating habits, and nesting and resting areas. Numerous studies have

IMPACTS OF URBANIZATION

examined the link between watershed urbanization and its impact on stream and wetland biodiversity. These studies reveal that a relatively small amount of urbanization (as little as 10 percent impervious cover) has a negative effect on aquatic diversity. The hydrologic, physical, and water quality changes caused by watershed urbanization all stress the aquatic community and collectively diminish the quality and quantity of available habitat. As a result, these stressors generally cause a decline in biological diversity, a change in trophic structure, and a shift towards more pollution-tolerant organisms.

Urban conditions that negatively affect biodiversity include deposition of sediment in streambed substrate, large woody debris removal, stream crossings, increased water temperatures, increased pollutant loads, decreased base flows, loss of pools and riffles, channel straightening or hardening, increase in turbidity, and algae blooms.

Unfortunately, when land undergoes development much of the existing vegetation is unintentionally damaged or it is removed to provide for the construction of roads, parking areas and buildings. As vegetation is removed animals become displaced and they are required to seek other food sources and habitat. Often, these displaced animals struggle to adapt to their new environment. Aquatic organisms, aquatic insects, fish, amphibians, freshwater mussels, wildlife, and other species of animals and plants can also struggle for survival when sediment is introduced into their environment. Sediment causes turbidity (cloudiness of water) which in turn limits photosynthesis and plant growth. This can affect the entire aquatic food chain and interrupt reproduction processes. Suspended sediments can damage the gills of fish and severely reduce stream depth. Sedimentation of the channel can destroy or cover fish spawning grounds and can even limit the movement of fish upstream and downstream to get to these spawning grounds.

Urbanization usually has a negative impact on waterways and drainage channels. As storm water runoff and stream velocities increase, the potential for streambank erosion and scouring of the channel bottom is greatly increased. The eroding banks eventually slump, destroying naturally occurring undercuts that provide shade, cover and habitat for fish and other aquatic animals. This slumping process can be further exacerbated by clearing any existing riparian buffers. Streambank erosion also contributes to sediment deposition in the bottom of the channel which reduces channel depth. The waterway or drainage channel then tries to compensate for the reduction in channel depth by widening the channel. Once sediment has been introduced into the drainage system, it can remain in the system for a very long time. The following is a list of some long-term impacts associated with sediment deposition in stream channels:

- As sediment loads move through the drainage system they abrade the streambanks and destroy the food supply and habitat of aquatic organisms.
- Sandbars often increase in size, further restricting channel flow which usually results in increased flow velocities and accelerated streambank erosion.
- Reduction in channel depths leads to potentially less interchange of water, dissolved gases, and organic material between the water column and streambed.
- Macroinvertebrate diversity and numbers are decreased due to microhabitat change and degradation.
- Food supplies, spawning beds, and fish habitat is destroyed.

As shown in the previous discussion, development in one part of a watershed can have a significant impact and consequences on downstream areas of the watershed. However, when preservation and conservation measures are put into practice, nonpoint source pollution can be diminished and water quality can be maintained or even improved in some instances. Plant and animal communities can be protected and under ideal circumstances they can increase in number and diversity. Overall, water quality and the health of the entire watershed can be improved if storm water quality measures are properly installed and maintained.

Many of the previously discussed issues have rarely been addressed by local units of government when they regulate construction and land-disturbing activities. However, many communities are becoming more aware of these issues and are developing local programs to address erosion, sedimentation and storm water issues related to quantity and post-construction pollutants.

There is a wide variety of storm water quality measures that can be implemented on construction sites to prevent or minimize erosion and the associated environmental damages. These measures include both structural and nonstructural measures. Nonstructural measures are typically used to prevent or control erosion at its source. Structural measures on the other hand are designed to manage runoff and filter or allow for the settling of sediments suspended in storm water runoff. Erosion controls have a distinct advantage over sediment controls because they reduce the amount of sediment generated and transported off-site, thereby reducing the need for extensive sediment control measures. When erosion controls are used in conjunction with sediment controls, the size of the sediment control measures and associated maintenance may be reduced, resulting in decreased treatment costs.

Simple precautions such as identifying ecologically sensitive areas and marking them as “off limits” or protecting them from construction activity is one simple method of protecting the resource(s) from construction activity. This measure can be used to protect trees, native plants designated for preservation or use in the final landscaping, and animal habitats. It should be noted that erosion and soil loss is unavoidable during land-disturbing activities. While proper

IMPACTS OF URBANIZATION

siting and design will help prevent areas prone to erosion from being developed, construction activities will invariably produce conditions where erosion will occur.

Pollutants that are associated with the post-construction land use can also be minimized by targeting specific pollutants and utilizing appropriate storm water quality measures. Post-construction impacts can also be reduced through planning projects that utilize natural site features and that incorporate principles that reduce impervious surfaces and the generation of pollutants.

A key element to storm water management that should be used on all projects is a storm water pollution prevention plan. This type of plan is very important in reducing the environmental impacts that are associated with active construction and post-construction land use. An effective storm water pollution prevention plan will incorporate design principles and an integrated system of structural and nonstructural storm water quality measures to minimize the adverse impacts to the watershed's ecosystem.

Following chapters of this manual provide more detailed discussion in regard to storm water pollutants associated with urbanization and identify storm water quality measures that can be used to minimize the impacts of urbanization.

POLLUTANTS ASSOCIATED WITH URBANIZATION

The previous "Impacts of Urbanization" section discussed the impacts of urbanization and the pollutants that are associated with existing development, new development, and active construction sites. The pollutants associated with existing and new development are directly related to the land use. The primary pollutant associated with construction sites is sedimentation. Sediment is the number one pollutant by volume of surface waters in the United States. In addition to sediment, other pollutants associated with construction activities may include pesticides, petroleum products, nutrients, solid wastes, and various chemicals.

Other types of activities also have specific pollutants associated with them. These pollutants are generated from the operation and maintenance of roads, highways, and bridges as well as everyday activities and have a direct impact on the environment.

Roads, Highways, and Bridges

Pollutant sources associated with roads, highways, and bridges include both those generated during construction activity as well as those that are generated once the roadway becomes operational. Sources of pollutants associated with construction activities include sedimentation, on-site fuel storage and fueling operations, solid waste generation, chemicals associated with day-to-day operations, and nutrients from soil amendments used during site stabilization. Pollutants associated with operational activities include roadway maintenance operations (e.g., fertilizers, pesticides), solid waste generated from littering, and pollutants washed from the pavement (e.g., hydrocarbons, heavy metals, deicing agents).

Highway maintenance garages and rest areas can be major contributors to pollutant loadings. Maintenance garages are typically used for refueling and storage of sand and salt materials. If not properly managed, these substances can become potential pollutants. Rest areas can contribute to pollutant loadings because of their large, impervious parking areas and the high volume of vehicles that stop at these facilities.

General Sources (Including Household, Commercial, and Landscaping)

General sources of pollutants are those that are generated as the result of day-to-day activities by the public and businesses. Household activities, lawn and garden care, turfgrass management, vehicle use and maintenance, on-site sewage disposal systems, illegal discharges, and pet and domesticated animal wastes are the primary sources of pollutants associated with general day-to-day activities.

POLLUTANTS ASSOCIATED WITH URBANIZATION

Everyday household activities generate numerous pollutants that may affect water quality. Common household waste includes paints, solvents, lawn and garden care products, detergents and cleansers, and automotive products such as antifreeze and oil. A household product that contains hazardous substances becomes household hazardous waste once the consumer no longer has a use for the product and disposes of it. These pollutants are typically introduced into the environment due to ignorance on the part of the user or the lack of proper disposal options. The public unknowingly assumes that storm drains discharge into sanitary sewers and dump materials into storm drains under the assumption that treatment will occur at the sewage treatment plant. It is also commonplace for users to dump or dispose of many of these types of products directly onto the ground, not realizing that the materials can be carried to surface waters by runoff or pollute ground water if they are leached through the soil. Hazardous waste from households is not regulated as hazardous waste under federal and Indiana laws.

Landscaping activities are another common contributor to the pollutant loading of waterbodies within a watershed. For example, improper application or overapplication of fertilizers and pesticides can impair surface waters. In addition to surface water impairment, overapplication of nitrogen fertilizers can pollute ground water when it leaches through highly permeable soils. Improper disposal of lawn trimmings also leads to increased nutrient levels in storm water runoff. Lawn trimmings deposited in street gutters can be washed into drainage systems and result in elevated nutrient loadings of the receiving waterbody.

Litter and debris are significant contributors to the degradation of surface and ground water. Smaller materials are often carried by storm water runoff and deposited in surface waters. Improper disposal of larger items such as refrigerators and air conditioners can impair water quality through the release of fluids into surface water and ground water. These items degrade the aesthetic and recreational value of surface water and are a hazard to wildlife and aquatic organisms.

Domestic pet droppings have been found to be an important contributor of nonpoint source pollution. It has been shown that these waste materials can elevate fecal coliform and fecal streptococcal bacteria levels of waterbodies. This type of pollutant is most commonly associated with dogs. However, other urban animals such as domesticated or semi-wild ducks and Canadian geese can be major contributors to the nonpoint source pollution problem in areas where their populations are high.

Potential for impairment of surface waters and ground water can be greatly reduced through the proper handling, storage, management and disposal of the pollutants discussed above. The aforementioned techniques are discussed in the post-construction sections of this manual.

POLLUTANTS ASSOCIATED WITH URBANIZATION

Typical Urban Pollutants

Pollutant	Contaminants	Sources	Effects	Impacts
Nutrients	• Phosphorous • Nitrogen	• Septic Systems • Agricultural runoff (fertilizers, animal waste) • Urban landscape runoff (fertilizers, detergents, plant debris)	Phosphorous is typically the primary nutrient of concern in freshwater systems as is nitrogen in saltwater systems. These nutrients encourage algal growth that can contribute to greater turbidity and lower dissolved oxygen concentrations. Lower dissolved oxygen can cause the release of other substances (pollutants) into the water column. Higher levels of nitrogen (nitrates) in groundwater are most commonly associated with agricultural practices and malfunctioning septic systems.	• Can limit recreational values (swimming, boating, fishing, and other uses) • Can reduce animal habitat • Potential contamination of water supplies
Solids	• Sediment (clean and contaminated) • Floatable wastes	• Construction sites • Agricultural lands • Disturbed and/or unvegetated lands including eroding stream banks • Floatable wastes are contributed from street litter and careless disposal practices	Increased turbidity and deposition of sediment.	• When deposited, clean sediment can decrease storage capacity to waterbodies, destroy benthic habitat (including animal nesting and spawning areas), and smother benthic organisms • Suspended solids can decrease transmission of light through water and interfere with animal respiration and digestion • Contaminated sediment acts as a reservoir for particulate forms of pollutants, such as organic matter, phosphorous, or metals that could be released later • These pollutants can be toxic or can decrease dissolve oxygen levels through the process of sediment oxygen demand (SOD) • Floatable wastes reduce the aesthetic value of the resource area and can cause clogging
Pathogens	• Bacteria • Viruses	• Animal waste (including pets and birds) • Failing Septic systems • Illicit sewage connections	Presence of bacteria and viral strains including fecal streptococcus and fecal coliform, in high numbers	• Can pose health risks • Can close or restrict use of shellfish beds and beach areas
Metals	• Heavy metals including lead, copper, cadmium, zinc, mercury, and chromium	• Industrial activities and waste • Illicit sewage connections • Automobile wear, exhaust and fluid leaks • Atmospheric deposition	Increased toxicity of runoff and availability of metals that can enter into the food chain.	• Metals can accumulate in certain animal tissues that could be ingested by humans or other animals • Can affect sensitive animal species, plants and fisheries

POLLUTANTS ASSOCIATED WITH URBANIZATION

Typical Urban Pollutants (continued)

Hydrocarbons	• Oil and grease • Petroleum-based substances • Polycyclic aromatic hydrocarbons (PAHs)	• Parking lots and roadways • Oil Leaks • Auto Emissions • Illicit sewage connections • Illegal dumping of waste oil	Degraded appearance of water surfaces; limiting water and air interactions (lowered dissolved oxygen).	• Toxic to sensitive animal species • Degrades fisheries habitats
Toxic Organics	• Pesticides • Polychlorinated biphenyls (PCBs)	• Indoor and outdoor use • Industrial activities • Illicit sewage connections	Increased toxicity to sensitive animal species and fishery resources.	• Causes loss of sensitive animal species and fishery resources
Acids	• Nitrates (NO_3) • Sulfides (SO_2)	• Incomplete combustion process coupled with atmospheric reactions (acid rain)	Increased toxicity to sensitive animal species and fishery resources.	• Causes loss of sensitive animal species and fishery resources
Humic Substances	• Plant materials such as grass clippings and leaves	• Urban and suburban landscapes	Increased loading into waterbodies of organic materials that require oxygen to decompose; lowered dissolved oxygen levels can cause the release of other substances (pollutants) into the water column.	• Degrades fishery resources • Reduces fish populations
Salt	• Sodium • Chloride	• Road salting procedures	Increased toxicity to organisms, reduction of fishery resources, and increased levels of sodium and chlorides in surface and ground waters. Could stress plant species' respiration processes through their effect on soil structure and can cause loss of other compounds necessary for plant viability.	• Causes loss of sensitive animal species, plant species, and fishery resources • Contaminates surface and ground waters

CHAPTER

2

Construction Site Assessment & Planning

INTRODUCTION TO SITE ASSESSMENT & PLANNING

Construction site assessment and planning is an important part of any construction project. Prior to planning, designing, or laying out a project, it is important for the plan designer to have knowledge of the project site and adjacent areas. To accomplish this objective it is necessary to collect information about the proposed project site. This information can then be used by the plan designer to make informative decisions in regard to project planning, design, and layout. In addition, it allows the plan designer to develop a set of construction plans that will allow for development of the project in an efficient, cost-effective, and environmentally sensitive manner.

Construction site assessment and planning usually involves three steps. Step one is site assessment and data collection. The second step is to analyze the collected data. The third and final step is to begin incorporating this information into a preliminary concept and design.

SITE ASSESSMENT & DATA COLLECTION

Site assessment and data collection is the first step in the planning, design, and layout of any construction project. This step involves collection of resource information applicable to the project site. Information can be obtained through research of existing publications, maps, studies, and other resources. In addition to obtaining information through research of existing documents, it is important to walk the project site to obtain a visual appreciation of the site and site features.

Taking good notes and documenting information is very important in this phase of site assessment and planning. Collected information can be documented in narrative or graphical format. Information that is collected in graphical format such as maps should be of the same scale whenever feasible. This allows the plan designer to overlay different site maps and compare various resources and data at a quick glance.

Key information that should be collected includes but is not limited to the following items.

Vegetative Cover

The type and amount of vegetative cover is one of the easiest forms of data to collect for a project site. This information gives plan designers an understanding of the stability of the site and its current susceptibility to erosion.

Vegetative cover can be documented in narrative and/or graphical format. Graphical documentation should be on a map or overlay and at a minimum include the delineation and identification of existing vegetation such as grass, shrubs, trees, groupings or clusters of trees, unique vegetation, and so on. If the site is farmed, documentation should identify the crop and/or crop residue at the site. Narrative documentation should include the quality and condition of the vegetation, its ecological and aesthetical value, and its potential for use in the planning, design, and layout of the proposed project.

Soils Information

Soils information is another key component in the planning, design and layout of construction projects. Soil types in conjunction with site topography can provide valuable information in determining areas with a high potential for erosion. Soils data can also be used in the selection, sizing, design, and placement of storm water management measures.

Soils information can generally be obtained from the U.S. Department of Agriculture's Natural Resources Conservation Service county soil surveys which are available through local county soil and water conservation district offices. Soils data can also be obtained through the services of private soils consultants or firms who prepare geotechnical reports.

SITE ASSESSMENT & DATA COLLECTION

Soils data should be documented in both graphical and narrative form. Soil types should be delineated directly onto an aerial photograph or an overlay of the same scale as the topographic map(s) for the project site. This facilitates the comparison of soil types and their relationship with the topography of the site.

Data collection should also include information pertaining to critical areas or features such as steep slopes (see Topographical Information below), rock outcroppings, seepage zones, and any other unique or noteworthy landscape features.

Soils data should be documented in narrative form as well as graphical form. The narrative should describe the respective soil types including their physical characteristics and their limitations and/or hazards for the intended land use. Soils information that is most commonly collected and useful in the design and layout of a project includes but is not limited to depth of topsoil, soil texture and particle size, infiltration rate, permeability, depth to limiting layers (i.e., bedrock, fragipan, glacial till), shrink-swell potential, low strength, susceptibility to erosion, ponding, and depth to the seasonal water table.

Topographical Information

Site topography is critical to project planning, design and layout. Topographic maps provide useful information that the plan designer can use to determine drainage patterns, slope gradient and length, and the location of ecologically sensitive features such as waterbodies.

Topographic elevations for a project site should be documented in graphical form. Topographic information can be obtained from United States Geological Survey quadrangle maps (these may not provide the detail appropriate for site planning) or the data can be collected by conducting an on-site topographic survey. If the data is collected through an on-site survey, the topographic map should show existing contour elevations at intervals that are appropriate to determine drainage patterns and slope of the land. One foot and five foot contour intervals are the most common intervals used when making an on-site topographic survey. However, in areas with steep terrain it may be acceptable to use an interval of ten feet

Hydrological Information

Hydrologic features are critical in planning, designing, and laying out a construction project. It is extremely important to identify, delineate, and record all depressional areas such as ponds, lakes and wetlands and conveyance systems, including swales, ditches, streams, creeks, rivers, and areas of concentrated flow that are on or adjacent to the project site. This information allows the plan designer to determine drainage patterns, evaluate the condition of various drainage features, determine if they can be incorporated into the project, and select storm water management measures to protect ecologically sensitive areas.

SITE ASSESSMENT & DATA COLLECTION

Streams, ponds, and other water features located downstream from the project site should be surveyed to determine their carrying capacity and sensitivity to sedimentation and flooding. It is important to consider their potential for channel or shoreline erosion as a result of increased storm water runoff volumes, velocities, and peak discharge flows.

Many Indiana soils have a seasonal high water table. Over the years, landowners have installed numerous subsurface tile drainage systems to manage the seasonal water table for agricultural production. Interconnected subsurface drainage systems frequently cover several parcels of farmland. Breakage or disruption of a subsurface drainage system often affects the drainage on adjacent properties and can result in ponding or flooding of upstream areas. Therefore, when land is converted from agricultural uses to urban uses, it is extremely important to identify and delineate these subsurface drainage systems so that they can be integrated into the planning process. Locating subsurface drainage tile is generally more difficult and requires on-site exploration. Some landowners may have a written record or graphical plans showing the location of subsurface drain tiles on their properties. In extremely rare instances, local soil and water conservation districts may have aerial photographs showing the location of subsurface drain tiles or written records/graphical plans showing drain tile locations.

Hydrologic data of a project site should be documented in graphic and narrative form. Major conveyance systems and waterbodies can generally be identified using U.S. Geological Survey quadrangle maps and U.S. Fish and Wildlife Service National Wetlands Inventory maps. Smaller features may require on-site visual inspection and documentation.

Hydrologic features should be delineated on a topographical map or overlay. All locations where storm water runoff may enter, cross, and/or exit the project site should be clearly identified. Areas where storm water runoff may concentrate on the project site should also be identified on the map or overlay.

Once again, hydrologic features should be documented in narrative form as well as graphical form. The narrative should describe the condition of the drainage feature, its ecological value, its aesthetic value to the project, and its potential for use in the project's overall storm water drainage and management system.

Adjacent Areas

Site assessment and data collection should include an evaluation of adjacent properties and their respective land uses. This information provides the plan designer with valuable information that can be used to determine the effects that storm water runoff and pollutants associated with upstream watershed land uses (e.g., single-family residential, multi-family residential, commercial, industrial, agricultural, woodland, etc.) might have on the proposed project site. It also aids in projecting what impacts a project might have on downstream watersheds and sensitive areas.

Features of significance that should be documented and evaluated include but are not limited to rivers, streams, creeks, lakes, ponds, wetlands, wooded areas, roads, culverts, houses and other structures. Site assessment should include documenting the potential for sediment deposition and damage to adjacent properties as a result of sheet and rill erosion from the project site once construction begins.

Adjacent land uses and site features should be identified and delineated on a site map or overlay. If a particularly important feature(s) is located a significant distance outside the limits of the project site, the feature should be documented in a detailed note on the site map or a smaller scale map should be used to clearly identify the location and specific details of the feature.

Utility & Highway Corridors

Utility and highway corridors and easements on or adjacent to a construction project should be identified and delineated on a project site map. This information is useful when planning, designing, and laying out a project and developing a construction plan for the project.

Existing Infrastructure & Potential Problem Areas

A commonly overlooked aspect of site assessment and data collection is the identification of past activities and potential problem areas associated with the project site. These issues can often delay or even stop a project if they are overlooked.

All existing structures and infrastructure associated with a project site should be identified on a project map. If buildings and other structures are present and are to be demolished, an assessment of the building materials and contents should be characterized and documented in the narrative.

Some of the more common areas of concern that should be identified on a site map or in the project narrative include abandoned wells, underground storage tanks, improper disposal of trash and debris, subsurface drainage tile, buried waste materials, and contaminated soils.

Natural, Historical & Archeological Features

Natural, historical, and archeological features can also delay or stop a project if not addressed in the planning, design and layout of a project. This element of site assessment and data collection should include features that may be impacted by the overall project, from initial construction through the final land use.

SITE ASSESSMENT & DATA COLLECTION

The project site should be assessed for the presence of any historical or archeological features. This includes but is not limited to historic buildings/features, burial sites, and artifacts. Common artifacts include spear points, arrowheads, knives, chipped or broken stone debris, ground stone axes, grinding stones, mortars and pestles, awls, gouges, pottery, clothing and ornamental pins, decorative items and ornaments, scraping tools, hammerstones, bone fishhooks, stone perforators, and beads. For more information regarding historical and archeological issues, please contact the Indiana Department of Natural Resources, Division of Historic Preservation and Archeology.

Natural features such as bodies of water, floodplains, wetlands, sinkholes, unique habitat, and presence of endangered or threatened species should be identified on a site plan map or in the project narrative.

Regulations

While is it still early in the planning, design and layout process and many decisions still need to be made, it is not too early to start evaluating what permits may be needed for the project.

Regulatory requirements can influence land use and project layout decisions. Often, a project's design or layout can be modified or adjusted to avoid the need for a specific permit or to meet specific regulatory requirements. Therefore, site assessment and data collection should include documentation identifying the need or potential need for local, state, and federal regulatory permits. The types of permits needed will be dependent on the nature and scope of the project.

ANALYSIS OF COLLECTED DATA

As the site assessment and data collection phase nears completion, a picture of the project site's potential and limitations will begin to emerge. The next step in the planning, design, and layout process is to analyze, interpret, and compare the site resource information and data that has been collected. As the data is analyzed it may be necessary to conduct additional research on one or more items associated with the project or to return to the site to make additional field observations.

The remainder of this section of the manual provides insight into the decision-making process and gives guidance in the review and interpretation of the data that was collected during the site assessment and data collection process.

Vegetative Cover

Analysis of vegetative cover should begin by identifying vegetation that is of high quality and value and may enhance the aesthetics of the overall project. Vegetative cover or features that may be of particular interest include but are not limited to unique habitat areas and riparian corridors. Trees in particular can be a very valuable asset and can significantly increase the aesthetics and salability of lots within a project. Some communities in Indiana have requirements to preserve trees when land is developed. When evaluating and assessing trees, it is often times very beneficial to consult a professional forester. They can identify which trees will add the greatest value to a project and identify which trees are diseased or may not survive construction activities.

Soils Information

As soils information is evaluated, it is often beneficial to group soils with similar characteristics. For example, grouping of soils with similar seasonal water table depths can help determine which areas of a residential project are best suited for home construction verses which areas might be used for common areas or greenways. Grouping of seasonal water table depths can also provide insight into which soils have limitations for roads and streets because of frost action.

Part of the data analysis process should include an understanding of state and local regulatory agency on-site waste disposal regulations. While grouping of soils with rapid permeability or slow permeability can help determine overall areas best suited for on-site sewage treatment disposal systems, it is generally recommended that specific on-site soil evaluations be performed on each individual on-site waste disposal system site to determine the soil's adequacy to support such a system.

In regard to water quality, soil erodibility is one of the first soil characteristics to review and evaluate. Soil erodibility will help determine the location and size of storm water management and treatment measures. For example, soils with a high percentage of mineral particles that are 0.02 mm or smaller in size will stay in

ANALYSIS OF COLLECTED DATA

suspension in the water column for long periods of time and will be difficult to remove via basic storm water quality treatment measures. In fact, these small soil particles often require extensive sediment basin design in conjunction with other storm water management and treatment measures. Land grading can also compound this effect because it typically results in the mixing of surface soil material with higher clay content subsoil materials.

Topographical Information

Slope gradient and length are the two primary factors to consider when analyzing and interpreting topographic information. This information is critical when designing and laying out the project because it will ultimately affect the decisions that will need to be made when selecting appropriate construction and post-construction water quality management and treatment measures. For example, decisions made in regard to areas of land disturbance and the removal of vegetation on steeper slope gradients will affect the selection, design, and location of storm water management and treatment measures (i.e., as unvegetated slope gradients increase the size and cost of the storm water management and treatment measures will also increase).

For ease of interpretation and comparison of data, slope gradients are typically grouped into the following four general ranges.

- 0 to 2 percent
- 2 to 6 percent
- 6 to 12 percent
- Over 12 percent

These ranges or groupings can be used to categorize various topographic limitations such as soil erodibility. A slope range of zero to two percent usually has a low erosion hazard whereas a two to six percent slope range has a low to moderate erosion hazard. A six to 12 percent slope range has a moderate to high erosion hazard, and slopes over 12 percent have a severe erosion hazard.

Slope length is another aspect that is important in identification of a site's erodibility hazard. As slope length increases within a slope gradient range, the potential for erosion increases exponentially. As a general rule, the erosion hazard will become critical if slope lengths exceed the following lengths within each respective slope range.

- 0 to 2 percent 300 feet
- 2 to 6 percent 200 feet
- 6 to 12 percent 100 feet
- Over 12 percent 50 feet

ANALYSIS OF COLLECTED DATA

Hydrological Information

Natural drainage patterns and other hydrologic features exist on the land and include overland flow, conveyance channels, swales, depressions, and other watercourses and natural waterbodies. It is important to evaluate these features for their potential to be incorporated into the project's overall storm water management system.

Understanding how storm water flows onto and off a project site is critical to project design and layout. Evaluation of hydrologic data often begins by examining areas up slope of the project site and determining the volume and velocity of storm water that will enter the project area. This information will be used to determine the type, location, and design of storm water measures that will be needed to manage storm water entering and/or flowing across the project site.

When subsurface tile drainage systems are encountered on a project site, it is important to evaluate the size of the drain tiles and the watershed area that they drain. Subsurface drainage systems should be evaluated to determine if rerouting of the system is necessary to maintain drainage of adjacent properties and prevent upstream ponding/flooding problems. Subsurface drain tile should not be used as storm drains. They are typically not designed for this purpose and their capacity is often exceeded, resulting in failure of the drainage system.

Another important aspect of evaluating hydrologic data is the assessment of existing construction and post-construction storm water runoff volumes, velocities and peak flow discharges from the project site, and determining what impacts they will have on downstream hydrologic features and land areas. This evaluation should include an assessment of potential streambank erosion in the downstream receiving channel(s). It should include an evaluation of the potential for sediment pollution from sheet and rill erosion. Once project planning, design and layout begins, it may be necessary to recalculate storm water discharge volumes and peak flows to assess the impact those decisions will have on off-site features such as channels and culverts. Once again, this information will provide insight into identifying the type, location, and design of storm water measures that will be needed to minimize off-site resource impacts to downstream areas.

Adjacent Areas

Data that has been collected in regard to adjacent properties should be evaluated to determine what effect adjoining land uses might have on the proposed project. Evaluate if these land uses will require the installation of storm water management measures on the project site to manage runoff quantity and treat storm water runoff and pollutants associated with the upstream land use(s). Also

ANALYSIS OF COLLECTED DATA

evaluate what effects storm water runoff and potential pollutants from the proposed project might have on adjoining properties located down slope from the project site.

Utility & Highway Corridors

Utility and highway corridor data should be assessed to determine how the proposed project's infrastructure might be tied into these corridors or whether or not these corridors can be incorporated into the overall project design. Evaluate what effect these land uses might have on the proposed project.

Existing Infrastructure & Potential Problem Areas

Potential problem areas identified during the site assessment and data collection phase should be reviewed and evaluated to determine what effect they will have on the project. Assess data to determine if any remedial actions will be needed to reclaim or restore areas of concern on the proposed project site.

Natural, Historical and Archeological Features

Proper analysis of natural, historical, and archeological data is critical in preventing the delay of a project. Identification of many of these features often requires the developer to apply for local, state, or federal permits. Therefore, this data should be analyzed to determine what permits might be needed.

Regulations

As the data for the project is reviewed and analyzed, the designer should keep in mind the permits that may be required for the project.

Permit application processes can often delay construction projects. During this phase of planning, it is important to identify the permits that will be required. If feasible and not dependent on design decisions, the permitting process should begin. This may include actual submittal of permits or, at a minimum, a dialogue with the regulatory agency to identify specific information that will be required to obtain a permit.

PLAN DEVELOPMENT & PROJECT LAYOUT

The final step in construction site planning and assessment is to incorporate the collected data and information into the overall project plan, design, and layout. This section will provide a broad overview and insight into that process. Later sections of the manual will go into much more detail in planning, designing, and laying out a project, including the selection of appropriate storm water measures.

Vegetative Cover

Vegetative cover is probably the most important factor in terms of preventing erosion. Vegetation is also valuable in its ability to act as a buffer and filter pollutants from storm water runoff. Therefore, every effort should be made to preserve and incorporate existing vegetation into the proposed project.

In the analysis of collected data phase of the construction site planning and assessment process the designer has identified areas of vegetation that are of value and should be preserved on the project site. As part of the planning, design, and layout process, these areas should be delineated on the project's construction plans. Delineate major areas or groupings of trees, grass, cultivated land, etc. on the overall project site. Delineate areas that are designated for protection and specify how these areas are to be protected (i.e., a physical barrier such as a fence).

Identify areas that have a dense vegetative cover that can be used to provide effective erosion control as long as the area is not graded, or areas where existing vegetation can be used to filter storm water runoff and allow suspended soil particles to settle out. Identifying vegetative cover that is suitable for use as a vegetative filter also allows the plan designer to substitute these filters for other sediment trapping measures which in turn will reduce the overall cost of a project.

In situations where existing vegetation cannot be saved or where there is no vegetation on-site, consider staging construction activities. Staging of construction activities involves stabilizing part of the project site before disturbing another section of the site. This minimizes the length of time that soil is exposed to the erosive forces of wind and water.

Temporary seeding and mulching can be used to stabilize unvegetated areas that would otherwise be exposed for long periods of time, thus reducing the erosion hazard.

Vegetated riparian buffers located adjacent to waterbodies and other sensitive areas are an effective means of protecting these features from storm water runoff pollutants. Existing riparian buffers should be delineated or identified on the construction plans and the plans should identify measures to protect or, where necessary, enhance or re-establish existing buffers.

PLAN DEVELOPMENT & PROJECT LAYOUT

Soils Information

Soils generally have the greatest impact on project planning, design and layout. Their inherent properties, limitations, and hazards can literally dictate the layout of building lots/pads, roads and streets, storm sewers, on-site sewage disposal facilities (where applicable), and other project infrastructure. Soil characteristics such as depth to bedrock, depth to the seasonal water table, permeability, shrink-swell potential, texture, and erodibility need to be evaluated and factored into the design and layout of the project.

Soils data must be taken into account when evaluating, selecting, locating, and designing storm water management measures that will be used to manage storm water runoff during active construction. Areas of highly erodible soils should be identified on the construction plans and the plans should identify management measures that can be used to minimize erosion on these areas.

Soils data must also be taken into account when selecting storm water management measures for post-construction activities. For example, infiltration measures will be ineffective in soils that have a high clay content or soils that have an extremely high gravel content. The use of filtration and infiltration measures may be severely restricted or impractical in soils with a seasonal high water table unless there is some way to artificially lower the water table.

Project planning, design, and layout should take into account critical areas such as steep slopes (see Topographical Information below), rock outcropping, seepage zones, and any unique or noteworthy landscape features that were identified in the site assessment and data collection phase. Many critical area features can impact the layout of roads and streets, building lots/pads, and on-site sewage disposal facilities. Often, critical area features can be incorporated into common areas and greenways within the development and can actually add aesthetic value to the project.

Topographical Information

Topographic information that has been collected should be used to delineate areas with similar slope gradients. Slope gradients are typically grouped into the four general ranges of zero to two percent, two to six percent, six to 12 percent, and 12 percent or greater. Many building/construction parameters and storm water management measure design specifications are based on these slope gradient ranges.

Using collected topographic information, delineate all major watershed boundaries that are associated with the project site. Often, these watershed boundaries will extend up slope or down slope of the actual project site boundaries. Delineation of the watersheds will help identify the direction of surface water flow. If a delineated watershed exceeds five acres, the plan

PLAN DEVELOPMENT & PROJECT LAYOUT

designer should subdivide the watershed into smaller watersheds. Smaller watersheds are more manageable units when predicting storm water runoff volumes and selecting storm water management measures. It is also important to keep in mind that many storm water management measures have design and application parameters well under the five acre threshold. In fact, the design and application of many measures are typically for one or two acres.

Watershed boundaries will be used many times throughout the planning, design, and layout process. For example, they will be used when calculating storm water runoff volumes, assessing erosion potential, estimating sediment yields, and selecting appropriate storm water management measures.

Hydrological Information

It is critical that the plan designer understands how water flows onto and off of a project site. Where possible, natural drainage systems should be incorporated into the project's design and layout and used to convey storm water runoff through and from the project site.

Using information and data collected on upstream watersheds, analyze the volume and velocity of storm water runoff from adjacent areas that may enter the project site. Evaluate and identify storm water management runoff measures that need to be installed or constructed on the project site to divert the storm water run-on away from construction zones and minimize impacts to the construction project.

Using the hydrologic data that has been collected and the watershed areas that have been delineated, calculate storm water runoff volumes, velocities and peak flows associated with existing site conditions, and begin laying out and designing the project site's drainage system. As drainage system planning, design, and layout decisions are made, it may be necessary to recalculate discharge volumes and peak flow discharges and assess their impact on off-site features such as channels and culverts.

The next step is to evaluate and determine what impact the project's proposed drainage system will have on downstream waterbodies. Storm water management measures must be incorporated into the construction plans to ensure that there is little or no impact to the carrying capacity and sensitivity to sedimentation and flooding of the downstream waterbodies.

In situations where subsurface drainage tile have been identified on the project site, tile locations should be marked on the construction plans. Where applicable, rerouting of these tiles should be identified and the new tile location shown on the plans.

PLAN DEVELOPMENT & PROJECT LAYOUT

Adjacent Areas

Special attention should be given to planning a project when there is potential for the project to impact adjoining properties and ecologically sensitive features. It is important to address downstream discharge points, the potential for sediment pollution, and/or downstream channel erosion and deposition and the effects they can have on downstream waterbodies. This includes the impacts that sheet and rill erosion could potentially have on adjoining properties located downstream of the project site. Appropriate storm water management measures must be identified and built into the construction project to minimize impacts to the previously identified downstream land use(s) and waterbodies.

Utility & Highway Corridors

Lay out lots/building pads, streets and roads, and on-site sewage disposal systems (if applicable) so that they do not interfere with existing utility and highway corridors. Utility corridors must be kept free of obstructions, especially if they require regular maintenance activities or if they present a safety hazard.

Identify specific storm water management measures that need to be installed on the proposed project site to address runoff from these land uses. For example, it may be necessary to incorporate storm water measures into the proposed project to provide for the runoff from roads and impervious surfaces.

As the project layout and design begins to take shape, tie proposed utilities, utility easements, and roads and streets into existing utility and highway corridors. Identify storm water measures needed to protect these corridors from erosion, sedimentation, and construction traffic. In addition to protecting the integrity of the corridors, it may be necessary to incorporate signage or safety fence to notify or restrict construction operations in these highly dangerous areas.

Existing Infrastructure & Potential Problem Areas

Identify and incorporate into the construction plans appropriate or remedial measures that will address potential problem areas that were identified in the site assessment and data collection phase. In situations where remedial action is delayed or it is impossible to correct or eliminate problem areas, allow for provisions to work around the area(s).

PLAN DEVELOPMENT & PROJECT LAYOUT

Natural, Historical & Archeological Features

Natural, historical and archeological features identified in the site assessment and data collection phase should be incorporated into the project plan, design, and layout. These features often can be incorporated as an aesthetic element in the design of common areas or greenways. Construction plans should include the identification of measures that must be installed to protect culturally and environmentally sensitive natural, historical, or archeological areas from construction equipment and construction activities.

In situations requiring permits, the permit application process can take anywhere from days to weeks or months. Therefore, the permit application process should be started as soon as possible.

Regulations

Permit application processes can often delay construction projects. As project decisions are made, the designer should evaluate each decision and how these decisions will affect the need for permits. This will require knowledge of local, state, and federal regulatory requirements. Part of this process may require additional research or dialogue with the appropriate regulatory agency. If permits are required, start the permit application process as soon as possible. Where feasible, consider adjusting the project design and layout to eliminate the need for the permit(s).

CHAPTER 3

Construction Plans

INTRODUCTION TO CONSTRUCTION PLANS

Construction plans are a representation of a project site and all activities that will be associated with the overall construction of the project. More specifically, a construction plan is a document that explains an entire construction project in detail including details of layout, design, and operational procedures.

Construction plans are a very important part of any construction project. They give contractors and subcontractors a visual of the proposed project, provide an orderly timeline and construction sequence, provide detailed standards and specifications, and give guidance in the day-to-day construction activities associated with the project.

This chapter gives a general overview of the purpose and contents of construction plans.

CONSTRUCTION PLANS — PURPOSE & CONTENT

Purpose

The purpose of a construction plan is to provide contractors and subcontractors with sufficient information to construct a project in the most efficient and cost-effective manner possible. To meet these objectives, construction plans must contain sufficient detail to adequately portray the layout of the project; identify areas of concern and provide measures to protect or overcome the identified concerns; provide an orderly timeline and construction sequence; provide detailed standards and specifications for various aspects of the project; provide a list of construction materials required for the project; and give appropriate guidance in the day-to-day construction process.

Content

The information in this chapter provides a general overview of the contents of a construction plan. Additional information may be required by regulatory authorities based on local, state, and federal regulations. It is the responsibility of the plan designer to identify specific requirements associated with applicable regulations and include that information in the construction plan.

In general, a construction plan should include an array of information that clearly depicts the overall project, including all construction activities and storm water management measures associated with the project. It should include but is not limited to a narrative about the project, project location information, predevelopment site conditions, a final project site layout plan, a drainage plan, a grading plan, and a storm water pollution prevention plan.

Construction Plan Index

In addition to the above, construction plans should include a plan index identifying the items that are contained in the plan and a reference as to where each item is located in the plan. An index is a key element to any construction plan and can be very useful to individuals using the plans as well as regulatory agencies who review the plans for compliance with local, state, and federal regulations.

The following sections in this chapter provide a brief overview of the key elements in a construction plan and their respective contents.

Plan Narrative

A plan narrative should be the first major element of any construction plan. A plan narrative is a written statement that describes the overall project. It should provide a clear understanding of the proposed project and can include a variety of items with the intent to inform, explain, and clarify issues associated with the site.

Construction plans require a variety of items. Some items and activities associated with a project may be portrayed more accurately in graphical or tabular form and located in a specific section of the construction plan while others may

CONSTRUCTION PLANS — PURPOSE & CONTENT

be adequately represented in the narrative. Therefore, there is no set standard for what should be included in a plan narrative.

Generally, a construction plan narrative will include items that do not have to be displayed in relation to other activities that will occur on the construction site. A few examples of items that could be discussed in the narrative section include a legal description of the project site, site characteristics, an explanation of expected pollutants associated with the project, construction schedules, operational procedures, and a general description of proposed storm water quality measures. Typically these items are not found on construction plan details sheets.

Project Location

Identifying a project's location is another key element of any construction plan. Typically, this information is provided as a graphical representation of the site as well as in narrative format.

Graphical identification of a project site is typically done by providing a vicinity map that depicts the site in relation to other identifiable areas in the city or county. Vicinity maps should contain sufficient detail so that someone unfamiliar with the area can locate the project site. U.S. Geological Survey topographic maps, county road maps, city street maps, custom drawn maps, etc. are acceptable types of vicinity maps as long as they adequately depict the site's location. Vicinity maps are typically placed on the cover sheet of the construction plan.

Narrative depiction of a project site is generally done by identifying the project site to the nearest quarter section, including township and range coordinates and civil township. Latitude and longitude coordinates identifying the approximate center point of the project should also be provided. Latitude and longitude coordinates can be obtained from U.S. Geological Survey topographic maps or from various Web sites.

Predevelopment – Existing Site Conditions

All construction plans should provide a representation of the project site that includes predevelopment conditions and existing site features. This information is extremely valuable in developing subsequent components of the construction plan. This element of a construction plan typically includes but is not limited to the following items.

Existing Vegetative Cover

A predevelopment plan should delineate and identify the existing types of vegetative cover such as grass, trees, brush, and so on. It is not necessary to identify individual species of plants.

CONSTRUCTION PLANS — PURPOSE & CONTENT

Identification of vegetative cover serves two primary functions. First, it provides the plan designer needed data when making storm water calculations for the project's storm water management system. Second, it provides a basis for evaluating the location, appropriateness, and adequacy of proposed storm water quality measures.

Adjacent Land Use

Predevelopment plans should clearly identify the land use of the upstream watershed and other areas adjacent to the project site. This information provides a basis for evaluating the effects that storm water runoff and pollutants associated with upstream watershed land use (e.g., single-family residential, multi-family residential, commercial, industrial, agricultural, woodland, etc.) might have on the proposed project site. It also aids in projecting what impacts a project might have on downstream watersheds and sensitive areas.

Site Topography

Existing site topography is critical in evaluating where storm water discharges will flow off-site and can be used in conjunction with final site topography information to evaluate areas and quantities of soil cut and fill. Existing site topography also provides a basis for evaluating the location, appropriateness, and adequacy of proposed storm water quality measures.

Site topography is typically depicted through the use of topographic contour lines or spot elevations. When using spot elevations, there should be a sufficient number of points to be able to visualize the site topography. To properly analyze and evaluate this information, all topographic lines, elevation numbers, and spot elevations must be legible.

In the case of linear projects such as highways, roads, utility lines, etc., cross-sectional views and plan and profile views of the project are generally acceptable since it is often difficult to show topographic contour lines or spot elevations for these kinds of projects.

Soils Information

Soils information should be an integral part of a project site's construction plans. The plans should contain a soils map and corresponding soils map unit legend that delineates and identifies the soil types located on the project site. A legible copy of the appropriate soils map taken from the U.S. Department of Agriculture Natural Resources Conservation Service county soil survey in the county where the project site is located is sufficient. Soils maps prepared by a professional soil scientist, soil boring logs, and geotechnical soils reports are also acceptable.

In addition to a soils map, the construction plans should include a discussion of the soil characteristics, limitations, and hazards associated with the project site and the measures that will be integrated into the project to overcome or minimize any adverse soil conditions. For example, if on-site sewage disposal systems are proposed for use on a single-family residential project site, the plan designer should provide information in regard to soil limitations such as a seasonal high water table, slow permeability, poor filtering qualities of the soil, and so on. The plan designer should also identify measures that can be integrated into the project to minimize the respective soil limitations. In the above scenario, the plan designer might specify that perimeter subsurface drainage tile are required to lower the seasonal high water table and minimize the wetness limitation or that a modified on-site sewage disposal system must be installed to compensate for the slow permeability or poor filtering qualities of the soil.

Soil properties also need to be considered when selecting post-construction storm water quality measures for a site. Many structural post-construction measures are designed based on the soil's natural ability to allow infiltration of storm water. If infiltration is too rapid, there is little time for removal of pollutants and storm water treatment. If infiltration is too slow, there is potential for the measure to fail.

Wetlands, Lakes, and Watercourses

Wetlands, lakes, and watercourses that are on or adjacent to a project site should be identified on the predevelopment plan. This information is important in evaluating proposed storm water measures and ensuring that they are appropriate and adequate to minimize water quality impacts to natural, sensitive areas both on and adjacent to the project site. Also, identification of nearby watercourses and waterbodies may place additional importance on sediment control in a particular area of the project.

Potential Discharges to Ground Water

Areas of potential ground water recharge should be clearly identified and located in the construction plans. These areas can have a profound effect on ground water quality.

Existing features such as sinkholes and abandoned, uncapped wells can serve as a direct conduit for contaminated surface water to enter ground water. Therefore, it is extremely important to protect these areas if they occur on or downstream of a project site. In addition, storm water infiltration measures such as drywells, which may be planned as part of the project, could have a potential impact on ground water quality.

Once identified, adequate measures should be incorporated into the construction plans to prevent storm water runoff from entering ground water recharge areas or, at the very least, provide for some type of storm water pretreatment before it is allowed to enter ground water. For example, abandoned wells should be properly capped.

CONSTRUCTION PLANS — PURPOSE & CONTENT

Final Project Site Layout

A final project site layout plan is an integral part of a construction plan. It provides a visual representation of what the project will look like after construction is completed.

Typically, a final project site layout plan identifies the location of lot boundaries, lot numbers, utilities, and streets including street names if available. It also identifies common areas such as community parks and greenways. On smaller residential projects and on commercial and industrial projects, the final project site layout plan may also show the proposed location of structures and parking areas.

Drainage Plan

Drainage plans are one of the most important elements of any construction plan. A drainage plan identifies how storm water will be managed on a particular project and determines what effect the project's storm water management system will have on adjoining properties and infrastructure. Elements of a drainage plan typically include but are not limited to the following items.

Site Topography

Drainage patterns and location of the drainage system is generally determined based on the topography of the site. Site topography is typically depicted through the use of topographic contour lines or spot elevations. When using spot elevations, there should be a sufficient number of points to be able to visualize the site topography. To properly analyze and evaluate this information, all topographic lines, elevation numbers, and spot elevations must be legible.

As noted earlier in this chapter, existing site topography is critical in evaluating where storm water discharges will flow off-site. Similarly, final site topography is critical in evaluating where post-construction storm water discharges will flow off-site and the location, appropriateness, and adequacy of proposed storm water measures. Therefore, it is important that a drainage plan show both existing and proposed site topography.

Existing site topography is typically depicted using a dashed or solid contour line, whereas final site topography is generally depicted using topographic contour lines that have a darker line density or through the use of spot elevations. In the case of linear projects such as highways, roads, utility lines, etc., cross-sectional views and plan and profile views of the project are generally acceptable since it is often difficult to show topographic contour lines or spot elevations for these kinds of projects.

CONSTRUCTION PLANS — PURPOSE & CONTENT

Location of Storm Water Drainage System

Nearly every drainage plan identifies the location of all proposed storm water drainage systems such as swales, drainage channels, piping, culverts, etc. associated with a project and indicates the respective sizes, dimensions, and construction details of the various drainage system components. Drainage plans should also identify all points where storm water discharges will leave the project site. If the plan's topographic contour lines or the storm water drainage system does not clearly define off-site discharge points, these points should be identified with a note(s) placed on the plan.

Storm Water Calculations

Most drainage plans include design data, such as pipe sizes and discharge rates, for sizing of storm water management systems. In addition, drainage plans often include sizing and trap efficiency data for sediment traps, sediment basins, open channels, grassed swales, and so on.

Drainage plan design data is generally given for both preconstruction and post-construction conditions. This is done to show the overall impact the project may have in relation to storm water runoff quantities and velocities and potential impacts on adjoining land uses.

Drainage plan data is generally arrived at by calculating the size of the drainage area for each structure or measure and a specific-sized storm event. The two most commonly used storm events are the 10-year frequency, 24-hour duration event and the 100-year frequency, 24-hour duration event.

Storm water calculations can be done via several methods. Some of the more common and acceptable methods are the rational method, Technical Release Numbers 55 and 20.

Receiving Waters

Drainage plans should identify all named streams or other waterbodies that may potentially receive storm water runoff from the project site. If the discharge is to a municipal storm sewer system, the plan should identify the owner of the storm drain system as well as the ultimate receiving water for the storm drain system.

Floodplains

Floodplains, floodways, and floodway fringes that are located on a project site should be delineated on the drainage plans. In situations where there is no floodplain, floodway, or floodway fringe on the project site but one exists within close proximity of the project area, the construction plans should show the feature(s) delineated on the drainage plan. At a minimum, include a discussion of their existence in the narrative or on the plans.

CONSTRUCTION PLANS — PURPOSE & CONTENT

When there are no floodplains, floodways, or floodway fringes associated with the construction project, a note should be placed either on the graphical representation of the drainage plan or in the project narrative stating that none exist.

Hydrologic Unit Code

Hydrologic unit codes are used to identify specific watersheds. This information is often used by local governmental entities to identify an individual watershed or watersheds and to analyze and compare various activities between watersheds. Local watershed groups also use this information to implement watershed studies and apply for funding to implement watershed plans.

Hydrologic unit codes are generally expressed in terms of 6-, 8-, 11-, or 14-digit codes. A 14-digit code represents the smallest watershed delineation and is probably the most often requested by local organizations and governmental entities.

Grading Plan

A grading plan is an integral part of any construction project.

Graphically, a grading plan should identify and delineate the construction limits for all earthmoving activities associated with a construction project. The extent of disturbance has a profound impact on what storm water quality measures may be necessary to adequately control erosion and the resulting sedimentation.

Grading plans should also depict the existing and proposed topography of the site. Typically this is done by delineating continuous contour lines or identifying spot elevations on the grading plan. In the case of spot elevations, it is important to have a sufficient number of locations to be able to visualize the site topography. This information is critical to the project planner and grading contractor because it allows them to calculate the areas and quantities of soil cut and fill that may be associated with the project. Often, it is beneficial to provide the cut and fill quantities in tabular format.

Grading plans should identify the potential location of soil stockpile areas, borrow areas, and soil disposal areas. Soil stockpile and borrow site locations can alter the direction of storm water flow during construction activities and can have a significant impact on the selection, location and adequacy of the storm water quality measures.

Often, borrow and disposal areas may occur outside the property boundaries of the project site. In these instances, it is important that project site owners realize all land-disturbing activities associated with their project must comply with Indiana's storm water rule for runoff associated with construction activity. The rule is found in the Indiana Administrative Code under Title 327, Article 15, Chapter

CONSTRUCTION PLANS — PURPOSE & CONTENT

5 (327 IAC 15-5). Unless these off-site borrow and disposal areas are commercially operated facilities permitted under other state regulations, they may need to be identified and included as part of the project site owner's plan submittal or as a separate project.

If a construction project does not have any planned soil stockpiles, borrow areas, or disposal areas associated with it, this should be stated as a note on the grading plan or in the narrative of the construction plans.

Storm Water Pollution Prevention Plans

A storm water pollution prevention plan is a working document that identifies potential pollutants associated with a project and serves as a blueprint for the selection, installation, and maintenance of construction and post-construction storm water quality measures designed to control or reduce the impact of the pollutants. It also specifies how storm water will be managed at the project site. A storm water pollution prevention plan should be part of the general construction plan and not a stand-alone document because of its interrelationship with other plan components. It is also important to understand that changes to one or more facets of the construction plans can drastically affect provisions that have been identified in the storm water pollution prevention plan.

The purpose of a storm water pollution prevention plan is twofold. First, it serves as the principle site reference identifying storm water quality measures that need to be implemented to reduce erosion and minimize the discharge of sediment and other pollutants associated with the project. The second purpose of a storm water pollution prevention plan is to address the reduction of pollutants associated with a project's post-construction land use. In order to choose the appropriate storm water quality treatment measures to meet these objectives, the plan designer must have an understanding of the project site, the intended land use, and the associated pollutant sources.

Development and implementation of a storm water pollution prevention plan should be done by individuals who have an understanding of storm water issues and erosion and sediment control because proper development and implementation is critical if pollutants are to be adequately reduced or controlled. Development of a storm water pollution prevention plan must address planning of the project, the assignment of responsibilities and resources, performance expectations, and standards for monitoring performance compliance.

Storm water pollution prevention plans contain an array or variety of storm water quality measures that are designed to protect water quality. In general, a storm water pollution prevention plan can be divided into two different components: (1) an erosion and sediment control plan and (2) a post-construction pollution prevention plan. Each of these plan components should identify and clearly convey when, where, and how each storm water quality measure will be installed and maintained. At a minimum each component should contain the following items.

- Appropriate storm water quality measures.
- Location of each measure on the project site.
- Design standards and specifications for each measure.
- Installation criteria for each measure.
- Construction schedule describing the implementation/installation of the storm water quality measures relative to land-disturbing activities.
- Maintenance of all storm water quality measures.

Many of the storm water quality measures identified in a storm water pollution prevention plan will be implemented throughout the life of the project. It is important to recognize that some post-construction measures can be modified to control sedimentation during a project's construction phase and then modified to its original design to treat post-construction storm water runoff and pollutants after construction has been completed.

Associated Local, State, and Federal Water Quality Permits

On many projects, numerous local, state and federal water quality permits are required. Often, it is beneficial to include a listing of associated water quality permits within the storm water pollution prevention plan, in the project narrative, or on appropriate plan sheets. This facilitates coordination of the permitting processes and can prevent lengthy delays of a project.

The types of water quality permits associated with construction projects include but are not limited to:

- Construction in a Floodway Permit from the Indiana Department of Natural Resources' Division of Water.
- National Pollutant Discharge Elimination System Permit from the Indiana Department of Environmental Management's Office of Water Quality.
- Section 401 Water Quality Certification Permit from the Indiana Department of Environmental Management's Office of Water Quality.
- Section 404 Water Quality Permit from the United States Army Corps of Engineers.

Later chapters of this manual will provide more in-depth discussion and instruction on the development and implementation of storm water pollution prevention plans and the selection of storm water quality measures available to reduce or control pollutants associated with a project's construction and post-construction activities.

CHAPTER

4

Planning Principles & Design Considerations

PLANNING PRINCIPLES & DESIGN CONSIDERATIONS

Project planning, design, and layout can begin once all site information and data has been collected and analyzed. The first step in planning, design, and layout is to develop a set of construction plans including a comprehensive site plan.

A site plan is a graphical depiction showing the layout of a project. Site plans typically include the location, design, and specifications for roads, streets and parking areas; storm water management systems, wastewater management systems, utilities, and other infrastructure; structures; landscaping and common areas; and other facilities associated with the project.

Development of the site plan should take into consideration all of the information collected during the site assessment and data collection process. When making planning, design, and layout decisions, it is extremely important to take advantage of the strengths and overcome the limitations of project site features identified in the assessment process. Adapting a plan design to existing site conditions and the natural features of the landscape can greatly reduce the project's environmental impacts.

Storm water management, including erosion and sediment control and post-construction pollution prevention measures, needs to be an integral part of the site planning process and not just an afterthought. Again, it is extremely important to take into consideration details for land clearing, grading, and cut and fill operations that will be used during the construction process when developing the site plan. Therefore, the best approach to developing a set of comprehensive construction plans is to prepare the site plan and storm water pollution prevention plan simultaneously.

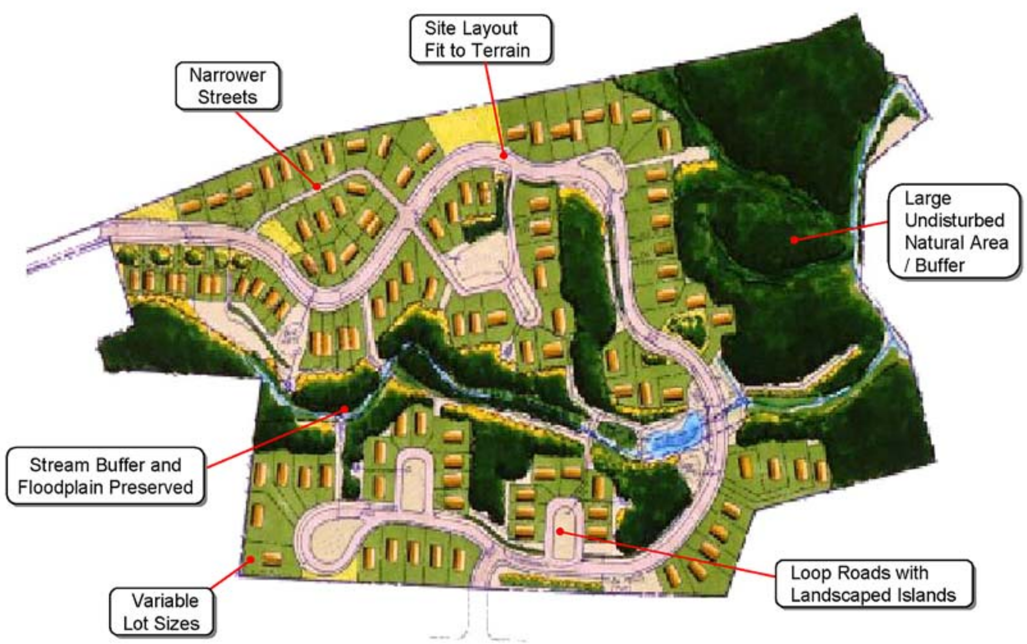
This section contains several basic planning principles and design considerations that should be reviewed and incorporated into the site planning process whenever possible. Using these principles and design considerations will help reduce environmental impacts and minimize project construction costs.

The following illustrations show a comparison of conventional design versus a design that incorporates planning principles and consideration for the natural site features.

PLANNING PRINCIPLES & DESIGN CONSIDERATIONS

Conventional Design

Improved Site Design



PRESERVATION & PROTECTION—NATURAL SITE DESIGN

One of the first activities that should be performed at a project site is a site assessment of resource issues. This process includes inventory and data collection of the resources that are associated with the project site. This process is described in more detail in Chapter 2 of this manual.

This section provides an in depth discussion of key natural features that may be encountered at a project site. The intent of this section to provide an understanding of each of these resource features and issues with an emphasis on protection. Incorporating these natural features into the design and layout of the project site can minimize the overall impact of the project. Benefits include but are not limited to a reduction of impervious surfaces, decreased generation of pollutants, and treatment of storm water runoff.

PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Preservation of Natural Vegetation

The ***preservation of natural vegetation*** *during construction provides natural buffer zones, protects soils from water and wind erosion, removes sediments and other pollutants from storm water runoff, and is aesthetically pleasing. This technique can be applied to all types of sites.*

Key Benefits

- Vegetation absorbs the energy of falling rain.
- Dense root structures hold soils in place and increase the soil's absorptive capacity.
- Plant roots hold soil particles in place and preserve and promote development of soil structure, resulting in increased soil permeability which increases the soil's ability to absorb storm water runoff.
- Vegetation also:
  - Slows the velocity of runoff and acts as a filter to trap sediment.
  - Serves as a buffer zone against noise.
  - Enhances aesthetics of the area.
  - Provides areas where wildlife can remain undisturbed.
  - Provides a source of shade during summer months.
  - May add to the value of residential and commercial properties.
  - Usually requires less maintenance than planting new vegetation.

Planning Consideration

- Extremely well-suited for use in areas prone to high rates of soil erosion where other soil erosion control measures would be difficult to establish, install, or maintain.
- Use in areas where it is desirable to reduce storm water runoff sheet flow velocities.
- Can be used to protect unique or endangered plant species.

PRESERVATION OF NATURAL VEGETATION

Discussion

Soil erosion is a leading cause of water quality problems in Indiana. It impacts water quality by degrading the habitat of aquatic organisms and fish, promotes the growth of nuisance weeds and algae, and decreases its recreational value. During construction, if disturbed land is left unprotected its erosion potential increases, storm water runoff volumes and sediment loadings increase, and the potential for surface water degradation increases.

The preservation of vegetation should be planned before any site disturbance begins. Planners should note the locations where vegetation should be preserved and consider this when determining the location of roads, buildings, or other structures. Highly visible barricades and signs should be erected to protect vegetation boundaries selected for preservation. Preventing damage is less costly than correcting it.

Planning should include the maintenance requirements of the existing vegetation. Based on soil types and climate, different species will require different maintenance activities such as mowing, fertilization, irrigation, pruning, and weed/pest control. These activities should be performed regularly during construction.

PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Riparian Buffer Zones

***Riparian buffer zones** are natural vegetative zones along creeks, streams, channels, or other water-bodies. They typically consist of tree, shrub, and grass plantings.*

Key Benefits

- Riparian buffer zones help:
  - Maintain the integrity of stream channels and shorelines.
  - Remove pollutants such as suspended solids, phosphorous, nitrates, trace metals, pesticides, and hydrocarbons from storm water runoff.
  - Remove nutrients and other pollutants from subsurface flow through filtering and plant uptake.

- Riparian buffer zones supply food, cover, and shade (thermal protection) to fish and other wildlife.
- Riparian buffer zones provide:
  - Green space and wildlife corridors.
  - Recreational areas such as parks and walking trails.

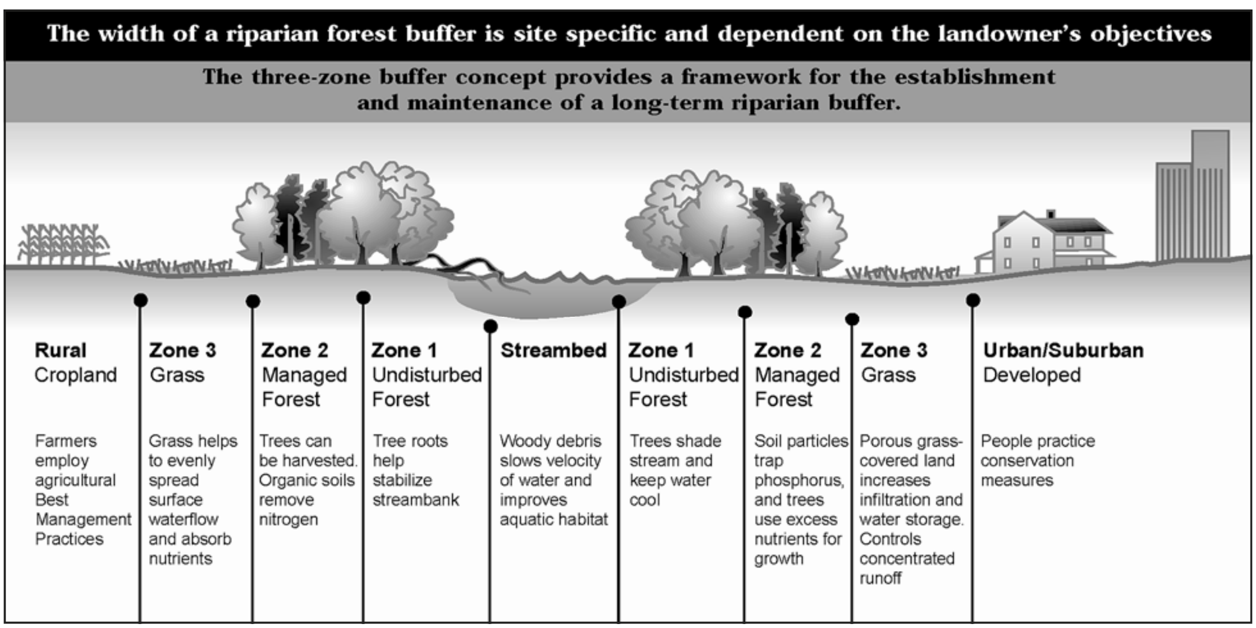
Planning Consideration

- Use along fields, housing developments, industrial and commercial sites, etc. where it is desirable to protect streambanks and drainage channels and to decrease nonpoint source pollution of waterbodies.
- Can be used along streams and drainage channels where it is desirable to preserve native vegetation and buffers both during and after active land-disturbing activities.
- Well suited for setting aside areas for wildlife food and habitat.

RIPARIAN BUFFER ZONES

Discussion

Riparian buffer zones are typically found connecting a stream system and a people-based system such as agriculture, housing, or industry. From the water's edge and continuing up slope, the area can be viewed in zones. The "three-zone buffer concept" is the most common type of riparian buffer zone system. Zone 1 is a mix of undisturbed, native trees and provides bank stabilization as well as shading and protection for the stream. This zone may also include wetlands and any critical habitats. Zone 2 is a transition zone consisting of native trees, shrubs, and grasses. This area can be used for various purposes such as timber harvesting, wildlife habitat, and outdoor recreation. Zone 3 consists of a dense mixture of grasses and forbs (broad-leaved herbaceous plants and wildflowers). This zone acts as a further setback between the waterbody and impervious surface areas. It provides more permeable surface area for infiltration of storm water runoff into the soil. The vegetation in this zone also helps convert concentrated storm water runoff into sheet flow, maximizing surface area for infiltration of runoff.



Riparian buffer zones are very important in minimizing nonpoint source pollution of waterways from adjacent land, protecting aquatic environments, enhancing wildlife habitat, and increasing biodiversity. The roots of riparian vegetation also help stabilize streambanks and shorelines and therefore are important in minimizing streambank and shoreline erosion potential.

RIPARIAN BUFFER ZONES

During construction of a project, riparian buffers that are to be preserved should be protected from excessive sediment loads by installing appropriate erosion and sediment control measures.

In general riparian buffer zones should be kept in their natural state. However, some upkeep such as planting to minimize concentrated flow, removal of exotic species, and removal of damaged or diseased trees may be necessary.

Installation of riparian buffer zones on agricultural lands should take into consideration the location of crop lands, grazing lands, livestock enclosures, and pasture lands. Developments along stream channels and drainageways in urban areas should utilize riparian buffers whenever feasible to protect the stream from nonpoint source pollution and provide for community recreational use. Urban riparian buffers should have easements allowing for protection and maintenance of the vegetation. Urban riparian buffer zones can also be an effective selling point when landowners want the benefits a buffer can provide or where a high level of benefit can be derived at an acceptable cost to the landowner and the public.

PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Wetlands

***Wetlands** are areas that are saturated by surface water or ground water for extensive periods of time and have the ability to support water-loving plants as a result of hydric soil conditions.*

Key Benefits

- Wetlands help remove excess nutrients and trap sediments and other pollutants contained in storm water runoff via infiltration, absorption, ion exchange, precipitation, and biodegradation thereby preventing pollutants from reaching rivers, lakes, and other waterbodies.
- Wetlands help slow and absorb flood waters.
- Wetlands provide habitat for thousands of species of aquatic and terrestrial plants and animals.

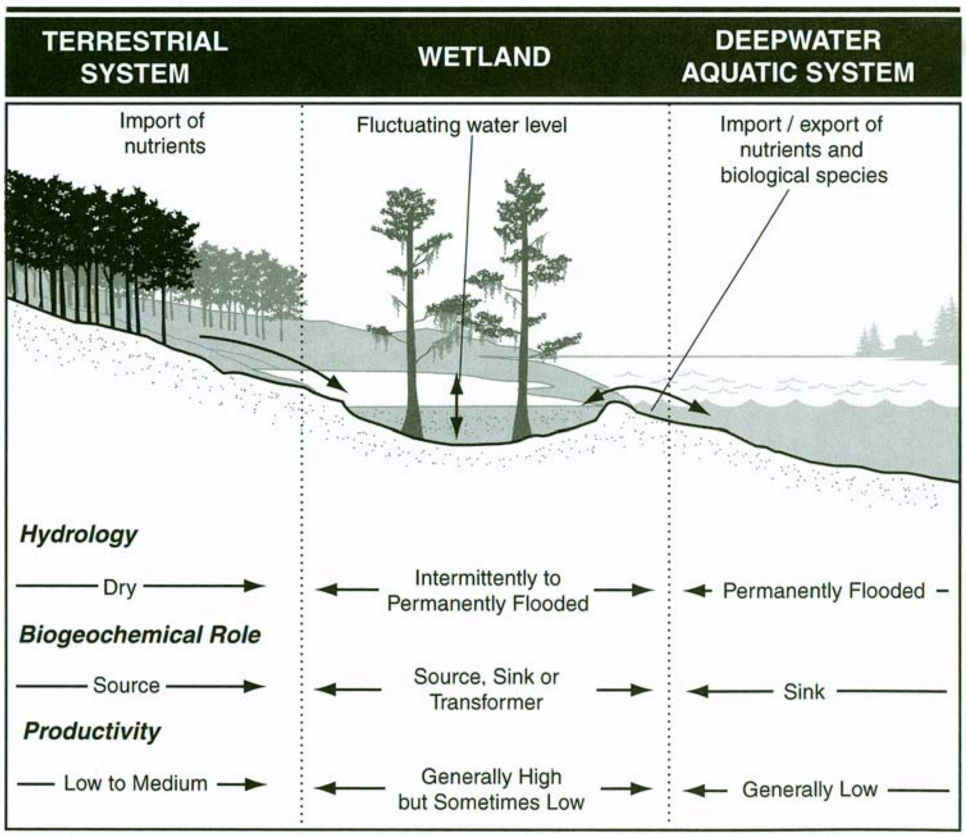
Planning Consideration

- Well suited for use in areas designated to be set aside for the preservation of plant and animal life and biodiversity.
- Can be used in areas where it is desirable to capture storm water runoff and allow ground water recharge.
- May be used to reduce flooding potential.
- Consider limited capacity for handling increased flows and pollutant loadings.
- Natural wetlands should not be used as a primary treatment measure to capture pollutants; consider pretreatment.

WETLANDS

Discussion

Wetlands serve important water quality improvement functions within the landscape. They are a major link between land and water. One of the functions performed by wetlands is the filtering of nutrients such as phosphorous and nitrogen. Due to their unique position in the landscape, wetlands serve as natural receptacles for storm water runoff and can absorb enough water to help control flooding. Wetlands also have the ability to soak up storm water runoff during storms and then slowly release the water over extended periods of time.



The above functions should be taken into consideration when developing storm water management strategies for lands undergoing land use changes. However, when considering diverting flows to a wetland (either from storm water sources or non-storm water sources), it is important to consider that they do have a limited capacity for handling increased flows or additional pollutant loadings. In urban areas wetlands are dramatically altered by uncontrolled run-off, either through natural drainage to those systems or direct discharge.

PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Flood Plains

***Flood plains** are areas consisting of drainage channels and adjoining dry land areas that are susceptible to being inundated by water from any natural source.*

Key Benefits

- Flood plains provide a natural right-of-way and temporary storage for large flood events.
- Flood plains protect people and structures from flood water harm and damage.
- Flood plains help preserve riparian ecosystems and habitats.
- Flood plains may be used in conjunction with riparian buffer zones to create linear greenways.

Planning Consideration

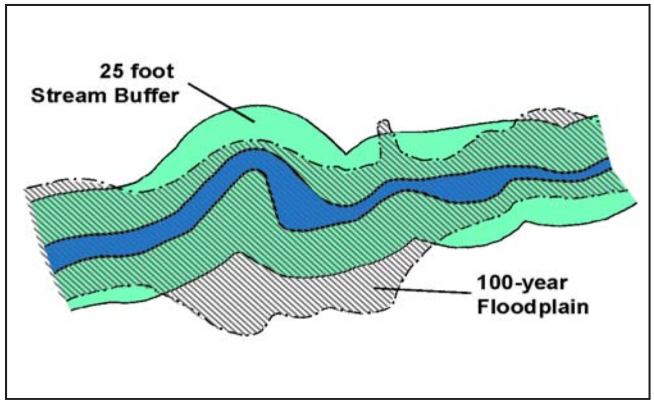
- Consider using in areas where there is a need to protect humans or structures from flood water harm or damage.
- Use where it is desirable to preserve aquatic and terrestrial habitats and biodiversity.

Discussion

A flood plain consists of a stream or drainage channel and low-lying areas bordering the stream or channel. When the stream or channel reaches its capacity after a heavy rain or a significant snow melt event, the channel overflows into the flood plain. This makes flood plains very beneficial because of their storage and conveyance capacity and ability to reduce the volume and velocity of flood waters. By reducing flood water volumes and velocities, flood

FLOOD PLAINS

plains have the added benefit of allowing for the settlement and removal of sediments and other suspended solids commonly found in storm water runoff. Flood plains are also very important to the survival of aquatic and terrestrial life and preservation of biodiversity.



Streams and other watercourses should be allowed to naturally flow through their own corridors. When development encroaches on a flood plain, its ability to convey storm water is greatly reduced and the potential for human or structural harm is elevated. Most communities regulate the use of flood plains in order to avoid these risks. Ideally the 100-year flood plain should be avoided for clearing and building. The best case scenario is one in which the entire 100-year flood plain is left in a natural state. Many times this area coincides with the riparian stream buffer. Both practices preserve the stream corridor in its natural state and protect existing wildlife habitat and vegetation. The boundaries of the 100-year flood plain may lie within or outside the riparian stream buffer zone.

Maps of 100-year flood plains are generally available through local planning, zoning, or building departments. It is important to note that developers and building designers must comply with Federal Emergency Management Agency requirements.

Flood plains are often inconspicuous on smaller conveyance systems, but they serve the same function as flood plains on larger creeks, streams, and rivers. To maintain the integrity and function of flood plains, construction activities and the placement of fill materials in the flood plain should be avoided. Wherever possible, construction activities and development in flood plains should be avoided. In may instances, flood plains can be integrated into the project design to create a level of aesthetic value and /or used as a natural or recreational area.

The Indiana Department of Natural Resources' Division of Water regulates activities conducted within the floodway of Indiana creeks, streams, rivers, and other conveyance systems. Site designers should ensure that activities associated with the project do not impact flood plains and that appropriate permits are obtained for flood plain areas that will be impacted by project operations before the actual activity commences.

PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Steep Slopes

***Steep slopes** consist of areas where the slope gradient is typically 15 percent or greater. These areas can occur on hillsides, ridges, or along the sides of ravines.*

Planning Consideration

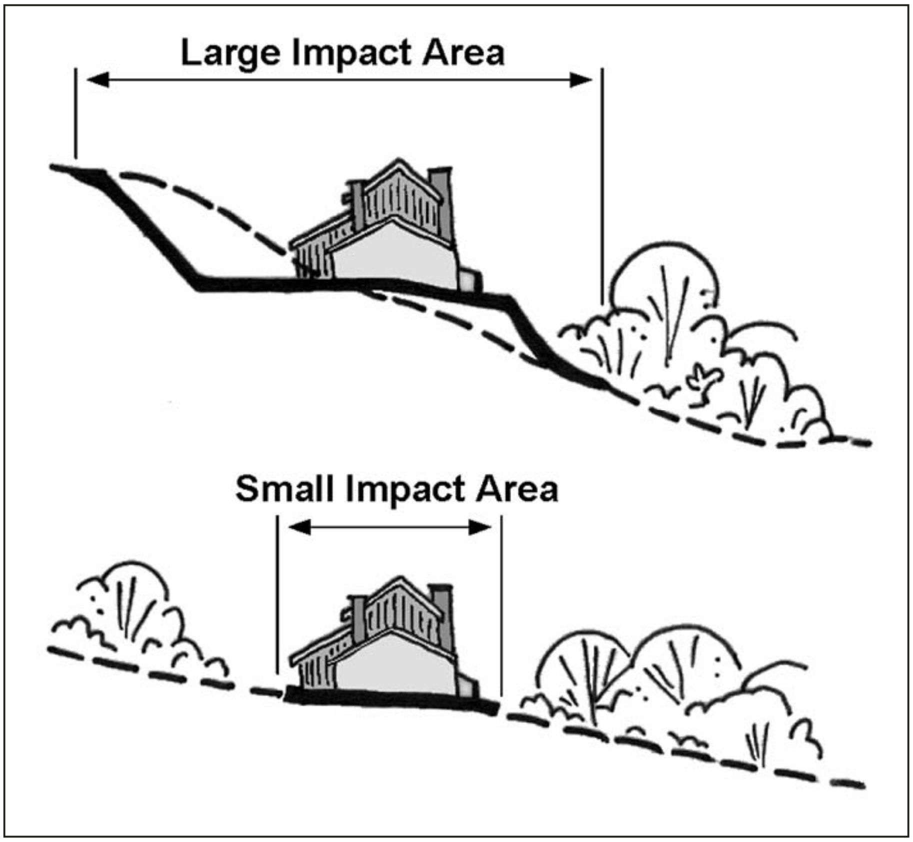
- Avoid development on steep hill, ridge, and ravine slopes, especially those with side slopes of 15 percent or greater.
- Preserve existing vegetation to minimize erosion potential and generation of sediment. (Preservation of existing vegetation eliminates the difficulty of trying to re-establish vegetation in these areas.)
- Build on flatter areas to reduce soil cut-and-fill volumes and the cost of grading operations.

Discussion

Developing on steep slopes causes increased soil erosion and storm water runoff during and after construction. U.S. Department of Agriculture Natural Resources Conservation Service studies have shown that soil erosion is greatly increased on slopes that have a grade of 15 percent or more. Developing on steep slopes also results in excessive sediment loading of storm water runoff. Therefore, developing on slopes with a grade of 15 percent or greater should be avoided whenever feasible in order to minimize erosion, soil loss, degradation of surface water, and excessive storm water runoff. Furthermore, slopes with a grade of 25 percent or more should be avoided altogether.

STEEP SLOPES

More land is disturbed when developing steep slopes versus development of flat ground. Ideally, steep slopes should be left in their natural, undisturbed state to preserve the natural topography and character of the site, the natural soil and associated soil characteristics, and existing vegetation. Leaving areas undisturbed will minimize erosion potential, protect water quality, and minimize grading costs.



PRESERVATION & PROTECTION—NATURAL SITE DESIGN

Karst

***Karst** is a landscape feature characterized by sinkholes, ravines, crevices, and underground streams and caves formed in soluble calcium carbonate or dolomite (calcium magnesium carbonate) limestone bedrock. These features are formed when the bedrock is dissolved by water.*

Planning Consideration

- Measures should be used to reduce concentration of runoff.
- Storm water conveyance structures should be used to allow increased infiltration and reduce pollutants generated.
- Investigate areas underlain by carbonate rock to identify sink holes.
- Where feasible, direct storm water runoff 1000 feet or more away from the edge of existing sinkholes and if possible, discharge it to an area that is not underlain by limestone bedrock.

Discussion

From a storm water management perspective it is very important to identify karst sinkholes, fractures, and cavities due to their potential to pose environmental threats and/or construction hazards.

In karst areas, surface water flows very quickly into caves and sinkholes resulting in very little time for storm water to infiltrate into the soil. Storm water runoff often picks up contaminants such as human and animal waste, pesticides, fertilizers, petroleum products, and other pollutants as it flows across the earth's surface. When this contaminated runoff enters karst features it can travel great distances underground and may result in the contamination of wells, springs, and aquifers. Spills of pollutants such as chemicals and hazardous materials are of special concern in these areas. In addition, impacts on aquatic cave-dwelling species can result in adverse effects of biologic communities. For example,

KARST

endangered species such as the blind cave fish are especially prone to the adverse effects of contaminated storm water runoff.

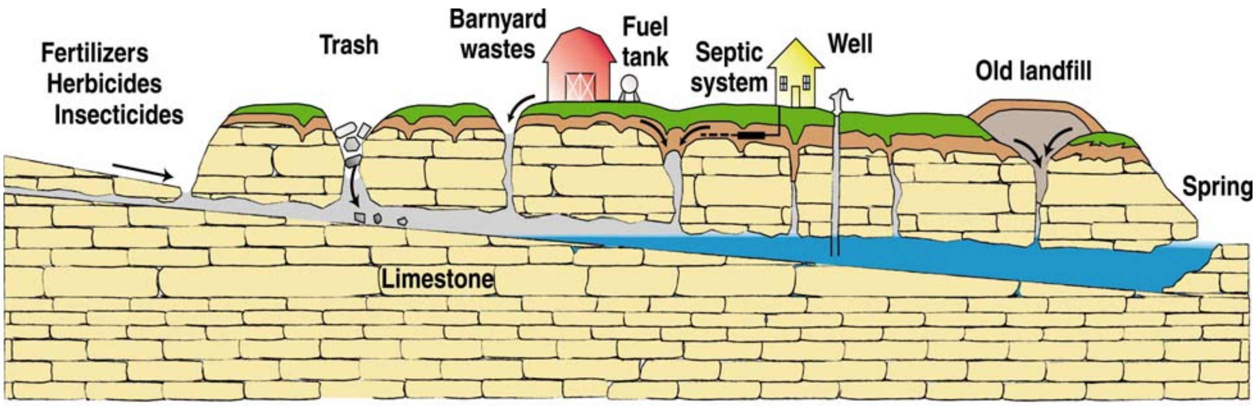


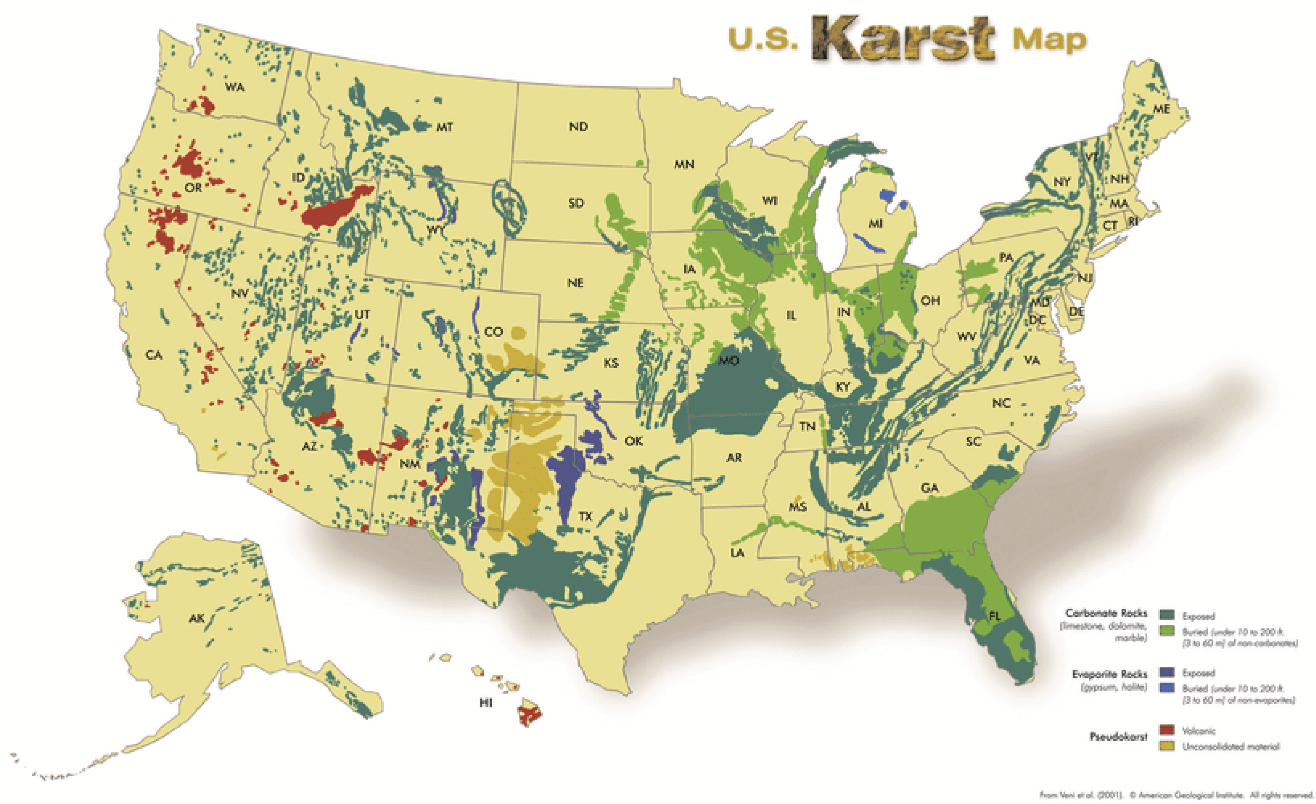
Diagram concept by Indiana Geological Survey, R.L. Powell; drafted by R.S. Taylor

Percolation of surface water into the soil and underlying limestone bedrock of karst areas often results in sinkholes and underground caves. Construction activities often accelerate sinkhole formation due to the disturbance of existing soil and bedrock conditions and the alteration of existing hydrology and drainage patterns. To help reduce the impact, emphasis should be placed on reducing run-off through aggressive mulching and seeding measures. In addition, the increase in impervious surface cover and increased structural loads on the soil frequently result in ground failure. For these reasons detention/retention ponds should be designed and constructed with a liner and discharges from storm water management facilities and impervious surfaces should be routed to stable areas. The use of buffers are encouraged adjacent to karst features, especially in areas where

large amounts of impervious surface must be added. One way to accomplish this is to maintain large vegetative strips on slopes to help filter and slow runoff. In addition, alternative measures can be substituted for impervious surfaces to allow more absorption of flow and less runoff. These measures include but are not limited to porous pavers, pervious concrete, and porous asphalt. The use of infiltration measures should be carefully evaluated before their use. Where feasible, storm water flows should be directed away from limestone bedrock.

For the protection of ground water quality, storm water conveyance measures that are to be used in karst areas should be designed to spread or disperse storm water runoff over the largest area practicable. Dispersion of storm water runoff helps eliminate concentrated flows and the pooling or ponding of runoff. Grass waterways are another effective storm water management measure that can be used in karst areas.

KARST


U.S. Karst Map
WA
OR
CA
NV
ID
MT
WY
UT
AZ
NM
CO
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
VT
NH
ME
MA
CT
RI
NJ
DE
MD
DC
AK
HI
Carbonate Rocks
(limestone, dolomite, marble)
Exposed
Buried (under 10 to 200 ft. (3 to 60 m) of non-carbonates)
Evaporite Rocks
(gypsum, halite)
Exposed
Buried (under 10 to 200 ft. (3 to 60 m) of non-evaporites)
Pseudokarst
Volcanic
Unconsolidated material
From Veni et al. (2001). © American Geological Institute. All rights reserved.

LAND/SITE UTILIZATION

After gaining an understanding of the natural resources occurring on the project site it is time to begin to understand how the project can be designed with each of these features in mind.

This section provides an in-depth discussion of several project management activities that should be considered early in the design process. These activities include fitting the design and layout of the project to the natural landscape, restricting land disturbance in unique resource areas, planning land disturbance in an orderly fashion to reduce the amount of bare earth exposed at a given time, and utilizing existing buffers, riparian corridors, and vegetated areas as either amenities or part of the storm water management system. There is also a discussion of the importance of soil properties and how soils are directly related to site planning, design, and the selection of storm water measures.

Incorporating these land use decisions into the design and layout of the project site can minimize the overall impact of the project. Benefits include but are not limited to site aesthetics, reduction of impervious surfaces, decreased generation of pollutants, and treatment of storm water runoff.

LAND/SITE UTILIZATION

Soil Properties

***Soil properties**, limitations, and hazards play a very important part in the planning, design, and layout of a project. This planning principle affects nearly every aspect of a project.*

Planning Consideration

- Leave highly erodible or unstable soils in their natural condition to prevent erosion, sedimentation, and water quality degradation problems.
- Leave highly erodible or porous soils as undisturbed conservation areas.
- Use permeable soils as nonstructural storm water infiltration zones.

Discussion

Soils generally have the greatest impact on project planning, design, and layout. Their inherent properties, limitations, and hazards can literally dictate the layout of building lots/pads, roads and streets, storm sewers, on-site sewage disposal facilities (where applicable), and other project infrastructure. Soils also play a significant role in the selection and installation of construction and post-construction storm water management measures.

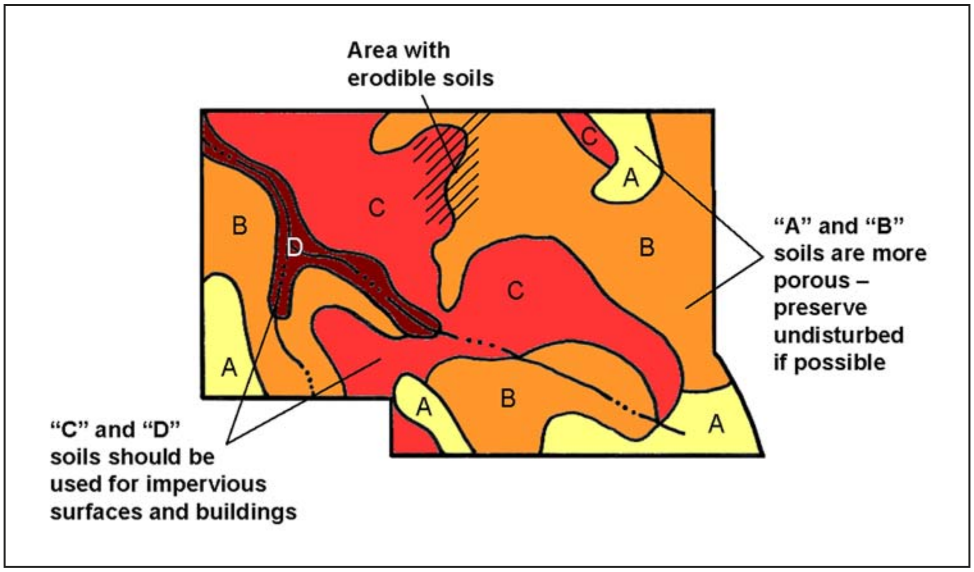
Planning, Design, and Layout

Soil characteristics such as depth to bedrock, depth to the seasonal water table, permeability, shrink-swell potential, texture, erodibility, etc. need to be evaluated and factored into the design and layout of a project. Soils data must also be taken into account when evaluating, selecting, locating, and designing construction and post-construction storm water management measures for the management and treatment of storm water runoff.

General soils maps, found in Natural Resources Conservation Service county soil surveys, are often an excellent place to start when incorporating soils information into the site plan and storm water management plan. General soils maps

SOIL PROPERTIES

provide groupings of soils with similar properties. Depending on the size of the project, general soils maps can be used to guide the placement of buildings and impervious surfaces and select the most suitable areas of the project site for common areas, greenways, buffer zones, and natural preservation.



Local soil resource maps and interpretive tables, also found in Natural Resources Conservation Service county soil surveys, can be useful in the planning, design, and layout of a project site. The soil resource maps can be used to identify and delineate specific soil types on the site plan and the tables can be used to group soils with similar characteristics, properties, limitations, and hazards. For example, these maps and tables can be used to identify highly erodible soils and unstable soils that should be maintained in their natural state to minimize erosion potential and sediment impacts and avoid potential structural damage to buildings.

Construction

Soils can have a significant impact on the location and stability of buildings and roads and streets. Soils with a seasonal high water table can affect the stability of roads and streets and result in frost action problems in colder climates. A high water table can result in flooded crawl spaces or basements of buildings.

Development of the site plan must take soil properties, limitations, and hazards into account when determining the location of buildings and roads and streets. Areas of highly erodible or unstable soils should be avoided to the greatest extent practicable to avoid erosion, sedimentation and potential structural problems. If structures must be located on highly erodible soils, the storm water pollution prevention plan should identify storm water measures that can be used to minimize erosion on these areas.

SOIL PROPERTIES

Permeable soils suitable for infiltration of storm water runoff should be left in their natural state and to the greatest extent practicable, preserved for use as natural space such as common areas and greenways. On projects requiring the construction of buildings and roads/streets, locate the structures on soils with more restrictive permeabilities or very rapid permeabilities and reserve the permeable soils for storm water infiltration and treatment.

Post-Construction

Soils play a major role in the selection and implementation of post-construction storm water quality measures. Soil properties can literally dictate whether or not to use filtration and/or infiltration measures. For example, the use of filtration and infiltration practices may be severely restricted or impractical in soils with a seasonal high water table unless there is some way to artificially lower the water table. Infiltration measures will be ineffective in soils that have a high clay content or soils that have an extremely high gravel content.

Porous sandy and gravelly soils allow storm water runoff to infiltrate and recharge ground water supplies. Dispersion of storm water runoff over these highly permeable soils helps reduce the amount of runoff and reduces peak discharges. Areas of permeable soils should be considered as a storm water management option, provided that the soils are not easily erodible or unstable.

Permeable soils, such as sands and sandy loams (hydrologic soil group A and B), provide infiltration into the subsoil at a rate that allows for the removal of some storm water pollutants. Conversely, very rapidly permeable soils like coarse sands and gravel provide little opportunity for the removal of storm water pollutants.

LAND/SITE UTILIZATION

Reduce Limits of Clearing & Grading

***Reducing the limits of clearing and grading** is a planning principle that can be used to preserve existing vegetation, natural drainage patterns, and the aesthetics of a project site. In addition, this principle helps minimize the clearing and grading costs associated with a construction project.*

Planning Consideration

- Natural conservation areas and other site features can be protected using these techniques.
- More undisturbed natural area on a site is preserved.
- Set up limits of disturbance for development activities.
- Limit the site footprint to reduce the clearing and disturbance of a site.

Discussion

Minimizing clearing and grading on a construction site helps to preserve existing vegetation and natural drainage patterns of the site. Preservation of these features often enhances the project's aesthetics and helps minimize the costs associated with clearing and grading of the project. Clearing and grading of areas highly susceptible to erosion generally requires the installation of more sophisticated and costly storm water quality measures to control erosion and sedimentation on the construction site.

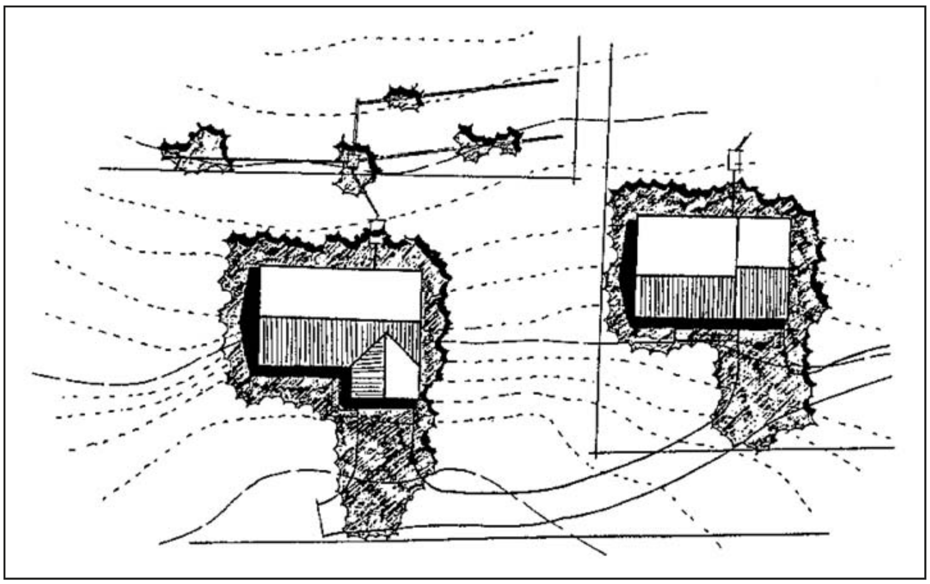
To the greatest extent practicable, clearing and grading activities should be confined to the least critical areas on the project site. Long, steep slopes, areas of highly erodible soils, unique natural areas, etc. should be used as open space or natural areas on the project site. Where possible, minimize the number and width of site access roads and locate them in areas that will be used later for streets, utility corridors, and rights-of-way. Locate areas designated for staging of construction equipment, employee parking areas, construction offices/trailers,

REDUCE LIMITS OF CLEARING & GRADING

and construction material and soil stockpile areas in zones designated for future clearing and grading.

There are several methods that can be used to reduce the limits of clearing and grading. These methods are typically referred to as minimal disturbance methods. The most common minimum disturbance methods used include limiting the footprint of land disturbance and development, fitting the site design to existing terrain, and using special procedures and equipment.

The limit of disturbance should reflect reasonable construction techniques and equipment needs together with the physical characteristics of the development site such as soils or slope. Limit of disturbance distances may vary depending on the type of development, the size of the project site, and the specific development features involved.



Limiting the footprint of construction is another method that can be used to reduce the limits of clearing and grading. This method maps all of the limit of disturbances to find the smallest possible area to be cleared or disturbed. The photograph on the next page illustrates the use of this method to minimize disturbance of existing vegetation.

REDUCE LIMITS OF CLEARING & GRADING

The third method used to reduce the limits of clearing and grading is fitting the project site design to the existing terrain. This method and the use of special procedures and equipment is discussed further in other sections of this manual.

LAND/SITE UTILIZATION

Fit the Design to the Existing Terrain

***Fitting the design to the existing terrain** allows for the planning, design, and placement of buildings, roads/streets, utilities, and other infrastructure in a manner that compliments the existing topography and minimizes the amount of clearing and grading of the project site.*

Key Benefits

- Aids in preserving the natural hydrology and drainageways of a site.
- Decreases the need for grading and land disturbance.
- Minimizes erosion potential, environmental impacts, and project costs.

Planning Consideration

- Plan and lay out roads and streets to follow natural landforms.
- Position buildings and other impervious surfaces away from steep slopes, drainageways, and flood plains.

Discussion

When developing a project, the site design should be tailored to fit existing site conditions and avoid unnecessary land disturbance. Buildings, roads/streets, utilities, infrastructure, and other features associated with the project should be tailored to fit the existing terrain. Taking this approach lessens the impact to the existing soil and vegetation and preserves the hydrology and natural drainage patterns of the site. Fitting the design of the project to the terrain also reduces the amount of clearing and grading which in turn minimizes erosion, environmental impacts, and project costs.

Buildings and impervious surface areas should be kept away from steep slopes, natural drainageways, and flood plains. They should be located in areas of existing, flat terrain to allow existing drainage systems to remain in place. The major axis of buildings should be kept parallel to the contour of the land.

FIT THE DESIGN TO THE EXISTING TERRAIN

Roads and streets should follow the natural landforms and should be designed around natural drainageways and stream buffer zones. For example, in rolling, dissected terrain, collector roads and streets should follow ridgelines and natural valleys/ravines. This greatly reduces the amount of clearing and grading required. Roads and streets branching off of these main collector streets should form short loops or end in cul-de-sacs. This pattern resembles the branched pattern of ridgelines and drainageways in the natural landscape. This pattern also minimizes the removal of vegetation on existing, steep grades and reduces the number of natural stream and drainageway crossings. In places where the terrain is flat, it is easier to lay the roads and streets out in a grid like pattern because drainage patterns will be less complicated.

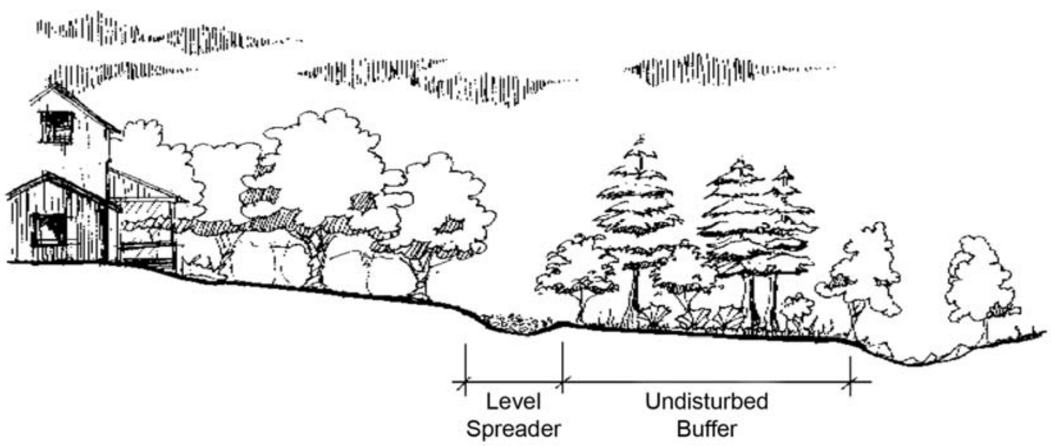
Development on Steep Terrain

Development on Flat Terrain

LAND/SITE UTILIZATION

Utilize Undisturbed Areas & Natural Buffers

***Preserving undisturbed areas and using natural buffers** is a planning and site design principle that can be effectively used to minimize clearing and grading, filter and infiltrate storm water runoff, reduce environmental impacts, and minimize the cost of development. The theory behind using undisturbed areas and natural buffer zones is to intercept storm water runoff before it becomes concentrated and disperse it evenly over the natural area or buffer zone.*



Key Benefits

- Makes use of vegetated areas to filter and infiltrate storm water runoff.
- Directing runoff towards pervious vegetated areas increases overland flow time and reduces peak flows.
- Natural depressions provide for inexpensive storage and detention of storm water runoff.

Planning Consideration

- Minimize the amount of impervious surface area and use storm water management measures to convert concentrated flows from the impervious areas into sheet flow that is discharged into pervious, vegetated areas.
- Use storm water management measures to convert concentrated flows into sheet flows and direct the runoff towards vegetated buffer zones and undisturbed areas.
- Use natural depressions for storage of storm water runoff.

UTILIZE UNDISTURBED AREAS & NATURAL BUFFERS

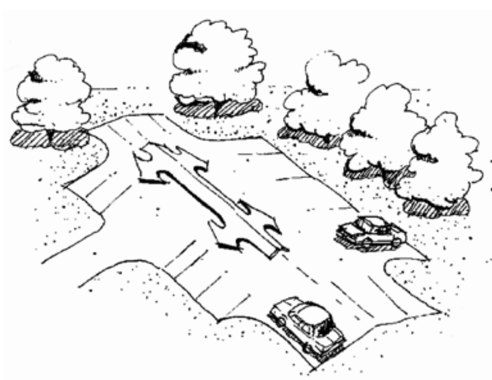
Discussion

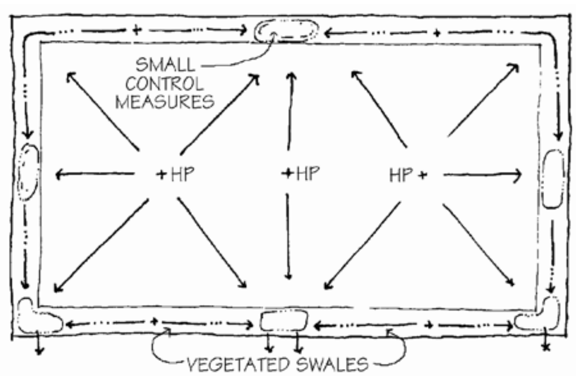
Directing storm water runoff from impervious surface areas to undisturbed natural areas, vegetated areas, riparian buffer zones, and other undisturbed natural areas slows storm water runoff and allows the runoff to infiltrate into the soil. These vegetated areas and buffer zones also facilitate the removal of storm water pollutants via infiltration, absorption, ion exchange, precipitation, and biodegradation thereby preventing pollutants from reaching rivers, lakes, and other waterbodies.

Natural depressions can be used to store storm water runoff temporarily and allow it to infiltrate into the underlying soil (especially in areas of porous soils). In this way, the runoff is “disconnected” from hydraulically efficient structural conveyances such as a curb and gutter or storm drain systems.

Methods for disconnecting impervious areas include using roof designs that drain to vegetated areas, directing storm water runoff from impervious surfaces to vegetated areas, diverging the direction of storm water flow from impervious surfaces (e.g., parking lots), and shaping landscaped areas to shed storm water sheet flows to pervious areas.

Paved Surfaces Designed to Disperse Flow to Vegetated Areas





PLANNING PRINCIPLES

Once the designer is knowledgeable of the project site and begins to plan the layout, design, and infrastructure there are still many decisions to be made. There are numerous storm water quality measures that can be selected to manage storm water quantity, treat storm water runoff, and reduce the discharge of pollutants that will be associated with the final land use. Before the final selection of storm water quality measures, there are other planning and design opportunities that should be taken into account by the designer.

This section provides an in-depth discussion of several planning or design principles that should be considered early in the project. The principles described in this section are a variation of typical project design. The principles include but are not limited to creative development design, roadway design, building and parking lot footprints, setbacks and frontages, and storm water conveyance system alternatives. Communities across Indiana have strict guidelines or ordinances that apply to the design of subdivisions, commercial projects, and other development. Most of the principles described in this section have not necessarily been adopted or incorporated into local ordinances and may require a special approval or a variance from local plan authorities.

Incorporating these planning principles into the design and layout of the project site can minimize the overall impact of the project. Benefits include but are not limited to site aesthetics, reduction of impervious surfaces, decreased generation of pollutants, and treatment of storm water runoff.

PLANNING PRINCIPLES

Creative Development Design

Creative development design *is a planning principle that can be used to reduce the amount of impervious cover on a project site. The theory behind this principle is to reduce storm water runoff volumes and velocities by reducing the percentage of pervious cover, allowing for increased infiltration of storm water into the soil.*

Examples of Reducing Impervious Cover

Cul-de-Sac with Landscaped Island

Narrower Residential Street

Landscape Median in Roadway

"Green" Parking Lot with Landscaped Islands

Key Benefits

- Reduces storm water runoff volumes and velocities.
- Reduces amount of pollutants generated.
- Minimizes environmental impacts.
- Minimizes disturbance to wildlife habitat.
- Preserves aesthetics of project site which can increase salability of lots.

CREATIVE DEVELOPMENT DESIGN

Planning Consideration

- Minimize roadway lengths and widths.
- Minimize building footprints.
- Minimize parking footprints.
- Reduce setbacks and frontages.
- Reduce the radius of cul-de-sacs.
- Use fewer or alternative cul-de-sacs.

Discussion

A primary focus of urban and suburban storm water management planning is to minimize the frequency and severity of flooding. This is generally done by reducing peak discharges from new development. Reducing peak discharges requires generating a site design that minimizes the use of pavement and impervious surfaces, incorporates infiltration measures to restore predevelopment runoff volumes, and uses vegetated drainage swales designed to match predevelopment storm water runoff velocities.

One of the most essential parts of better site design is related to the amount of impervious cover. Impervious cover includes sidewalks, roads, rooftops, parking lots, and basically any surface that does not allow water to infiltrate into the soil. The more impervious cover in an area, the greater the amount of storm water generated. Large amounts of storm water increase pollutant loadings. Conversely, a site designer can reduce the amount of storm water that is generated by reducing the amount of impervious cover.

"Cluster development" is one design concept that can be used to reduce impervious surface cover. This design concept minimizes the amount of land disturbance, concentrates utility lines and connections in one area or corridor, and provides more open, natural space. "Cluster development" also reduces environmental impacts by decreasing the amount of soil exposed to erosive forces and decreasing the amount of impervious surface area which results in less storm water runoff. Another advantage of "cluster development" is that it generally reduces overall development costs by reducing the amount and size of clearing and grading operations, paving materials needed for roads and streets, and infrastructure for storm water conveyance/control and treatment.

The principle behind "cluster development" is to concentrate development within one section of a site. Parking areas, driveways, and common or open areas are shared. Lot sizes are reduced in size and typically are more irregular in shape. Clustering buildings in a centralized area minimizes land disturbance and requires less land area for the installation of utilities and construction of roads and streets.

CREATIVE DEVELOPMENT DESIGN

Planning and designing "cluster developments" should begin by developing a prototype cluster(s) on paper for the desired unit type and site situation before addressing lot layout on the total project site. This avoids many of the pitfalls encountered in laying out roads first and then building lots. By working out the objective and problems of lot-street relationships in advance, you can more readily see opportunities to capitalize on the project site's physical characteristics. For example, the site planner will have greater opportunities to minimize the project's environmental impacts and maximize the aesthetics and amenities of the site.

PLANNING PRINCIPLES

Roadway Design

***Roadway design** is a planning principle that can be used to reduce impervious surface cover by reducing the lengths and widths of roadways and cul-de-sacs.*

Key Benefits

- Minimizes storm water runoff and associated pollutants generated by reducing the amount of impervious surface cover.
- Reduces the cost of roadway construction and maintenance.

Planning Consideration

- Reduce overall street length by considering different site and road layouts.
- Reduce street width by using narrow street designs.
- Consider alternative cul-de-sac designs.

Discussion

In many communities, streets are designed and installed at a greater width than necessary. Implementing alternative street layouts can often reduce the total length of streets and significantly minimize the impervious surface cover of a development site. Therefore, site designers should evaluate different street and cul-de-sac layouts that will result in reduced lengths and widths. Site designers should also look for associated landscaping measures that will provide additional infiltration of storm water runoff discharging from impervious surface areas.

ROADWAY DESIGN

Streets and Cul-de-Sac Widths

Typically, streets are designed to accommodate two rows of traffic and a row of parked cars on either side of the street. To reduce the amount of impervious surface cover, residential and private streets within a development should be designed for the minimum required pavement width that is needed for travel lanes, on-street parking, and emergency vehicle access. Some alternatives for accomplishing these objectives might include:

- Reducing on-street parking to one lane.
- Implementing single lane, one-way loop roads.
- Eliminating parking on cul-de-sacs with less than 200 average daily trips and two-way loop streets with less than 400 average daily trips.
- Using parking bays to accommodate the parking requirements of local residents.

Using the above approaches allows for a substantial reduction in the amount of impervious surface cover.

Turnarounds

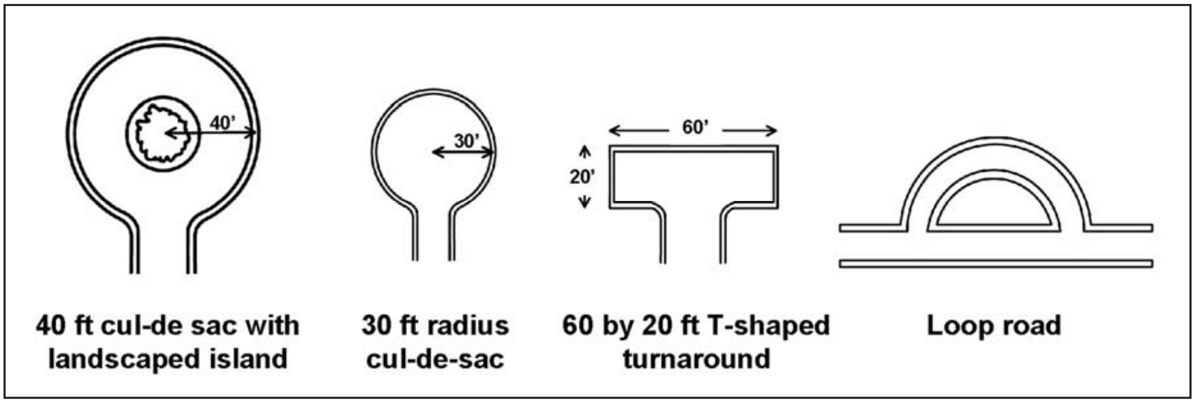
Many cul-de-sacs and turnarounds have a radius of more than 40 feet. From a storm water management perspective, this creates a huge amount of impervious surface cover, increasing the quantity of storm water runoff. Therefore, to minimize the amount of impervious surface cover generated at a site, the size of cul-de-sacs and turnarounds should be reduced via alternative designs or eliminated altogether.

Providing enough turnaround area for different types of vehicles that may need to use cul-de-sacs and turnarounds is a significant aspect to consider in the planning and design process. For example, many vehicles like fire trucks, service vehicles, and school buses generally require a larger turning radius than passenger vehicles. In recent years some fire trucks have been designed with a smaller turning radius and some service vehicles are now equipped with triaxles which require a smaller turning radius. In regard to school buses, it is becoming commonplace for school children to board the bus at the intersection of the cul-de-sac and collector street rather than the bus entering the individual cul-de-sacs.

Many alternative cul-de-sac and turnaround designs generate less impervious surface cover than the traditional 40-foot cul-de-sacs. When planning and designing cul-de-sacs and turnarounds, use alternative designs to provide the minimum radii required to accommodate emergency and maintenance vehicles. Some of these alternatives include:

ROADWAY DESIGN

- Reducing the radius of cul-de-sacs to 30 feet.
- Creating hammerhead turnarounds.
- Using loop roads.
- Using pervious islands in the center of the cul-de-sac.



Some communities have specific planning and design criteria for streets, cul-de-sacs, and turnarounds. Therefore, altering street and cul-de-sac designs may require obtaining variances from the local plan department. In the future, local plan departments may be considering updates or modification of their local ordinances to allow for alternative designs.

Changing street and cul-de-sac designs may also require public information and outreach marketing strategies to educate the local residents about the environmental benefits of such design changes.

PLANNING PRINCIPLES

Building Footprints

*The principle behind "**building footprints**" is to reduce the impervious footprint of commercial buildings and residences by constructing taller buildings while maintaining the same building floor-to-soil surface area ratio.*

Key Benefits

- Maximizes the amount of pervious surface area for storm water infiltration.
- Minimizes the amount of storm water runoff.
- Minimizes the amount of pollutants delivered to receiving waterbodies.

Planning Consideration

- Use building designs that are taller in order to reduce the impervious footprint of buildings.

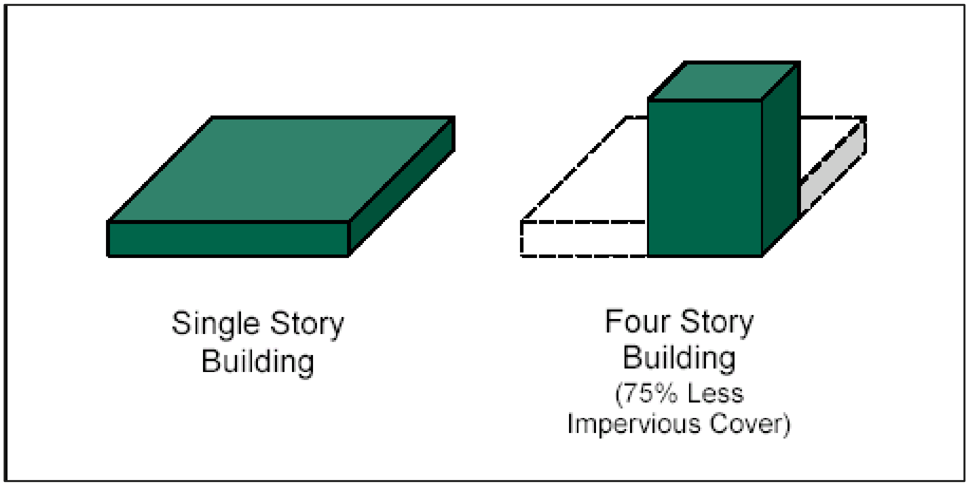
Discussion

The building unit-to-lot relationship is a facet of site planning too often accepted as a "given," even though it offers a good opportunity to reduce runoff volumes, runoff velocities, and peak discharges. Planning and designing a development project should take into consideration the unit-to-lot relationship and attempt to match it to the existing site and hydrologic conditions.

Using alternative building designs and constructing taller buildings helps minimize the amount of impervious surface cover by reducing the building footprint and rooftop area.

Combining or consolidating the functions of a building or segmenting facilities can also be effective methods for reducing individual building footprints.

BUILDING FOOTPRINTS



PLANNING PRINCIPLES

Parking Lot Footprints

*The principle behind "**parking lot footprints**" is to reduce the amount of impervious surface cover associated with parking lots.*

Key Benefits

- Reduces the amount of impervious surface cover.
- Reduces storm water runoff and amount of pollutants delivered to receiving waterbodies.

Planning Consideration

- Minimize the number of parking spaces.
- Reduce stall dimensions.
- Consider parking structures and shared parking.
- Consider using porous surfaces in vehicle overflow areas.

Discussion

Parking lots are often larger than necessary. This is due to the practice of designing for peak occupancy. As the following table shows, the number of parking spaces provided can often be reduced significantly if average parking demand numbers were used in the planning and design process.

PARKING LOT FOOTPRINTS

Conventional Minimum Parking Ratios

Land Use	Parking Requirement		
	Parking Ratio	Typical Range	Actual Average Parking Demand
Single family homes	2 spaces per dwelling unit	1.5–2.5	1.11 spaces per dwelling unit
Shopping center	5 spaces per 1000 ft^2 GFA*	4.0–6.5	3.97 per 1000 ft^2 GFA*
Convenience store	3.3 spaces per 1000 ft^2 GFA*	2.0–10.0	-----
Industrial	1 space per 1000 ft^2 GFA*	0.5–2.0	1.48 per 1000 ft^2 GFA*
Medical/dental office	5.7 spaces per 1000 ft^2 GFA*	4.5–10.0	4.11 per 1000 ft^2 GFA*

*GFA = Gross floor area of a building without storage or utility spaces.

There are several methods that can be used to minimize impervious surface cover associated with parking lot footprints. Some of these methods are:

- Setting maximum sizes for parking spaces.
- Minimizing parking stall dimensions.
- Providing spaces for compact cars.
- Incorporating efficient parking lanes.
- Constructing multi-level parking structures.
- Sharing parking lots.
- Installing alternative porous surfaces in overflow parking areas.

PARKING LOT FOOTPRINTS

One of the easiest and least costly methods of reducing parking lot footprints is adjusting the size of individual parking stalls. Reducing the length and width of parking stalls can greatly reduce the size of parking lots. Designing parking lots with areas and parking stalls designated for specific types of vehicles, such as compact cars or sport utility vehicles, can provide for an efficient use of space.

Parking structures can also have a huge impact on the reduction of the overall parking lot footprint.

Shared parking is a method that works well in mixed use areas. For example, an office complex where employees work daytime hours throughout the week may share a lot with a church which typically meets on weekends and evenings.

Installing porous or permeable surfaces in parking lot overflow areas is an effective method for minimizing the amount of storm water runoff generated from these areas. These systems can be used in both new development and redevelopment/retrofit projects.

Porous paver or porous pavement systems are well suited for use in parking lot overflow areas. Porous pavers consist of structural units which have voids filled with a pervious material such as sand or gravel. Porous paver systems can be vegetated so that the paver system is inconspicuous or they can be left visible to the public. Porous pavement systems include porous asphalt and pervious concrete. These systems have an advantage over conventional asphalt and concrete because they allow storm water runoff to be stored and treated.

Proper installation and maintenance of porous paver and pavement systems is essential if they are to perform properly. These systems do require more maintenance than conventional asphalt and concrete parking areas.

PLANNING PRINCIPLES

Setbacks & Frontages

*The principle behind “**setbacks and frontages**” is to reduce the total length of impervious streets and driveways.*

Key Benefits

- Reduces the amount of impervious surface cover.
- Reduces the amount of storm water runoff and the amount of pollutants delivered to receiving waterbodies.

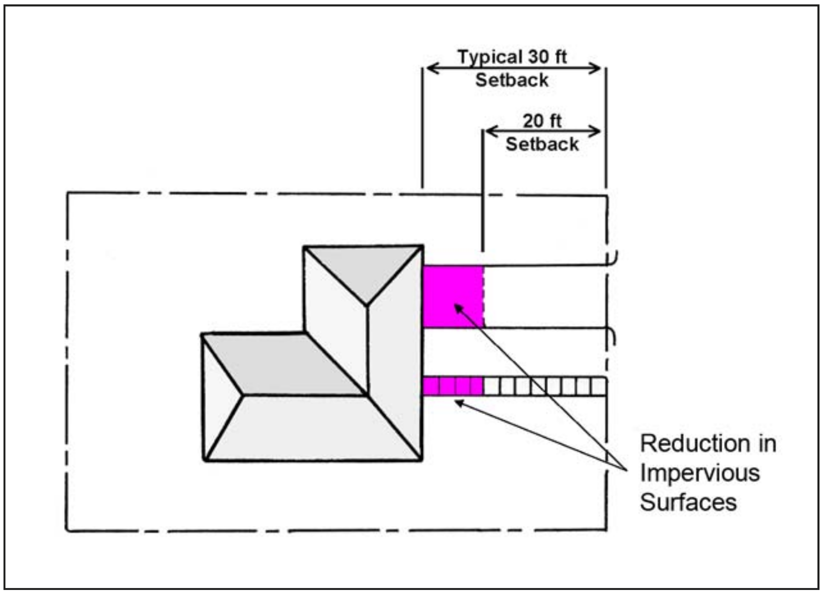
Planning Consideration

- Reduce front and side setback distances for homes and buildings.
- Use narrower frontages.

Discussion

The reduction of setback and frontage distances will reduce the amount of impervious surface cover associated with a development site. For example, on residential and commercial developments, shortened setback distances reduce the amount of impervious cover from driveways and entryways. A setback of 20 feet is generally sufficient for parking a vehicle in a driveway without infringing on the public right-of-way. Reducing a setback distance from 30 feet to 20 feet can reduce driveway and sidewalk impervious surface cover by 30 percent or more.

SETBACKS & FRONTAGES



As shown in the photograph of this measure, minimizing side yard setbacks and using narrower frontages can significantly reduce impervious surface cover and total street lengths. This is especially important in cluster developments and open space designs.

PLANNING PRINCIPLES

Natural Drainageways vs. Storm Sewers

*This principle takes advantage of **natural drainageways** by incorporating them into a project's storm water management system.*

Key Benefits

- Lowers the expense of road and storm sewer construction as well as the need for land disturbance and grading.
- Maintains natural storm water runoff storage, infiltration, and treatment.
- Storm water filtration and infiltration occurs when it is used with buffer systems.
- Provides for longer travel times and lower peak discharges of storm water runoff than hydraulically efficient man-made channels.

Planning Consideration

- Preserve natural flow corridors.
- Direct runoff to natural drainageways, ensuring that peak flows and velocities will not cause channel erosion.
- Use vegetated channels (enhanced wet or dry swales or grass channels) in place of curb and gutter to convey and treat storm water runoff.

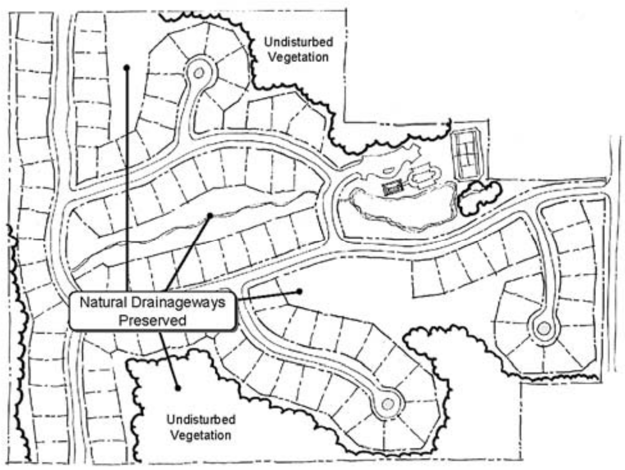
Discussion

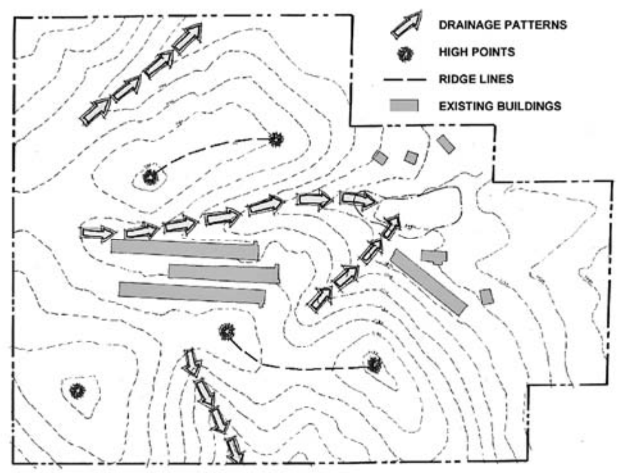
Natural drainage features such as creeks and streams that flow through or are adjacent to a project site are an amenity that can add aesthetic value to the property and therefore should be incorporated into the project design and layout. Incorporating natural drainageways into the project's drainage system also helps

NATURAL DRAINAGEWAYS VS. STORM SEWERS

minimize the cost of the project by reducing grading costs, the investment in man-made drainage structures, and installation of the drainage system.

Storm sewers and other structural drainage systems are generally used in urban development projects to convey storm water runoff in the most efficient manner. Using these man-made systems increases storm water runoff, runoff flow velocities, and delivery of pollutants to the receiving water body. The alternative to this approach is to use constructed drainageways and vegetated swales to carry the storm water. In low-density developments and subdivisions, drainageways are well suited for removing storm water runoff pollutants, allowing filtering and infiltration of runoff, lowering peak flow discharges, providing higher storage capacities, and reducing the velocity of storm water runoff.





Planning, Design, and Layout

Incorporating natural drainageways into a site plan requires identifying natural drainage patterns such as overland flow and swales and conveyance systems where water will concentrate. Where possible, these natural drainage features should be integrated into the location and design of storm water management measures, especially around critical areas where water will concentrate. Natural drainage features should also be used to convey storm water runoff over and off the site to avoid the expense and issues associated with constructing an artificial drainage system.

Drainage System

The planning and design of a project's primary drainage system must take into consideration expected storm water runoff volumes and velocities from the final land use. It is critical that the drainage system be planned and designed to accommodate increased runoff from the project site. It is also critical to design a conveyance system that will be resistant to the erosive forces created by increased storm water runoff volumes and velocities.

At this stage of planning and design, it is often advantageous to begin evaluating potential sites for detention/retention ponds.

Secondary Drainage System

Secondary drainage systems associated with a project site also require careful evaluation. Where feasible, choose natural or constructed, vegetated drainage swales over a conventional storm sewer system and curbs and gutters. Existing natural drainage swales or constructed grass-lined swales are much more effective in regulating water quality and quantity and are less expensive to construct and maintain than a conventional storm sewer system.

As with the primary drainage system, it is critical that secondary, man-made conveyance systems be properly designed to accommodate expected runoff from the final land use. Again, these secondary, man-made systems will need to be properly stabilized to reduce the erosive forces of storm water runoff. If it is anticipated that runoff flows will increase, route the augmented flow into a man-made storm water conveyance system or detention area and preserve the natural storm water conveyance system.

Natural conveyance systems often have an adjoining floodplain which is used to temporarily store excess storm water runoff and reduce downstream flooding potential. Wherever possible, construction activities and development in floodplains should be avoided. In many instances, floodplains and natural riparian buffer zones can be integrated into the project design to create a level of aesthetic value and/or used as a natural or recreational area. It is also important to preserve natural areas where storm water runoff flow enters the drainage system.

When incorporating natural drainageways into a project's drainage system, it is important to install storm water management measures that will ensure downstream drainageways are protected from erosion, degradation, and high post-development flows from project site storm water discharges.

Occasionally the site designer will propose moving or relocating a natural drainageway. It is important to note that modification or relocation of natural drainageways requires a high level of coordination and generally requires the use of sophisticated storm water quality measures to prevent the discharge of sediment and other pollutants associated with the construction activity. Relocation of natural drainageways can be a costly venture, even if done correctly, and usually requires permits from state and/or federal agencies.

1. **What does the hydrological cycle primarily describe?**
   Water movement through soil layers
   Pollution transport in urban runoff
   The movement of water between atmosphere, land, and water
   The interaction between groundwater and vegetation

2. **Which of the following is not a fate of precipitation after it reaches the earth's surface?**
   Immediate chemical breakdown
   Evaporation
   Transpiration
   Infiltration

3. **Urbanization most significantly alters hydrology through:**
   Increased forest cover
   Decreased rainfall
   Increased impervious surface area
   Reduced construction activities

4. **Which of the following best defines stormwater runoff?**
   Water that percolates into groundwater
   Water retained by vegetation
   Precipitation that does not infiltrate and flows over land
   Water stored in lakes and reservoirs

5. **What pollutant is the most common by volume from construction sites in the U.S.?**
   Pesticides
   Sediment
   Petroleum hydrocarbons
   Phosphorus

6. **Stream channel erosion is least likely to result in:**
   Channel siltation
   Reduced water temperature
   Streambank instability
   Reduced aquatic vegetation

7. **What is the effect of increasing impervious surface on peak runoff volume?**
   It decreases peak runoff
   It eliminates runoff
   It increases both volume and velocity
   It reduces pollutant loads

8. **Which land use is most likely to produce high hydrocarbon and heavy metal concentrations in runoff?**
   Agricultural fields
   Residential lawns
   Forested areas
   Commercial parking lots

9. **The loss of vegetative cover during construction primarily leads to:**
   Improved soil structure
   Reduction in groundwater recharge
   Increased erosion and runoff
   Increased atmospheric CO_2

10. **Which feature is critical to preserving stormwater infiltration capacity in an ecosystem?**
    Impervious parking lots
    Subsurface drainage pipes
    Native vegetation
    Synthetic mulch

11. **One acre of construction land can contribute up to how many tons of sediment annually?**
    1 tons
    10 tons
    30 tons
    500 tons

12. **What is a major consequence of sediment accumulation in wetland depressions?**
    Decreased water-holding capacity
    Increased groundwater recharge
    Enhanced biodiversity
    Stabilization of plant habitat

13.Which of the following is a benefit of urban trees?

They increase impervious area
They trap snow and provide shade
They reduce infiltration
They promote channel straightening

14.Streambed scouring is primarily caused by:

Low-intensity rainfall
Decreased sediment load
Leaf litter decomposition
Increased flow velocities from runoff

15.The effectiveness of vegetated filters depends on:

Dense vegetative cover and soil permeability
The use of impermeable liners
High slope angles
Mulching with concrete

16.What hydrologic factor is most influenced by land grading and compaction?

Rainfall intensity
Infiltration rate
Soil temperature
Atmospheric humidity

17.What is the most important consideration in the early stages of construction site planning?

Site assessment and data collection
Soil pH levels
Plant species selection
Drain tile depth

18.Which of the following pollutants is often introduced into water from pet waste?

Phosphorus
Lead
Ammonia gas
Fecal coliform

19. Why are historical and archaeological site assessments necessary in planning?

To improve aesthetics
To avoid construction delays or legal issues
To increase sediment deposition
To minimize plant diversity

20. Which is a common reason post-construction stormwater control is difficult in urban areas?

Limited space for treatment infrastructure
Excess vegetation
Excessive rainfall
Low runoff volume