United States Environmental Protection Agency

Source Water Protection Practices Bulletin

Managing Stormwater Runoff to Prevent Contamination of Drinking Water

Facts:

- Runoff is rainwater or snowmelt that flows over the land.
- Runoff can carry contaminants that flow to surface water and infiltrate to ground water sources.
- Impervious cover is land that has inadequate infiltrative properties.
- Contaminated stormwater can be injected into Class V wells.
- Vegetation slows the flow of water and helps filter contaminants.
- Impervious cover increases flooding events and pollutant transport and also decreases local ground water recharge.

Stormwater runoff is rainwater or snowmelt that flows over the land. Runoff can carry sediment and contaminants from streets, rooftops, and lawns to surface water bodies or can infiltrate through the soil to ground water. This bulletin focuses on the management of runoff in urban environments.

This document is intended to serve as a resource for professionals and citizens involved in planning and decision-making in the areas of stormwater management and source water protection. Those who may find this bulletin useful include: state and regional source water, stormwater, nonpoint source control, underground injection control (UIC), and other managers; members or representatives of watershed groups; local officials and permitting authorities; developers; and federal and state highway agencies.

1 - Street runoff in Colombia, MO.

Inside this Issue:

SOURCES OF POLLUTION IN STORMWATER RUNOFF

Urban and suburban areas are dominated by impervious cover. This includes pavement on roads, sidewalks, parking lots, and rooftops. It also includes heavily trafficked surfaces, such as dirt parking lots, walking paths, baseball fields, and suburban lawns that no longer have adequate infiltrative properties.

During storms, rainwater flows across these impervious surfaces, mobilizing contaminants. The pollutants carried in runoff originate from a variety of urban and suburban nonpoint sources. Oil, gasoline, and automotive fluids drip from vehicles onto roads and parking lots. Landscaping by homeowners, around businesses, and on public grounds contributes sediment, pesticides, fertilizers, and nutrients to runoff. Construction of roads and buildings can contribute large sediment loads to waterways. In addition, any uncovered materials such as improperly stored chemicals (e.g., household cleaners, pool chemicals, or lawn care products), pet and wildlife waste, and litter can be carried in runoff. Illicit discharges to storm drains (e.g., of used motor oil) can also contaminate water supplies.

Stormwater transports pollutants to water bodies such as lakes and streams. Contaminated stormwater can also be directly injected into the subsurface through Class V stormwater drainage wells, which promote subsurface infiltration (discussed below). These wells are commonly used to divert stormwater runoff from roads, other paved surfaces, and roofs. Direct injection is of particular concern from a water quality standpoint in commercial and industrial settings (e.g., in and around material loading areas, vehicle service areas, or parking lots).

WHY IS IT IMPORTANT TO MANAGE STORMWATER RUNOFF NEAR THE SOURCE OF DRINKING WATER?

Impervious surfaces in built-up environments prevent the natural infiltration of rainfall into the soil. This reduces ground water recharge and the pollutant removal that occurs when runoff moves through the soil. With less infiltration occurring, both the volume and flow rate of surface runoff increase. Development also reduces the amount of land available for vegetation, which would normally slow the flow of water and help filter contaminants. These changes have deleterious effects on water bodies. A relationship has been observed between the amount of impervious area in a watershed and surface water quality; degradation of water quality may begin with as little as 10 percent impervious cover[1]. There are three primary concerns associated with uncontrolled runoff: (1) increased peak discharge and velocity during storm events resulting in flooding and erosion; (2) localized reduction in ground water recharge; and (3) pollutant mobilization and transport.

The 1983 Nationwide Urban Runoff Program (NURP) study showed 77 of 127 priority pollutants tested were detected in urban runoff.

The increased runoff rate and volume caused by impervious cover contribute to erosion (especially in areas without vegetative cover), increased flooding in low lying areas, and sedimentation in surface water bodies. The excess sediment transported by streams can increase turbidity, provide a transport medium for pathogenic bacteria and viruses, and decrease reservoir capacity. Sediment can also smother aquatic species, leading to habitat loss and decreased biodiversity.

According to the 1983 Nationwide Urban Runoff Program (NURP) study[2], 77 of 127 priority pollutants tested were detected in urban runoff. Contaminants commonly found in stormwater runoff include heavy metals, organic compounds, pesticides and herbicides, pathogens, nutrients, sediments, and salts and other deicing compounds.

Some of these substances are carcinogenic; others lead to reproductive, developmental, or other health problems following long-term exposure. Pathogens can cause illness, even from short-term exposure. Urban runoff is commonly collected in storm sewers and discharged to waterways untreated. Thus, surface water bodies that are used for drinking water routinely receive contaminants carried in runoff. Ground water may receive contaminants through Class V stormwater injection wells. Under certain conditions, some contaminants may reach ground water through infiltration from the surface (see section below on ground water sensitivity and siting considerations for infiltration).

2 - Flood, Nashville, TN.

AVAILABLE MANAGEMENT MEASURES TO ADDRESS STORMWATER RUNOFF

A variety of management practices, including pollution prevention strategies and treatment strategies, are available to mitigate stormwater pollution. Individual prevention measures might or might not be adequate to prevent contamination of source waters. A robust management plan will combine individual measures in an overall prevention approach that takes into consideration a number of factors, including: potential contamination sources; cost of prevention measures vs. loss of resources from pollution; operational and maintenance requirements of the measures; vulnerability of the source waters; local soil and geology, precipitation, and land use characteristics; the public's acceptance of the measures; and the community's desired degree of risk reduction. Some of the more widely used management measures are described below.

Some of the substances found in runoff are carcinogenic; others lead to reproductive, developmental, or other health problems following long-term exposure. Pathogens can cause illness, even from short-term exposure.

Pollution Source Control and Prevention Measures

Pollution source control and prevention measures include public education for homeowners and business owners on good housekeeping, proper use and storage of chemicals, and responsible lawn care and landscaping. Other pollution prevention measures include storm drain stenciling, hazardous materials collection, and detection and elimination of illicit discharges. The incorporation of best management practices (BMPs) in building and site-development codes should be encouraged. On roadways, proper maintenance of rights-of-way, control of chemical and nutrient applications, street cleaning or sweeping, storm drain cleaning, use of alternative or reduced deicing products, and calibration of chemical application vehicles can reduce the pollutant content of runoff.

3 - Erosion

Erosion and Sedimentation Control (ESC)

Construction should be timed to coincide with seasons of low rainfall and low erosion potential.

Without appropriate erosion and sedimentation control (ESC) measures, construction activities can contribute large amounts of sediment to stormwater runoff. Erosion can be controlled by planting temporary fast-growing vegetation, such as grasses and wildflowers. Covering topsoil with geotextiles or impervious covers will also protect it from rainfall. Good housekeeping measures for construction sites include construction entrance pads and vehicle washing to keep sediment and soil on-site. Construction should be staged to reduce soil exposure or timed to coincide with seasons of low rainfall and low erosion potential. Other measures include sediment traps and basins; sediment fences; wind erosion controls (e.g., mulch, seeding, geotextile covers); and chemical and nutrient control. Ordinances and regulations for construction activities can be written to require plan reviews for evaluation of erosion concerns or to require ESC measures during construction. ESC measures should be inspected and kept in good repair.

Land Use Controls

Local governments can exercise a variety of land use controls. Subdivision controls, for example, help to ensure that expected development will not compromise drinking water quality or ground water recharge. Requiring proper stormwater management in new developments and redevelopments can help prevent excessive runoff.

4 - Stormwater management pond.

Environmentally Sensitive Design

Environmentally sensitive design principles that can be incorporated into new developments are an active area of research. Several of these are discussed in the next few paragraphs.

Rainwater Harvesting

Rainwater harvesting may also be incorporated into an environmentally sensitive design. The collection and storage of rainwater from rooftops, via gutters and downspouts, reduces runoff and associated pollution and provides water for irrigation and non-potable indoor use. A typical rain barrel is a 55- or 65- gallon drum. Larger vessels are called cisterns. Instructions and guidebooks for rainwater harvesting are available on the Internet (see "Additional Information" section below).

5 - Cistern in Istanbul.

6 - Rainwater harvesting barrels.

Low Impact Development (LID)

Rain barrels are 55- or 65- gallon drums. Larger vessels are called cisterns.

Low impact development (LID) techniques are used to mimic pre-development hydrology as closely as possible. Infiltration methods in particular can help to re-route rainwater to recharge ground water, although siting should be done carefully and pretreatment should be used to avoid ground water contamination.

LID techniques are used to mimic pre-development hydrology as closely as possible.

Directly Connected Impervious Areas (DCIAs)

Minimizing directly connected impervious areas (DCIAs) is important for reducing the flow and volume of runoff. Planners should direct runoff from roofs, sidewalks, and other surfaces over grassed areas. This will promote infiltration of stormwater into the ground and also allow for filtration of pollutants prior to discharge to surface water and ground water. Planting landscaped areas lower than the street level also encourages drainage.

7 - Porous pavement.

Porous Pavements

Use of porous pavements in parking lots provides another opportunity for stormwater to infiltrate into soils. (These are only appropriate in areas where no hazardous materials are used, generated, or transported.) One example of porous pavement, concrete grid pavement, is typically placed on a sand or gravel base with void areas filled with pervious materials such as sand, gravel, or grass. Stormwater percolates through the voids into the subsoil.

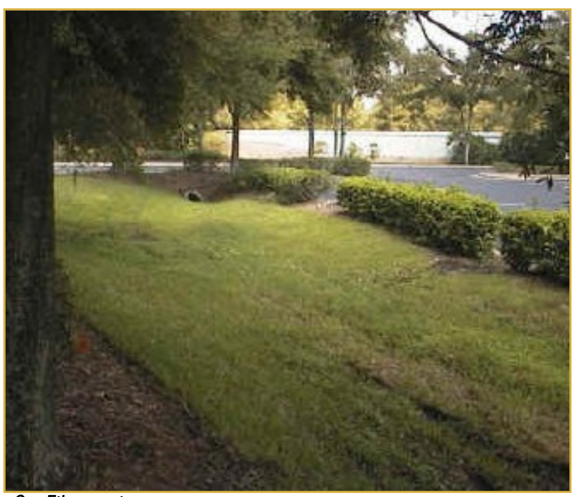
Structural Best Management Practices

Structural best management practices are used to control runoff or temporarily store stormwater on site. In addition to reducing runoff volumes and rates, these structures can reduce pollutant loads in runoff, especially through settling of particles. Several types of BMPs rely on soils and vegetation to help with filtration, infiltration, and trapping of suspended particles. Vegetation-based structures, such as swales and bioretention cells, may be incorporated into LID designs. Some of the more commonly used practices are described below. Information about the performance of BMPs can be found in the International Stormwater BMP Database (http://www.bmpdatabase.org).

Grassed Swales

Grassed swales are shallow, vegetated ditches that reduce the speed and volume of runoff. Soils remove contaminants by filtration and infiltration. Vegetation or turf prevents soil erosion, filters out sediment, and provides some nutrient uptake. Maintenance of grassed swales involves regular mowing, reseeding, weed control, removal of leaves and other debris, and inspections to check for erosion and ensure the integrity of the vegetative cover. To function properly, the inflow to the swale must be sheet flow (shallow, even flow) from a filter strip or an impervious surface. Pollutant removal efficiencies for structural BMPs vary, but swales have been found to be particularly effective at removal of total suspended solids, achieving up to 70 percent removal[3,4]. Besides grassed swales, grassed waterways (wide, shallow channels lined with sod) are often used as outlets for runoff from terraces.

8 - Two grassed swales. (foreground and background).



9 - Filter strip.

Filter strips sometimes form the outer edges of buffer strips and can also serve as pretreatments for other structural BMPs.

Filter Strips

Filter strips are areas of close growing vegetation (often grasses) on gently sloped land surfaces bordering a surface water body. Filter strips originated as an agricultural practice but are now being used in urban settings. They are intended to capture sheet flow, slowing runoff and allowing for trapping of sediment (and sediment-associated pollutants) and infiltration. Filter strips sometimes form the outer edges of buffer strips and can also serve as pretreatments for other structural BMPs. The width and length of the filter strip depend on the size and grade of the slope it drains. Maintenance activities include inspections, mowing, and removal of sediment buildup. Filter strips might not be appropriate for pollution hotspots because their ability to remove high levels of pollutants is limited.

Buffer Strips

Buffer strips are combinations of trees, shrubs, and/or grasses parallel to a stream, shoreline, or wetland. They provide a physical barrier to protect a water body from disturbance or encroachment and from pollution. They may be planted or consist of naturally occurring vegetation. By slowing runoff, buffer strips can moderate flooding and prevent streambank erosion. The vegetation and soils can also strain and filter sediments and sediment-associated pollutants. Constructed buffer strips are sometimes structured in zones, with trees closest to the stream, followed by one or two rows of shrubs, and a 20 to 24 foot wide grass zone on the outer edge. Buffer strips should be maintained by controlling weeds and mowing grasses once or twice annually. About 10 to 20 percent removal of solids has been demonstrated in buffer zones. Some buffer strips might provide infiltration, but many do not because they exist in low-lying areas with limited infiltration and storage capacity (or are in areas of ground water discharge rather than recharge).

Stormwater Ponds

Stormwater ponds (wet ponds) consist of permanent ponds where solids settle during and between storms, and zones of emergent wetland vegetation, where dissolved contaminants are removed through biochemical processes. Wet ponds are usually developed as water features in a community, increasing the value of adjacent property. Besides landscape maintenance, annual inspection of the outlets and shoreline is required. Vegetation should be harvested every 3 to 5 years, and sediment removed every 7 to 10 years. Removal of pollutants associated with particles can be expected through settling. Data from the International Stormwater BMP Database indicate that ponds are capable of removing nitrogen and phosphorous.

Structural BMPs:

- Grassed Swales.
- Buffer Strips.
- Filter Strips.
- Stormwater Ponds.
- Constructed Wetlands.
- Bioretention and Bioinfiltration Cells.
- Infiltration Basins.
- Green Roofs.

10 - Constructed wetland, construction (above) and after 2 years (below).

Constructed Wetlands

Constructed wetlands are similar to wet ponds but have more emergent aquatic vegetation and a smaller open water area. Constructed stormwater wetlands are similar in many respects to natural wetlands but typically have less biodiversity. A wetland should have a settling pond, or forebay, if significant upstream soil erosion is anticipated. Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool. Wetlands remove the same pollutants as wet ponds through settling of solids and biochemical processes, with about the same efficiency. Maintenance requirements for wetlands are similar to those for wet ponds.

Bioretention and Bioinfiltration Cells

Bioretention and bioinfiltration cells are shallow, landscaped depressions designed to store runoff and provide pollutant removal as runoff flows through layers of vegetation, mulch, and soil. A bioretention cell discharges to a surface conveyance, whereas bioinfiltration is intended to permit infiltration of the treated runoff into the surrounding soil. Properly selected vegetation and a soil mixture containing sand and organic material help with removal of a variety of pollutants, including metals, hydrocarbons, nutrients, and bacteria[6]. Bioretention and bioinfiltration are not recommended for large sites; they work best when they drain locations less than five acres in area.

11 - Bioretention cell

12 - Infiltration basin

Infiltration Basins and Trenches

Infiltration basins are shallow impoundments designed to permit stormwater to infiltrate into the soil. Infiltration trenches are long, narrow stone-filled excavated trenches, 3 to12 feet deep. Runoff is stored in a basin or in voids between the stones in a trench and slowly infiltrates into the soil matrix below, where filtering removes pollutants. Infiltration devices should be combined with pretreatment practices such as swales or sediment basins to prevent premature clogging and to remove particle-associated pollutants. Infiltration basins and trenches should be inspected annually and after major rain storms. Maintenance needs include debris removal, especially in inlets and overflow channels. Infiltration devices and associated practices can achieve a high degree of contaminant removal (55 - 90 percent) for selected common contaminants[5].

Green Roofs

Green roofs are partially or completely covered with vegetation. They are often constructed as a layered system with a waterproof layer, drainage layer, filter membrane, soil, and plants. "Intensive" green roofs may have a variety of plants including shrubs and small trees, and are intended to be accessible to people. They are labor-intensive. "Extensive" green roofs are not intended for human interaction and require only a thin layer of soil and minimal maintenance[7]. Plant options for extensive roofs are more limited than for intensive roofs because the plants must be able to thrive with little maintenance. Grasses, perennials, or succulents maybe used. A green roof can capture anywhere from 15 to 90 percent of rainwater[8]. The ability to absorb rainwater depends on a variety of conditions, such as climate and the selection of plants. Green roofs confer other benefits such as aesthetics and a reduction in energy consumption for the building. Green roofs have been used in Scandinavia for centuries and are popular in Europe.

13 - Chicago City Hall .

14 - Traditional sod roofs.

A green roof can capture from 15 to 90% of rainwater. They also reduce energy consumption in the building.

Staff Training

Staff training for stormwater management should include continuing education and certification to ensure that staff have up to date knowledge regarding the selection, planning, design, construction, and maintenance of stormwater management measures.

Operation and Maintenance Plan

An operation and maintenance (O&M) plan is an important part of a stormwater management program. The goal of an O&M plan is to ensure that individual and interconnected stormwater BMPs continue to meet performance and design objectives. This plan should include an inventory of BMPs, their locations, design parameters, and other life cycle data. The plan should also include and budget periodic inspections to determine whether BMPs require routine maintenance, repair, rehabilitation, replacement, or design adjustments to meet water quality and quantity objectives.

Many Real-Time Monitoring sensors are capable of monitoring for multiple parameters simultaneously, saving time and money.

Real-Time Monitoring

Real-Time Monitoring is not a management practice per se but it can be used to help determine the need for management practices by recording water quality measurements on a continuous basis. It is characterized by in situ sensors that take measurements of water quality in real or near-real time. This is an advantage over more traditional, less frequent sampling approaches in that it is less likely to miss abrupt changes in levels of contaminants and may allow for a quicker response to address a threat to public health or aquatic organisms. In addition, many of these sensors are capable of monitoring for multiple parameters simultaneously, saving time and money over periodic sampling for individual contaminants. Costs for these sensors are falling. For example, datasondes (a type of sensor used for real-time monitoring) range in price from $700 to nearly $3000.

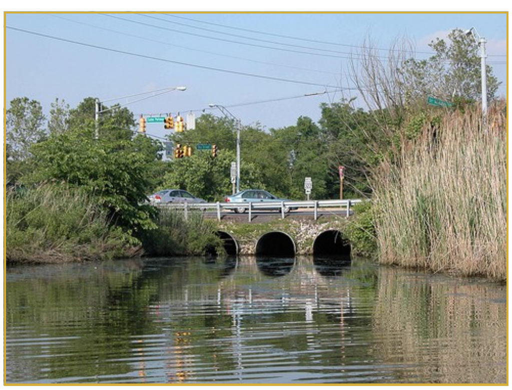
Environmental Management System

An Environmental Management System (EMS) can provide a framework for a stormwater management program by helping to set program objectives and benchmarks and implement stormwater management strategies. Responsibilities should be identified, training requirements specified, and documentation and communication protocols established. Through periodic program evaluations, areas of improvement can be identified. Modifications can then be made to the program and its O&M practices.

15 - Construction sites larger than 1 acre require NPDES permits.

EPA's NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMITTING PROGRAM

EPA's NPDES program regulates stormwater runoff from municipal separate storm sewer systems (MS4s) and industrial activity (including construction). The current rules establish permit requirements for more than 5,000 MS4s nationwide. NPDES stormwater permits issued to MS4s require those MS4s to develop the necessary legal authority to reduce the discharge of pollutants in stormwater to the maximum extent practicable and to develop and implement a stormwater management program that includes:



16 - Stormwater discharge into marshes.

- structural and source control measures to reduce pollutants in runoff from commercial and residential areas, including maintenance, monitoring, and planning activities;
- detection and prevention of illicit discharges and improper disposal into storm sewers;
- monitoring and control of stormwater discharges from certain industrial activities;
- stormwater control at construction sites; and
- public education and outreach.

In addition, the stormwater rule for certain small MS4s requires post-construction stormwater management controls. These local controls are in addition to existing federal regulations that require NPDES permits for all construction activities disturbing more than one acre.

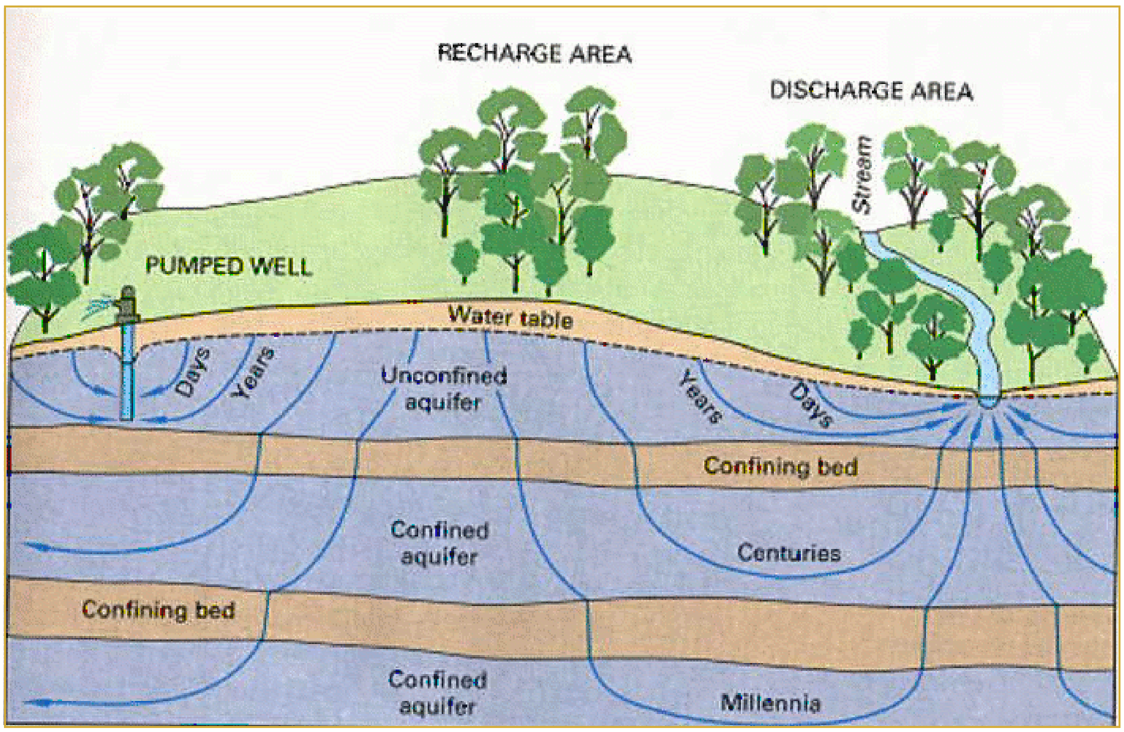
EPA has published more than 100 fact sheets on the wide variety of BMPs that small MS4s can use to control urban stormwater runoff. The menu is available from EPA's website at www.epa.gov/npdes.

GROUND WATER SENSITIVITY AND SITING CONSIDERATIONS FOR INFILTRATION

Infiltration of stormwater through the soil profile to ground water, whether planned by humans or due to natural features of the landscape, has long been an accepted and important component of stormwater management. As the nation's population has increased and become more urban, many natural areas have given way to development and impermeable surfaces, inhibiting infiltration and producing larger volumes of stormwater runoff over shorter time periods. As shown by the 1983 NURP study, this runoff may contain many contaminants. Such pollution can threaten surface waters that support ecosystems and human recreation and provide water for drinking, industry, and farming.

In an effort to protect surface waters from the effects of runoff, the use of infiltration practices (e.g., infiltration basins, infiltration trenches, bioinfiltration, and porous pavement) is being increasingly encouraged. Infiltration offers many benefits: reducing and delaying runoff volumes, enhancing aquifer recharge (thereby sustaining stream baseflow and supporting stream ecosystems), and decreasing flow velocities (allowing for pathogen die-off). However, under some conditions, these practices may introduce certain pollutants to ground water. Although contamination from stormwater runoff is usually greater than that resulting from infiltration and subsequent discharge, ground water is difficult and costly to remediate after contamination. Also, ground water movement can be challenging to predict and monitor. The potential for ground water contamination is of particular concern in areas where a shallow aquifer may serve as a drinking water source because ground water is generally not treated prior to consumption.

Stormwater managers can help protect underground drinking water sources from contamination by being aware of areas with sensitive ground waters and exercising care in deciding where to locate infiltration practices. Factors to consider in this decision include the nature of the soils, the type of aquifer, the depth to the water table, presence or absence of confining layers, and land use. Rare and highly valuable ground waters such as sole source aquifers (those that provide more than 50 percent of the drinking water in the area above the aquifer) should also be afforded careful protection.



17 - Generalized ground water movement.

Ground water can be difficult and costly to remediate after contamination. Also, ground water movement can be challenging to predict and monitor.

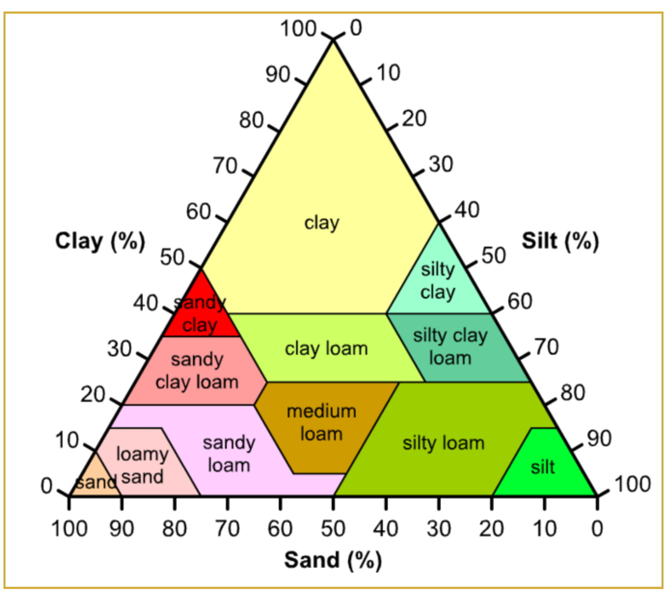
18 - Carlsbad Caverns karst formations.

Clay minerals and organic matter provide pollutant removal for metals and organic compounds.

Sandy soils with low clay and organic matter content may be problematic if runoff is highly contaminated. Clay minerals and organic matter provide pollutant removal for metals and organic compounds, and soils low in these constituents will be less effective at removing pollutants from infiltrating stormwater. It may be necessary to augment soils in certain infiltration BMPs, such as bioinfiltration cells, to provide adequate clays and organic matter.

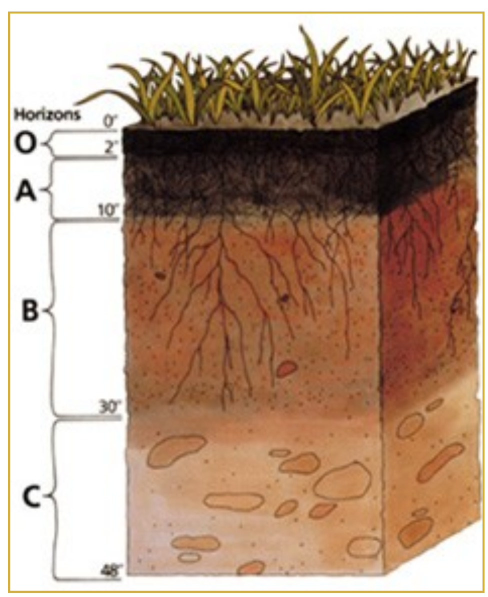
Certain types of aquifers are especially sensitive to contamination. These include gravel, fractured bedrock, and karst aquifers. In general, as grain size in an aquifer increases, permeability also tends to increase because pore openings are larger. Aquifers with large grain size and/or large fractures and openings tend to have relatively high permeability and may have high ground water flow rates. These high flow rates enable stormwater that has moved down to the water table to move rapidly through the subsurface. Although the upper soil layer in an infiltration structure removes pollutants, this removal may not be complete for all contaminant types. Also, the labile (active) organic carbon content of soil typically decreases with depth, making deeper soil horizons less effective at contaminant removal. Further pollutant removal can take place in the aquifer, but the high flow rates in highly permeable aquifers might not allow enough time for this removal to take place, and contaminants may travel long distances. A shallow water table also renders ground water vulnerable because there is only a narrow opportunity for pollutant removal between the ground surface and the water table. A combination of a sandy soil with low organic content, a shallow water table, and a highly permeable aquifer would be an especially vulnerable setting.

Karst areas present a particular challenge for remediation of contaminated stormwater due to the presence of large dissolution structures and rapid ground water flow rates. Karst is a type of geologic setting within which flowing ground water has dissolved significant portions of the rock (typically limestone). These regions are typically characterized by features such as sinkholes and underground drainage networks, with openings ranging in size from fractures to caverns. Given the solubility and heterogeneity of bedrock in karst areas, stormwater management should be approached very carefully in such regions.



19 - Soil types (left)

20 - Soil horizons (right)



Hotspots of trace metal and hydrocarbon contamination.

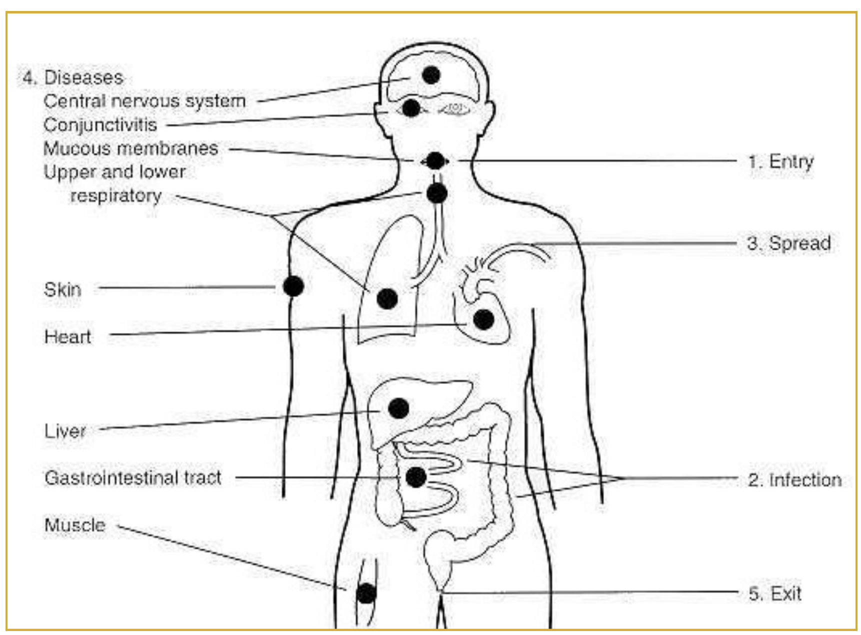
21 - Marina. (left)

22 - Gas station (right)

In addition to soil and aquifer characteristics, the amounts and types of pollution anticipated in runoff should be considered. Constituents that are not retained by soils or quickly degraded by microbes may move through the soil and reach ground water. Chloride is not attenuated by soil, and chloride carried in runoff can be expected to reach the water table. Because of this, deicing salts used in cold climates pose a ground water contamination problem. Nitrate moves readily through soil and is a common ground water contaminant. Among heavy metals, zinc is the most mobile, although it will undergo some removal by soils. Some pesticides are highly mobile, and if they do not degrade quickly, they can present a high ground water contamination potential. Among microbial contaminants, enteroviruses, if present in stormwater, are likely to have a high ground water contamination potential.

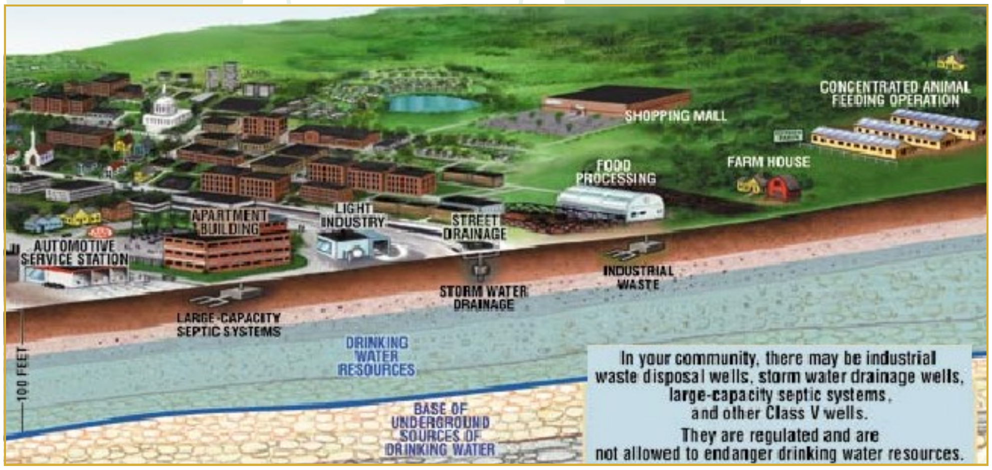
Chloride is not attenuated by soil. Nitrogen moves readily through soil. Zinc is the most mobile heavy metal. Enteroviruses are likely to have a high ground water contamination potential.

Land use and proximity to concentrated sources of contamination must also be considered in siting infiltration practices. This is a concern not only with surface infiltration but also with subsurface injection (i.e., stormwater drainage wells, discussed below). Sites of known contamination that have not undergone remediation would present a high risk; infiltration should be avoided at these sites. Also, hot spots of hydrocarbon and trace metal contamination in the urban landscape should be recognized as posing a high risk. These are often places associated with motor vehicles: gas stations, service stations, vehicle and equipment cleaning facilities, fuel storage areas, marinas, public works storage areas, and loading docks. They may also include facilities that generate or store hazardous materials. Many states have defined lists of such areas and some facilities are required to develop stormwater pollution prevention plans. In general, installing an infiltration system close to a hot spot is not advised. Ongoing research has shown, however, that soil media used in bioretention/bioinfiltration systems can be highly effective at removing hydrocarbons, heavy metals, and nutrients[6]. As research progresses, these systems may prove to be useful in settings where contaminants are expected in runoff.



23 - Enterovirus infectious pathway.

CLASS V STORMWATER DRAINAGE WELLS



Class V stormwater drainage wells are shallow disposal systems designed to infiltrate (inject) stormwater runoff below the ground surface. They are sometimes also called dry wells, bored wells, or infiltration galleries. They may pose a threat to underground sources of drinking water if they are not properly sited, designed, operated, and maintained. BMPs for Class V stormwater drainage wells address siting, design, pretreatment, and operation for these wells.

Siting BMPs for stormwater drainage wells include minimum setbacks from surface waters and drinking water wells. Having an adequate thickness of soil between the drainage well and the water table is especially important. Stormwater drainage wells may be prohibited from areas of critical concern, such as source water protection areas, or from areas where the engineering properties of the soil are not ideal for their performance. Having an organic-rich layer in or below a stormwater drainage well can help retain pollutants such as organic compounds and metals and limit their movement towards the ground water.

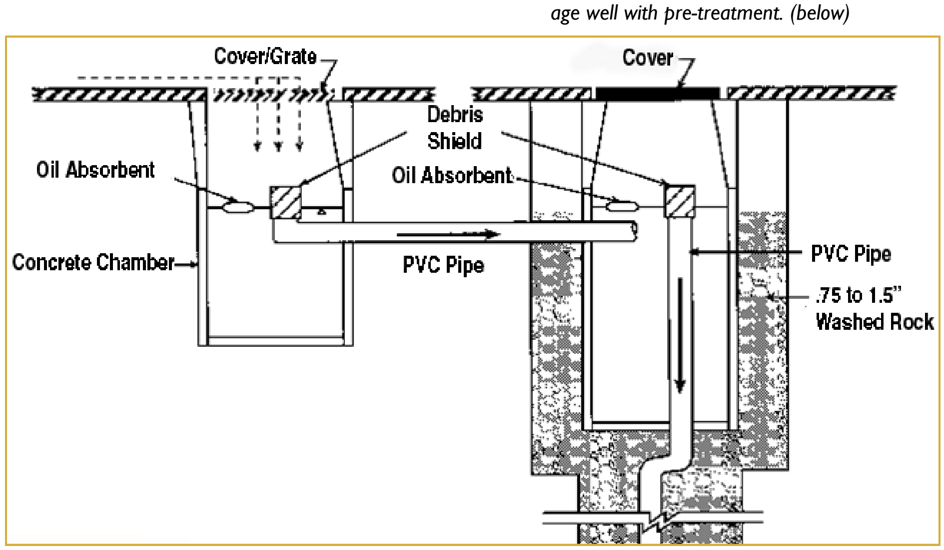
Available design BMPs for stormwater drainage wells include the use of sediment removal devices (such as filter strips) and oil and grease separators. Also, pretreatment structures can remove sediment and sediment-associated pollutants, helping both to protect water quality and to maintain infiltration capacity. Pretreatment structures can include such green infrastructure components as wetlands, bioretention cells, and vegetated filter strips.

Maintenance of stormwater drainage wells is crucial to their proper operation. Management measures related to operation include spill response, monitoring, and maintenance procedures. Source separation, or keeping spills and runoff from industrial areas away from stormwater drainage wells, involves using containment devices such as berms or curbs (see the fact sheets on vehicle washing and small quantity chemical use for more information on these devices).

The discharge of untreated stormwater directly to underground sources of drinking water through stormwater drainage wells should be avoided when the discharge might contain contaminants that can threaten water supplies—for example, discharge from urban and industrial sites, pollution hot spots, highways, or other areas where high levels of contaminants in runoff are anticipated. In such areas, use of other stormwater management measures such as green infrastructure or pretreatment of the discharge is recommended. Preferably, the infiltrating stormwater should have received pretreatment sufficient to ensure that contaminants of concern do not exceed drinking water maximum contaminant levels (MCLs) at the point of discharge.

24 - Location of wells in relation to drinking water. (above)

25 - Schematic of a Class V stormwater drainage well with pre-treatment. (below)



ADDITIONAL INFORMATION:

The sources listed below contain additional information on stormwater management measures. All of the documents listed are available for free on the Internet. State departments of environmental protection are good sources of information about all aspects of stormwater management, including compliance with underground injection regulations governing well injection of stormwater. State departments of transportation or agriculture are also good sources of information.
Contact state and local government authorities in your area to find out if there are regulations, guidance, or ordinances in place to guide your management of stormwater. To propose local ordinances or regulations to effect stormwater controls, contact city or county public works departments, zoning offices, permitting offices, or transportation departments. Numerous examples of local source water protection-related ordinances for various potential contaminant sources can be found at::

http://cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Publications&view=filter&document_type_id=105
http://www.epa.gov/owow/nps/ordinance, and
http://www.epa.gov/owow/nps/ordinance/links.htm.

Also, university extension services are excellent sources of information on water quality issues, including stormwater management. Oklahoma State University's Division of Agricultural Sciences and Natural Resources is one such example: http://pods.dasnr.okstate.edu/docushare/dsweb/View/Collection-590.

The following organizations and documents provide information on selection and design of specific management measures:

Low Impact Development Center. http://www.lowimpactdevelopment.org/sitemap.htm.

Kloss, C. 2008. *Managing Wet Weather with Green Infrastructure Municipal Handbook: Rainwater Harvesting Policies*. EPA-833-F-08-010. http://www.epa.gov/npdes/pubs/gi_munichandbook_harvesting.pdf.

North Carolina State University Cooperative Extension. 2007. *Rain Barrels*. http://guilford.ces.ncsu.edu/files/library/41/rainbarrel-2008.pdf.

The Center for Watershed Protection's Storm Water Manager's Resource Center (www.stormwatercenter.net) provides technical assistance on storm water management issues.

The Center for Watershed Protection's *Practice of Watershed Protection* provides numerous articles on issues related to watershed and storm water management. http://www.cwp.org/Resource_Library/pwp.htm.

The International Stormwater BMP Database provides BMP performance data from over 300 studies. http://www.bmpdatabase.org/.

U.S. EPA, Office of Ground Water and Drinking Water. September 1999. *The Class V Underground Injection Control Study. Volume 3: Storm Water Drainage Wells.* EPA/816-R-99-014c. http://permanent.access.gpo.gov/lps45859/volume3.pdf.

U.S. EPA, Office of Science and Technology. August 1999. *Preliminary Data Summary of Urban Stormwater Best Management Practices.* EPA-821-R-99-012. http://www.epa.gov/guide/stormwater/.

U.S. EPA, Office of Wastewater Management. May 2006. *National Pollutant Discharge Elimination System (NPDES), Menu of BMPs*. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.

U.S. EPA, Office of Wastewater Management. September 1992. *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and BMPs.* http://www.epa.gov/npdes/pubs/owm0236a.pdf.

U.S. EPA, Office of Wetlands, Oceans, and Watersheds. January 1993. *Guidance Specifying Management Measures for Sources of Non-point Pollution in Coastal Waters.* EPA-840-B-93-001c. http://www.epa.gov/nps/MMGI/.

U.S. EPA, Office of Ground Water and Drinking Water. *Class V UIC Study Fact Sheet: Storm Water Drainage Wells*. http://www.epa.gov/ogwdw/uic/class5/pdf/study_uic-class5_classvstudy_fs_storm_wells.pdf.

U.S. EPA: Green Infrastructure and Green Communities: Linking Landscapes and Communities. http://www.epa.gov/greenkit/green_infrastructure.htm.

U.S. EPA: Polluted Runoff (Nonpoint Source Pollution), Low Impact Development. http://www.epa.gov/nps/lid/.

U.S. EPA: Polluted Runoff (Nonpoint Source Pollution). 2008. National Management Measures to Control Nonpoint Source Pollution from Urban Areas. http://epa.gov/nps/urbanmm/.

Washington State Department of Transportation. June 2008. *Highway Runoff Manual*. M 31-16.01. http://www.wsdot.wa.gov/publications/manuals/fulltext/M31-16/HighwayRunoff.pdf.

Wyoming Department of Environmental Quality. February 1999. *Urban Best Management Practices for Nonpoint Source Pollution*. Draft. http://deq.state.wy.us/wqd/watershed/Downloads/NPS%20Program/92171.pdf.

REFERENCES CITED IN BULLETIN:

1 The Center for Watershed Protection. 2000. The Importance of imperviousness. Article 1 from The Practice of Watershed Protection. http://www.cwp.org/Resource_Library/Center_Docs/PWP/ELC_PWP1.pdf.

2 U.S. Environmental Protection Agency. 1983. Nationwide Urban Runoff Program (NURP) Priority Pollutant Monitoring Project: Summary of Findings. 12 Dec 1983. Available from National Technical Information Service, Springfield, VA 22161.

3 Wyoming Department of Environmental Quality. 1999. Urban Best Management Practices for Nonpoint Source Pollution. http://deq.state.wy.us/wqd/watershed/Downloads/NPS%20Program/92171.pdf.

4 Iowa State University. 2009. Iowa Stormwater Management Manual. http://www.ctre.iastate.edu/PUBS/stormwater/index.cfm.

5 Schueler, T. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments: Washington, DC.

6 Davis, A.P., Hunt, W.F., Traver, R.G., and Clar, M. 2009. Bioretention technology: Overview of current practice and future needs. Journal of Environmental Engineering, 135, 109-117.

7 Green Roofs for Healthy Cities North America. http://www.greenroofs.org/.

8 Duluth Streams: Green Roofs. http://www.duluthstreams.org/stormwater/toolkit/greenroofs.html.

IMAGE CREDITS:

1 Flickr Creative Commons. Attribute only search. Urban Drain, uploaded by "KOMUnews" on June 8, 2010.
http://www.flickr.com/photos/komunews/4683128554/in/set-72157624232753326/

2 Flickr Creative Commons. Attribute only search. Nashville Flood, uploaded by "tandemracer" on May 2, 2010.
http://www.flickr.com/photos/tandemracer/4572237007/

3 Erosion image from original document.

4 Flickr Creative Commons. Attribution only search. Baldwin Park Stormwater management pond, uploaded by "faceless b" on February 21, 2008. Photo credit to EPA Smart Growth. http://www.flickr.com/photos/smart_growth/2282048249/

5 Wikimedia Commons. Cisterna Basilica Junto a Santa Sofia Estambul. http://en.wikipedia.org/wiki/Basilica_Cistern

6 Flickr Creative Commons. Attribute only search. Photo.jpg, uploaded by "mjmonty" on May 25, 2008. http://www.flickr.com/photos/mjmonty/2521496870/in/photostream/

26 - Highway rain runoff.

7 Porous pavement image from original document.

8 Wikipedia. Bioswale. http://en.wikipedia.org/wiki/Bioswale

9 Filter strip image from original document.

10 Wikipedia. Constructed Wetland before and after 2 years. http://en.wikipedia.org/wiki/Constructed_wetland

11 Wikipedia. Rain Garden. http://en.wikipedia.org/wiki/Rain_garden

12 Infiltration basin image from original document.

13 Wikipedia. Chicago City Hall Green Roof, uploaded by "TonyTheTiger". http://en.wikipedia.org/wiki/Green_roof

14 Wikipedia. Norðragøta, Faroe Islands (2), uploaded by "Erik Christensen". http://en.wikipedia.org/wiki/Green_roof

15 Flickr Creative Commons. Attribute only search. Building a brand new world, Construction Cranes, Sculpture, Bellevue, Washington, USA, uploaded by "Wonderlane" on September 1, 2009. http://www.flickr.com/photos/wonderlane/3876730681/

16 Flickr Creative Commons. Attribute only search. Stormwater dischrage into marsh, uploaded by "Eutrophication&hypoxia" on April 15, 2010. Original photo credit to Jane Hawkey. http://www.flickr.com/photos/48722974@N07/4523319559/

17 Wikipedia. USGS public domain diagram. http://commons.wikimedia.org/wiki/File:Groundwater_flow.png

18 Wikipedia. Carlsbad Interior Formations, uploaded by "marshman" on April 1, 2004. http://en.wikipedia.org/wiki/File:Carlsbad_Interior_Formations.jpg

19 Wikipedia. SoilComposition, uploaded by "Zephyris" on Novemeber 2, 2009. http://en.wikipedia.org/wiki/File:SoilComposition.png

20 Wikipedia. SoilProfile from the USDA, public domain. http://en.wikipedia.org/wiki/File:Soil_profile.png

21 Flickr Creative Commons. Attribute only search. Marina Reflections, uploaded by "LyndaW1" on May 25, 2009. http://www.flickr.com/photos/27948818@N05/3564961372/

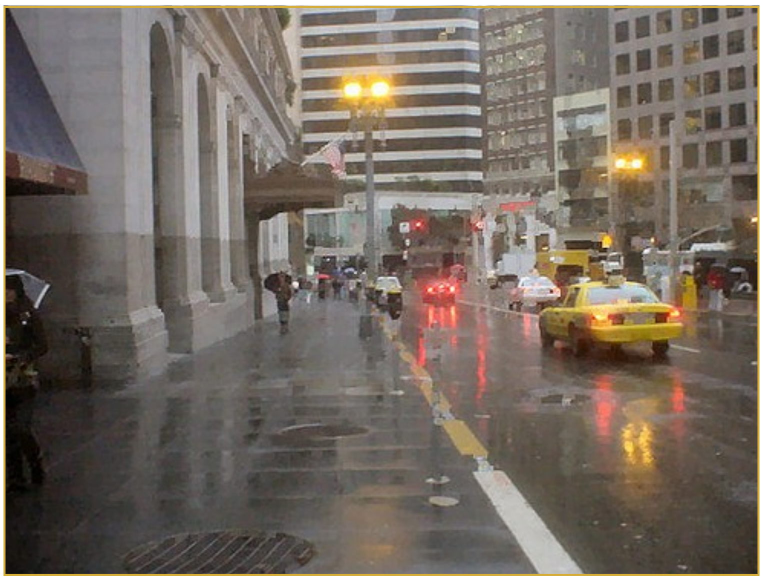
22 Flickr Creative Commons. Attribute only search. _TOR0910, uploaded by "geishaboy500" on May 25, 2008. http://www.flickr.com/photos/geishaboy500/2522978998/

23 The National Center for Biotechnology Information. Diagram: Pathogenesis of enterovirus infections from Medical Microbiology: The University of Texas Medical Branch of Galveston. Copyright 1996. http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=mmed&part=A2862&rendertype=figure&id=A2881

24 and 25 EPA Office of Water, Underground Injection Control. http://www.epa.gov/safewater/uic/class5/types_stormwater.html

26 Flickr Creative Commons. Attribute only search. Dangerous driving in the rain - tips, uploaded by "woodleywonderworks" on August 10, 2008. http://www.flickr.com/photos/wwworks/2750711244/

27 (back cover) Flickr Creative Commons. Attribute only search. Rain, uploaded by "tata_aka_T" on May 12, 2006. http://www.flickr.com/photos/12453467@N00/145330838/



Source Water Protection Practices Bulletin

Managing Stormwater Runoff to Prevent Contamination of Drinking Water

The mission of EPA is to protect human health and to safeguard the natural environment -- air, water and land -- upon which life depends.

USEPA East (EPA East) [Old ICC Building]
1201 Constitution Avenue N.W.
Washington, DC 20004

United States Environmental Protection Agency