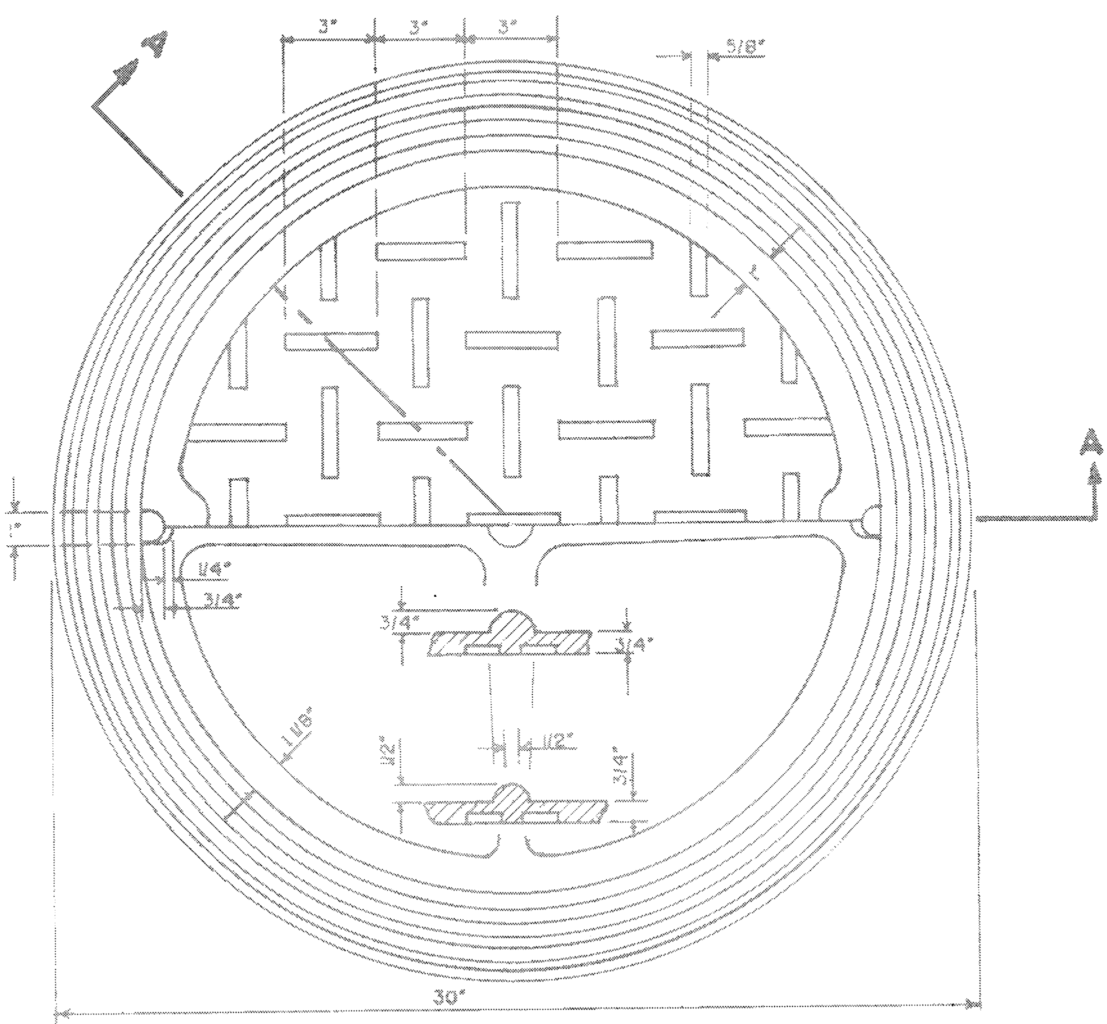
The Wisconsin Stormwater Manual

Part One: Overview

The Words "STORM DRAIN" Shall Be CAST Into The Top CENTER Of All Storm Drain Covers.



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The Wisconsin Stormwater Manual
Part One: Overview

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Wisconsin Department of Natural Resources
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Primary Author:
Jeffrey Prey

Contributing Authors:
Laura Chern
Steve Holaday
Carolyn Johnson
Terry Donovan
Percy Mather

Editing, Layout and Design:
Aaron Williamson

Table of Contents

Chapter Five: Best Management Practices

List of Tables

List of Figures

Preface

Part one of this two-part manual provides information on ways to reduce pollution from urban stormwater runoff. It is designed to help a variety of professionals involved in stormwater management in Wisconsin such as planners, engineers, developers, architects, inspectors, public works directors and government administrators. Part one covers a broad range of subjects including:

- Pollution prevention measures like leaf collection and pet waste cleanup
- Alternatives for administration and financing
- State and federal stormwater regulations
- Guidelines for stormwater planning
- A model stormwater plan

Part two of the stormwater manual "Technical Design Guidelines for Stormwater BMPs" will be available in the first quarter of 1995. For a copy, write or call:

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The contents of this manual reflect several basic assumptions and decisions about pollution prevention, quality versus quantity, and finance and administration.

Pollution Prevention

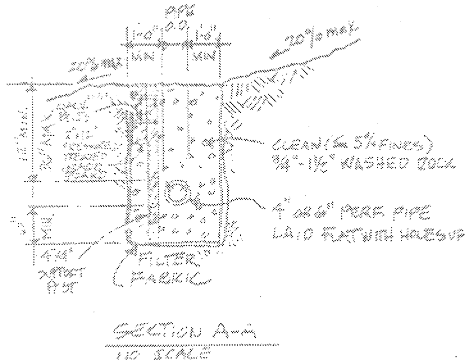
This manual purposely discusses pollution prevention practices before the section on best management practices (BMPs). Prevention is preferred since it usually costs less and is more effective than treatment to reduce pollution.

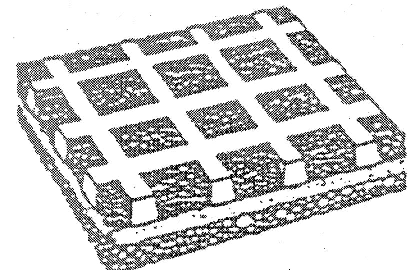
Quality Versus Quantity

While stormwater quality is related to quantity, part one does not address flood control. Facilities to improve stormwater quality are smaller and easier to fit into the urban landscape than flood control facilities. Stormwater structures can be designed for the 2-year/24-hour storm, with flood control structures designed for larger events. Despite this difference in storm design, many measures described here may be adapted or combined with other measures for flood control.

Finance and Administration

Expanding stormwater facilities to include controls for pollution and/or flooding will place greater demands on capital project budgets, maintenance programs and administration. To meet these demands, many larger communities may need new financing and administrative arrangements. Therefore, part one includes information about stormwater utilities and alternative financing techniques that other states use to meet these needs.

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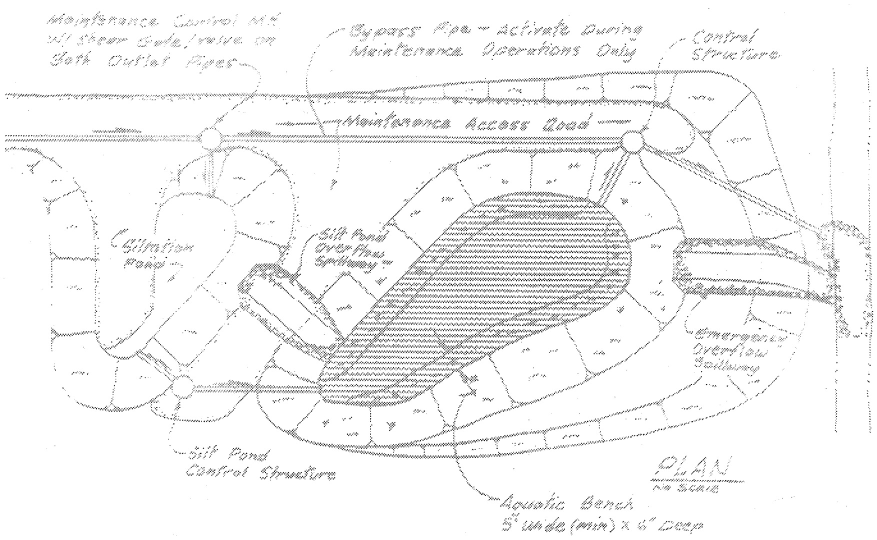
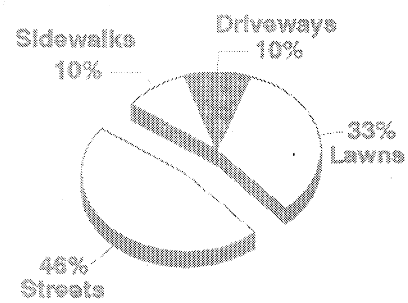
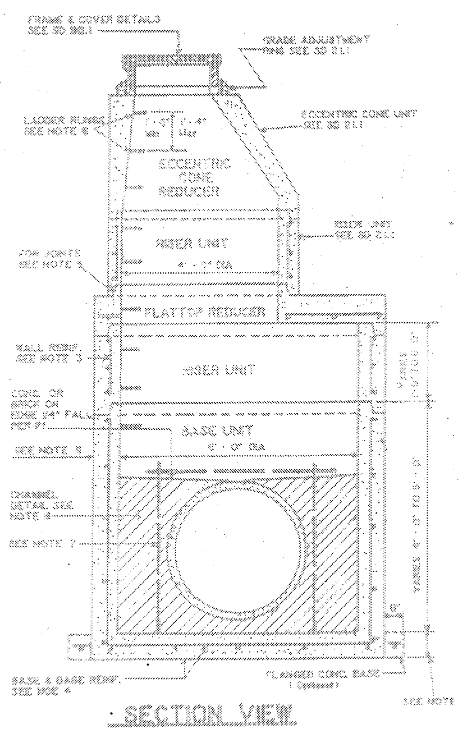
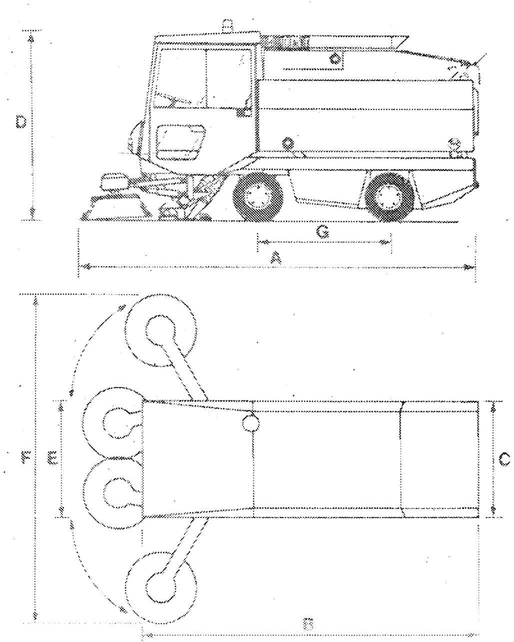








Chapter One: Introduction

This Chapter Discusses:

What is urban stormwater runoff?

Pollutants in urban stormwater

Sources of pollutants in urban stormwater

What is Urban Stormwater Runoff?

Stormwater runoff is water from rain storms or snow melt that flows over the land rather than evaporating or soaking into the ground. Urban areas generate more stormwater runoff than rural areas because buildings and pavement cover much of the land and prevent water from soaking into the ground (Table 1-1). To prevent street and basement flooding, extensive drainage systems carry "excess" water to nearby waterways. In these lakes and streams, urban stormwater creates a variety of problems including:

- Increased storm flows and decreased baseflow
- Eroding channels and wider flood plain
- Poor water quality
- Loss of habitat and recreational use

Although urban development covers only a small portion of the land in Wisconsin, urban stormwater runoff seriously affects the quality of the state's water resources. To restore the value of these water resources for human use as well as for fish and other aquatic life, addressing stormwater runoff problems is essential. The following sections explain in greater detail the impacts of urban stormwater runoff.

TABLE 1-1: TYPICAL IMPERVIOUS AREA PERCENTAGES

Land Use	Percent Impervious Cover
Business / Shopping District	95-100
High Density Residential	45-60
Medium Density Residential	35-45
Low Density Residential	20-40
Open/Green Areas	0-10

Source: Brach 1989

Changes in Flow

From the day construction begins, urbanization dramatically changes the cycle of water movement (Figure 1-1). Clearing the site removes much of the vegetation that intercepts rainfall before it reaches the ground. Once the trees and grasses are gone, less water is returned to the air through *evaporation* or *transpiration* (loss of water vapor from plants). Instead, rain falls directly on the exposed soil.

As grading proceeds, soil conditions also change. Top soil is usually stripped away and heavy construction equipment compacts the remaining subsoil. Both top soil loss and compaction of subsoil affect what happens to rain that falls on the site. Less water soaks into the ground after the "spongy" layer top soil is removed. More water runs off the compacted subsoil instead of percolating down to recharge underground water supplies. Water that once seeped through the upper layers of soil as *interflow* now runs off the surface. The loss of this shallow groundwater is significant because it supplies much of the *baseflow* in streams between storms.

In many development projects, major grading changes the shape of the land surface to provide better drainage. Developers fill low spots and wetlands to provide more "buildable" land. These natural detention areas no longer collect stormwater for gradual release after a storm. Instead, storm sewers or ditches are built to improve drainage by carrying runoff directly to lakes and streams.

Stormwater runoff problems continue after builders complete construction. Water runs off hard surfaces covered by buildings, streets, and parking lots, picking up speed and pollutants along the way. In some places, however, spreading stock-piled top soil and planting trees and grass, allows the land to regain much of its ability to soak up stormwater.

As Figure 1-2 shows, the increase in stormwater runoff reflect changes in the waterways that flow through an urbanizing area.

Figure 1-1: Water Balance
Source: Schueler 1987

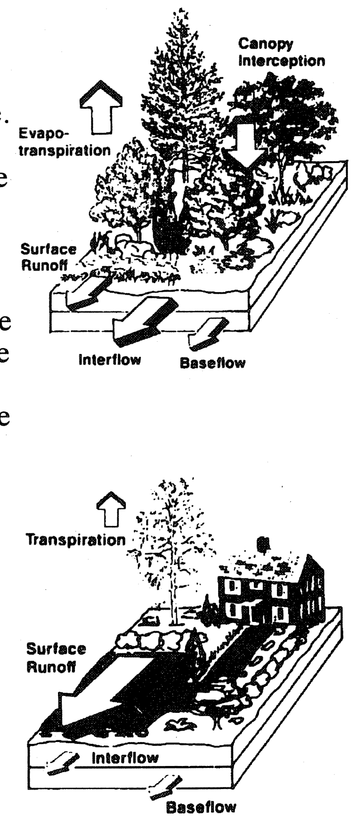
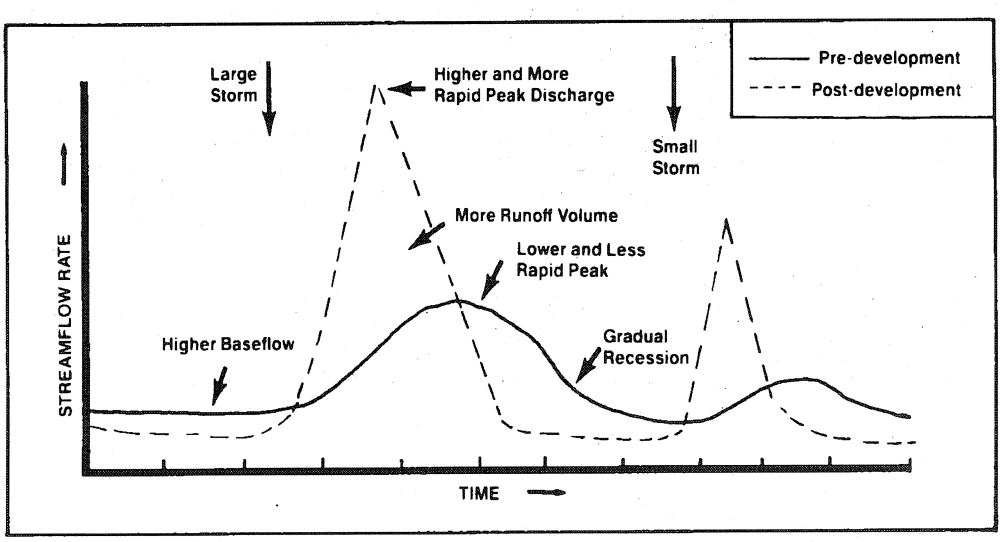


Figure 1-2: Hydrograph
Source: Schueler 1987



The amount and timing of stream flows change in the following ways (Leopold 1968; Schueler 1987):

- *Peak discharge*: Peak storm flows after development are two to five times higher than before. Consequently, the frequency and severity of flooding increases. A stream that once overflowed its banks once every two years may now flood three or four times a year.
- *Volume*: The volume of runoff produced by a storm increases about 50 percent in a moderately developed watershed.
- *Timing*: Because urban drainage systems are efficient, the time required for runoff to reach the stream can decrease by as much as 50 percent. Furthermore, high flows are compressed into a shorter period. Urban streams are often described as "flashy" because water levels rise and fall very quickly in response to storms.
- *Velocity*: Flow velocity increases during storms because peak discharges are higher and drainage system surfaces are smoother.
- *Baseflow*: Between storms, stream flow is reduced. Small streams that once flowed year-round may become seasonally dry.

These dramatic changes in stream flow have extensive consequences in terms of flooding patterns, channel erosion and habitat destruction.

Urban streams are often described as "flashy"...

Channel and Floodplain Impacts

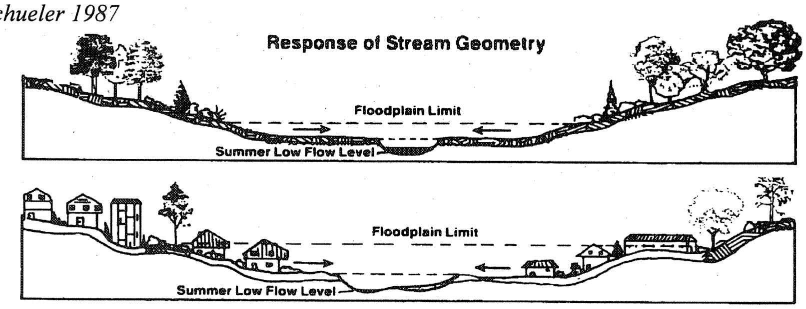
Under natural conditions, a stream develops a channel large enough to hold the one-half to two-year peak flow, the highest flow likely to occur on the average of every two years (Leopold 1968). Therefore, the capacity of a stream is somewhat larger than the average annual flood.

Urbanization significantly increases the two-year peak flow. In response, a stream tries to erode a larger channel. Most streams become two to four times wider after urbanizing their watersheds.

Erosion is often quick and severe because most floodplain soils are loose and wash away easily. However, downstream transport of eroded sediment is slow. Much of the sediment moves downstream gradually as "bed load." These constantly shifting deposits may form sand bars and smother bottom life for many years.

The floodplain as well as the channel of a stream become wider as development occurs in the watershed (Figure 1-3). Just as the two-year peak flow increases, so do peak flows for larger storms. Land and buildings that were once safe even from the 100-year storm may now be at risk.

Figure 1-3: Stream Geometry
Source: Schueler 1987



Water Quality

The water that runs off city streets, parking lots, driveways and lawns carries a heavy load of pollutants to nearby lakes and streams. Although some pollutants found in urban runoff are unique to urban areas, others are similar to the pollutants found in rural runoff. Both urban and rural runoff carry "conventional" pollutants: sediment, nutrients, oxygen-demanding materials and bacteria.

Sediment

Like rural runoff, urban runoff is loaded with sediment. Older parts of a city may have less soil erosion than rural areas since much of the land is covered by buildings and pavement. However, these areas produce a unique mix of sediment that contains flakes of metal from rusting vehicles, particles from vehicle exhaust, bits of tires and brake linings, chunks of pavement and soot from residential chimneys and industrial smokestacks.

Generally, the concentration of sediment in urban runoff is lower than rural runoff, but because more water runs off impervious surfaces in cities, the total load of sediment from urban areas is comparable to rural areas (Bannerman et al. 1983).

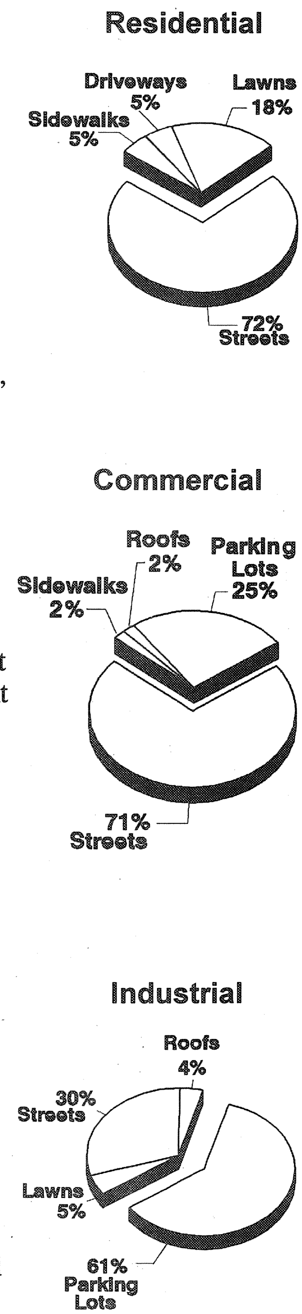
Land uses that produce the highest sediment loads in existing urban areas are industrial sites, commercial development and freeways. Parking lots are the predominant source in industrial areas (Figure 1-4) (Bannerman et al. 1992). In residential and commercial areas, street surfaces are the primary sources of sediment.

Although existing urban areas are important sources of sediment, by far the highest loads of sediment come from areas under construction. The Wisconsin Department of Natural Resources (DNR) estimates that an average acre under construction delivers 60,000 pounds (30 tons) of sediment per year to downstream waterways, about 60 times more than any other land use (Pfender et al. 1991).

Two factors account for the importance of construction sites as sediment sources: high erosion rates and high delivery rates. Construction sites have high erosion rates because they are usually stripped of vegetation and topsoil for a year or more. Typical erosion rates for construction sites are 35 to 45 tons per acre per year as compared to one to ten tons per acre per year for cropland (Schueler 1987; DATCP "T by 2000").

More importantly, construction sites have very high delivery rates compared to cropland. During the first phase of construction, the land is graded and ditches or storm sewers are installed to provide good drainage. This efficient drainage system does not allow sediment to settle out. While runoff deposits most of the soil eroded from a farm field in a low spot on that field or the next field downhill, most soil eroded from a construction site gets deposited in a lake or stream. Typically, runoff carries more than half the soil eroded from a construction site to a lake or stream, compared to three to ten percent of the soil eroded from cropland (Bannerman et al. 1979).

Figure 1-4: Suspended Solids by Source Areas

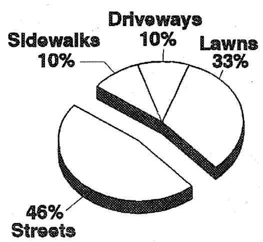


Nutrients

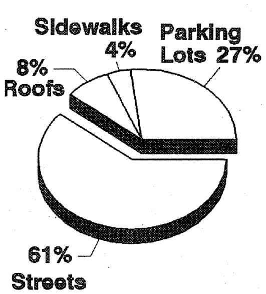
Runoff from urban and rural areas contains nutrients such as phosphorus and nitrogen. Phosphorus is of greatest concern in stormwater runoff because it usually promotes weed and algae growth in freshwater lakes and streams. Like

Figure 1-5: Phosphorus by Source Areas

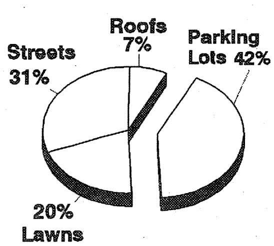
Residential



Commercial



Industrial



sediment, phosphorus concentrations are lower in urban runoff than in rural runoff, but phosphorus loads per acre of urban land are comparable to loads from rural areas (Bannerman et al. 1983).

Because phosphorus compounds attach themselves to sediment particles, land uses that produce high sediment loads also tend to produce high phosphorus loads. This makes construction sites a significant source of phosphorus as well as sediment. In existing urban areas, most phosphorus washes off paved surfaces such as streets, parking lots, driveways and sidewalks (Figure 1-5). Lawns, however, are an important source of phosphorus in residential areas (Bannerman et al. 1992). The phosphorus in runoff from existing urban areas comes from fertilizer spills, leaves and grass left on paved areas, and from vehicle exhaust.

Nitrogen is usually so abundant in Wisconsin lakes and streams that nitrogen in runoff does not usually increase weed and algae growth. However, certain nitrogen compounds such as ammonia and nitrate have other adverse impacts on human and aquatic life. For example, the microorganisms that convert ammonia to nitrite consume large amounts of oxygen. This nitrification process can kill fish and other aquatic life by using available oxygen.

Nitrate forms of nitrogen also become a problem when they contaminate drinking water. Unlike phosphates, nitrates are easily soluble and do not attach to soil particles. This allows nitrates to readily leach into groundwater when nitrogen fertilizer application rates exceed plant needs. Septic systems are another common source of nitrate contamination in groundwater.

Drinking water contaminated with high levels of nitrate is a health hazard. In babies less than six months old, it causes "blue baby syndrome." This disease is usually limited to babies because they do not have stomach acid strong enough to prevent the growth of bacteria that convert nitrate to nitrite. Nitrates may also cause health problems for adults. Recent studies suggest that long-term use of drinking water contaminated with high levels of nitrate may cause some types of cancer.

Oxygen Demanding Material

Urban runoff carries organic material such as pet waste, leaves, grass clippings and litter. As these materials decay, they use oxygen needed by fish and other aquatic life. The sudden increase or "pulse" in oxygen demand after a storm can totally deplete oxygen in an urban lake or stream. Shallow, slow-moving waterways are especially vulnerable to fish kills caused by the oxygen demand from urban runoff. Besides affecting aquatic life, oxygen depletion affects the release of toxic chemicals and nutrients from sediments deposited in a waterway. Runoff with the highest oxygen demand comes from older residential areas with more pavement, pets, and combined sewers.

Bacteria

The levels of bacteria found in urban runoff usually exceed public health standards for water contact recreation such as swimming and wading. Generally, fecal coliform bacteria counts in urban runoff are 20 to 40 times higher than the health standard for swimming (Bannerman et al. 1983; Bannerman 1991). These high levels of bacteria are typical of runoff from small and large cities in Wisconsin

(Blake 1991; Schreiber 1992). Sources of bacteria in urban runoff include sanitary sewer overflows, pets and urban wildlife such as pigeons, rats, raccoons, geese and deer.

Trace Metals

The greatest challenge in urban watershed stormwater pollution control is toxic pollution, particularly trace metals. Metals are the most understood toxic pollutants in urban runoff because they were extensively monitored as part of the National Urban Runoff Program (NURP) in the early 1980s. Data collected recently in Wisconsin cities verify that trace metals such as lead, zinc and copper contaminate runoff from small and large cities (Bannerman 1991; Blake 1991; Schreiber 1992).

Lead is an "indicator" for other toxic pollutants because it is relatively easy to monitor. Lead is a problem for both human and aquatic life. Its human health effects include damage to the nervous system and kidneys, high blood pressure and digestive disorders (Young 1990).

Lead can also be toxic to aquatic life. According to recent monitoring, about 40 percent of the runoff samples from a primarily residential area (Monroe Street in Madison), and 70 percent of the samples from a commercial area (Wood Center in Milwaukee) have lead levels that exceed acute toxicity standards for aquatic life. Despite these continued violations of water quality standards, lead levels in urban runoff are much lower today than they were before the move to unleaded gasoline. Average lead concentrations at both Monroe Street and Wood Center decreased 75 percent during the past 10 years (Bannerman 1991).

...bacteria counts in urban runoff are 20 to 40 times higher than the health standard for swimming.

Zinc is another trace metal in urban runoff that commonly violates water quality standards. While zinc does not create human health problems, it can be toxic to aquatic life. Zinc levels in urban runoff are more likely than lead to violate acute toxicity standards for aquatic life. About 90 percent of the samples from Monroe Street and 97 percent of the samples from Wood Center exceeded acute toxicity standards for zinc (Bannerman 1991).

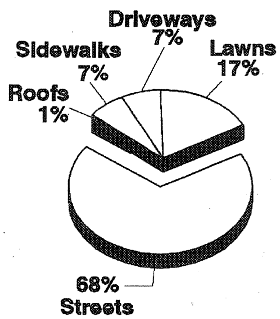
Like zinc, copper concentrations in urban runoff frequently violate water quality standards. About 78 percent of the samples from Monroe Street and 93 percent of the samples from Wood Center exceeded acute toxicity standards for copper (Bannerman 1991). All of the samples collected from the Eau Claire storm sewer also exceeded acute toxicity standards for copper (Schreiber 1991). Like lead, copper is toxic to both humans and aquatic life. Human health effects include anemia, liver and kidney damage (Stewart et al. 1988).

Cadmium is another trace metal commonly found in urban runoff. Unlike zinc and copper, cadmium concentrations usually do not exceed acute toxicity standards. However, cadmium has a low standard for chronic toxicity frequently exceeded by urban runoff (Bannerman 1991). This means cadmium concentrations are seldom high enough to kill aquatic life, but are likely to have long-term health effects. The tissues of plants, animals and humans retain cadmium. Long-term health problems for people may include cancer and kidney damage (Young 1990).

Like cadmium, chromium is frequently detected in urban runoff but usually does not violate acute toxicity standards. Unlike cadmium, organisms can excrete chromium very quickly and keep it from building up in body tissues. One form of chromium (chromium IV) is considered highly toxic to humans. It is known to

Figure 1-6: Lead by Source Areas

Residential



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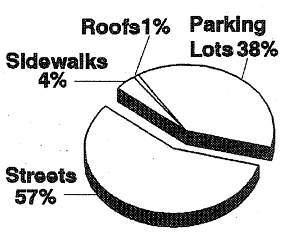
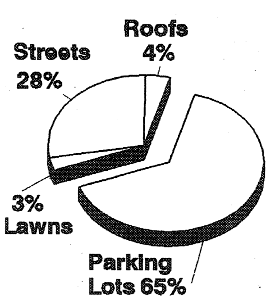


Industrial



cause cancer and damage the liver and kidneys. It may also affect the immune system and reproduction (Young 1990).

A primary source of many trace metals in urban runoff is vehicle traffic. Concentrations of zinc, cadmium, chromium and lead correspond to the volume of traffic on streets that drain into a storm sewer system. As Figure 1-6 shows, the primary sources of lead in all land uses are streets and parking lots (Bannerman et al. 1992).

Another significant source of trace metals is runoff from rooftops. Many roofs have galvanized gutters and downspouts that contaminate stormwater with zinc. As Figure 1-7 shows, in industrial areas like the Syene Road area in Madison, galvanized roofs and gutters are the leading source of zinc (60%). In residential areas of Madison, roofs are a less significant source of zinc (7%). This dramatic difference happens because most residential downspouts in Madison discharge onto lawns that filter out zinc while most industrial downspouts in the Syene Road area discharge directly into storm sewers. Another source of trace metals on some roofs is copper flashing. Runoff from these roofs carries high concentrations of copper and lead (Bannerman et al. 1992).

In some cities, a significant source of trace metals is uncovered outdoor storage piles of scrap metal, coal and salt. According to USGS monitoring, scrap metal piles are the primary source of mercury in the area surrounding the Milwaukee harbor. Scrap metal piles are also a source of arsenic. Coal piles are another source of arsenic while salt piles are a source of chromium and lead (SEWRPC 1987).

The list of other sources of trace metals is long, ranging from combustion to deteriorating metal and paint. For example, paints and plated metals commonly contain cadmium or chromium. Fishing weights, lead shot and paint sold before 1977 may contain lead. Air-borne emissions from burning coal, oil or municipal waste may carry cadmium, copper, lead or mercury. Wood used in outdoor construction may contain arsenic, chromium, copper or zinc to prevent rotting.

Pesticides

While much is known about the sources of trace metals in urban runoff, the sources of pesticides are a subject of some debate. Turf experts conducted tests that suggest properly applied pesticides are bound up in plants and soil so little runs off (Watshke & Mumma 1989). However, monitoring data for Wisconsin shows urban runoff contains many pesticides. Table 1-2 lists the pesticides of greatest concern since they are frequently found in urban runoff at levels that violate surface and/or ground water quality standards (Bannerman 1991).

Regulated insecticides may no longer be widely used. These insecticides persist in the environment, meaning they do not degrade rapidly after application. Except for lindane, these insecticides are banned in Wisconsin. Lindane is still sold at garden centers for home use in controlling woody plant pests. It is also available for some commercial uses including seed treatment, Christmas tree plantations and farm animals (DATCP 1992).

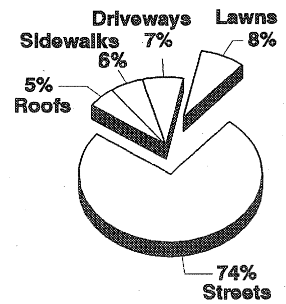
Common lawn and garden insecticides like diazinon and malathion may not persist in the environment, but they are toxic to bees, fish, aquatic insects and other wildlife. Diazinon is toxic to birds and is banned on golf courses and sod farms because of waterfowl deaths in diazinon treated feeding areas (EPA 1988).

Table 1-2: PESTICIDES IN URBAN RUNOFF

Regulated Insecticides	Lawn & Garden Insecticides	Agricultural Herbicides
Aldrin	Diazinon	Alachlor
Chlordane	Malathion	Atrazine
DDT	Cyanazine	
Endrin		
Heptachlor		
Lindane		
Toxaphene		

Figure 1-7: Zinc by Source Areas

Residential



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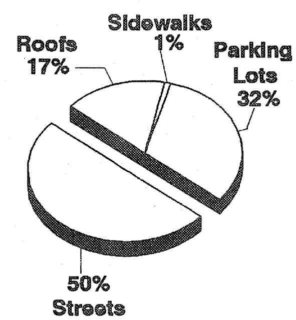

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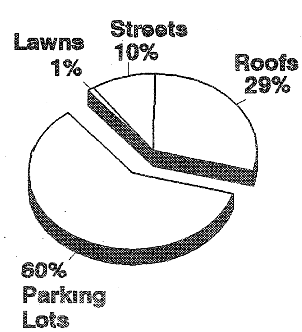

Finding agricultural herbicides like alachlor, atrazine and cyanazine in urban stormwater may seem surprising since these herbicides are not used in lawn and garden compounds. However, studies in Minnesota suggest that concentrations of atrazine observed in urban stormwater are consistent with concentrations observed in rainfall. These herbicides apparently evapotranspirate from farm fields. Some regulations now apply to alachlor, atrazine and cyanazine use. Only certified applicators can apply these chemicals and DATCP regulations restrict atrazine use in many Wisconsin counties due to groundwater contamination (DATCP 1992).

Other Toxic Chemicals

The other toxic chemicals found in urban runoff are organic compounds with names so long they are commonly refer to by their initials. Some of these chemicals are health hazards even in very small doses and therefore have water quality standards set in parts per billion (ppb). Because sampling for these chemicals can be difficult and costly, data on them are very limited. Monitoring suggests that polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) are the two groups of chemicals present in large enough concentrations in urban runoff to be of concern.

Polycyclic aromatic hydrocarbons (also called polynuclear aromatic hydrocarbons) are a large group of about 10,000 compounds. They are common by-products of incomplete combustion from vehicles, wood and oil burning furnaces, and incinerators. PAHs are used as ingredients in gasoline, asphalt and wood preservatives. The best known PAH is benzene, which gained notoriety as the contaminant found in popular brand of bottled water. Benzene is used both as a solvent and as an antiknock additive in gasoline. While benzene levels in Wisconsin stormwater do not exceed surface or ground water standards, several other PAHs do exceed standards (Bannerman 1991).

PAH's in Surface and Ground Water:

- Benzo-a-pyrene
- Benzo-ghi-perylene
- Chrysene
- Fluoranthene
- Phenanthrene
- Pyrene

PAHs affect human health in a variety of ways but they are of particular concern because several of the most toxic carcinogens known are PAHs. Laboratory tests on animals show that benzo-a-pyrene causes cancer, and reproductive and fetal development problems. Other tests suggest that some PAHs damage the lungs, liver, skin and kidneys (Young 1990). Some studies also suggest that PAHs are responsible for tumors and lesions in fish, especially those that feed on river bottoms (National Research Council of Canada 1983). According to monitoring from Wisconsin cities, more than 95 percent of urban runoff samples violate the human cancer criteria for benzo-a-pyrene and benzo-ghi-perylene. More than 60 percent violate the human cancer criteria for chrysene, phenanthrene and pyrene (Bannerman 1991). Human cancer criteria are set at a level to keep the incremental risk of cancer below 1 in 100,000 for people who eat fish from lakes and streams in Wisconsin.

Polychlorinated biphenyls are a group of over 200 compounds. They are very stable compounds that do not easily degrade, burn, dissolve in water, or conduct electricity. PCBs have been used for many purposes that include insulation in transformers and electrical capacitors for fluorescent light fixtures and appliances. They have also been used as coolants or lubricants.

...most of Wisconsin's urban runoff samples still violate the human cancer criterion for PCBs.

PCBs are of special concern because they remain in the environment for a long time. They can build up in the food chain, accumulating in the fatty tissues of animals and humans, and may eventually cause health problems. Short-term effects of PCB exposure include skin sores and liver problems. Longer term effects may include cancer as well as problems with reproduction, fetal development, immunity to disease and liver functions (Young 1990). PCB production stopped in 1977, but most of Wisconsin's urban runoff samples still violate the human cancer criterion for PCBs (Bannerman 1991).

Temperature

Besides changes in water chemistry, urbanization changes the quality of waterways by raising their temperature. Reasons for increased temperatures in urban lakes and streams include:

- Pavement and roofs that store the sun's heat, warming stormwater running over them
- Shallow ponds and impoundments that heat up between storms and release a pulse of warm water during a storm
- Fewer trees along streams shade the water

Temperature is a critical factor in determining what species can live and, more important, thrive in a lake or stream since increases in temperature affect waterways in several ways. At higher temperatures, water holds less oxygen and many processes that consume oxygen speed up, including chemical reactions, metabolism, respiration and decomposition. Therefore, as water temperatures rise, the demand for oxygen increases while the supply decreases. Other effects of water temperature include some toxic substances like zinc, which is more toxic at higher temperatures. Even if oxygen supplies are adequate and toxic chemicals are not present, each species of fish and other aquatic life has an optimum temperature range for growth and a maximum temperature it can tolerate.

Habitat and Recreational Use

Changes in flow and water quality directly influence the value of a stream for fish as well as people. Each change may impact various species of fish differently. For example, streams turbid with sediment or algae make feeding difficult for sight-feeders like northern pike. Smallmouth bass are especially sensitive to sediment deposits that smother the gravel stream bottoms where they spawn. Low oxygen levels and warm temperatures are intolerable for trout. Toxic chemicals may affect fish in a variety of ways ranging from disorientation to impaired reproduction, lowered disease resistance, or even death. Over time, these individual impacts add up to three major changes in fish populations:

- Diversity decreases
- Abundance decreases
- Pollution-tolerant species replace pollution-sensitive species

Similar changes occur in aquatic insect populations. The high flows and pollutants typical of urban runoff create serious problems for aquatic insects. High flows may scour these bottom-dwelling organisms from some parts of the stream while sediment deposits may smother them in other places. Toxic chemicals may kill them or affect their ability to feed and reproduce.

Smallmouth bass are especially sensitive to sediment deposits...

As fish populations change, urban waterways become less valuable for recreation and tourism. In Wisconsin, fish such as carp, buffalo and suckers populate urban streams and lakes. These species are less popular for sport fishing than the northern pike, smallmouth bass, or trout, typically found in unpolluted waterways. Another concern about fishing in urban areas is that some fish may be unsafe to eat due to contamination with toxic chemicals. Chemicals like mercury and PCBs deposit in muscle or fatty tissue and become more concentrated as they move up the food chain. These chemicals are especially dangerous to human health.

Besides losing their value for fishing, streams in developed areas also lose much of their value for other types of recreation. Urban streams turbid with sediment or algae are less attractive for boating, swimming, or even picnicking near their shores. Furthermore, they may be unsafe for swimming, wading, and other types of "body-contact" recreation if bacteria counts or toxic chemical concentrations are too high. When urban waterways lose their recreational and aesthetic values, people often regard them as sewers and subject them to more dumping and spills, and enclosures in concrete channels or underground pipes.

Summary

Although urban areas cover only a small part of the land in Wisconsin, they are responsible for significant water quality problems, flooding, and habitat destruction. Acre per acre, urban areas deliver as much sediment and phosphorus as rural areas. But more important, urban areas generate a variety of toxic pollutants that make waterways unsafe for people, fish and wildlife. Cleaning up urban runoff may be expensive, but the potential payoff from this investment is high. The rewards include making urban neighborhoods healthier places to live, providing recreation close to home, and fostering waterfront redevelopment.

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Chapter Two: Stormwater Planning

This Chapter Discusses:

Elements of a stormwater plan

Stormwater financing

Stormwater utility

Components of Stormwater Planning

Stormwater planning is an activity that any municipality can carry out. There are four required components in a stormwater plan, they are:

- Land use planning
- Performance or design criteria for BMPs
- Financing mechanisms
- Stormwater ordinance

Before completing any component, the municipality must develop an outline for a stormwater plan. Below is a suggested outline for a stormwater plan. This outline guides both water quantity and quality aspects of stormwater planning. There are four fundamental elements to consider when protecting human and environmental concerns:

- Flood Control
- Urban Water Resource Protection
- Generic Urban Nonpoint Sources Pollution Control
- Specific Urban Nonpoint Source Pollutant Control

Elements of a Stormwater Plan

I. Introduction

A. Purpose of plan

B. Scope of plan

C. Products of plan

D. Components of plan

II. Description of Watershed(s)

A. Delineation of land uses

1. Current land use
2. Future land use (20 year min.)

B. Delineation of existing stormwater management practices

III. Statement of Problems

A. Beneficial uses of waterbodies

B. Problems and threats impairing beneficial uses

1. Environmental problems

2. Flow related problems

IV. Sources of Problems (quantity and quality)

A. Sources of stormwater runoff

1. Existing land uses

2. Planned land uses

3. Delineation of critical runoff quantity areas

B. Sources of pollutants in stormwater runoff from existing and planned urban areas

1. Construction site erosion

2. Dry weather pollutant sources

3. Wet weather pollutant sources

4. Total loadings and concentrations for all sources

5. Delineation of critical runoff quality areas

V. Pollutant reductions and improvements needed to achieve beneficial uses

A. Reductions in water runoff

1. Peak shaving

2. Storage

B. Pollutant load reductions

VI. Determining effectiveness of alternative control practice combinations to reduce pollutant loadings and water runoff from critical source areas

A. Alternative combinations of control practices on critical areas for water **quantity** runoff

1. Three alternatives - low, medium and high levels of control

B. Alternative combinations of control practices on critical areas for water **quality** runoff

1. Three alternatives - low, medium and high levels of control

VII. Costs of Control practices identified in alternative combinations

A. Current costs of alternatives selected

VIII. Ranking alternative combinations of control practice alternatives

A. Ranking alternative combinations of control practices for water quantity runoff

B. Ranking construction site erosion control practices needs

- C. Ranking streambank erosion control practices needed
- D. Ranking alternative combinations of control practices for water quality runoff
- E. Ranking dry weather flow pollution control practices

IX. Engineering Feasibility

- A. Locating selected control practice structures
- B. Compliance of control practices with DNR standards and criteria
- C. Public opinion surveys

X. Selecting a stormwater drainage management program for a municipality

- A. Priorities for selection:
  1. Flood control
  2. Achieving water quality objectives
  3. Minimum cost alternative needed to meet above criteria
- B. Other management programs
  1. Pollution prevention
  2. Public Education
- C. Financing mechanisms
- D. Ordinance development for adoption by municipality
  1. Construction site erosion ordinance
  2. Stormwater ordinance
  3. Modification of zoning ordinance (if needed)

Land use planning is one of three points the U.S. EPA believes will solve nonpoint source pollution.

Land Use Planning and Zoning

Integrating both economic and environmental needs can spare urban water resources from permanent damage.

Land use planning is one of three points the U.S. Environment Protection Agency believes will solve nonpoint source pollution (Reilly 1991). In Wisconsin, both federal and state agencies support land use planning, but it is the local unit of government that is responsible for meeting its citizen needs through a good land use plan.

Two Wisconsin statutes describe land use control powers for water quality protection. State statute 61.345 gives authority to villages to enactment construction site erosion control and stormwater management zoning ordinances. Similarly, state statute 92.11 gives authority to a county, city or village to develop land use regulations to control nonpoint source pollution.

The scope of authority to control land use decisions depends on the number of participants, each of which has certain powers to control land use and improve water quality. Table 2-1 lists the scope of authority for each participant.

TABLE 2-1: SCOPE OF ACTIVITIES FOR WATER QUALITY PROTECTION

Activity	DNR	Regional Planning Commission	County	Local Government
Water Quality Planning	S	D	D	
Groundwater Management	S	D	D	
Lake Management Planning	S	D	D	
Stormwater Management	S	A		S
Isolated Wetland	S			
Land Use Planning		S	S	S
Zoning / Land Use Control		A	S	S
Preserving Land	S		S	S

S = Statutory Authority D = Delegated Activity A = Advisory

The DNR has three tools for water quality planning, they are point source controls, limited stormwater management controls, and sewer service area delegation. Under the sewer service area delegation, the DNR has certain controls over land use development within the community if that development threatens water quality.

Automobile Traffic and Land Use Planning

There are two major variables that contribute to urban nonpoint source runoff pollution: the percent of impervious ground and automobile traffic density. There is usually a direct relationship between these two variables. As the percent of impervious ground increases, so does automobile traffic and urban nonpoint source pollution.

The automobile has changed society in many ways, but it has also been a leading cause of global pollution. As automobile use rises, nonpoint source pollution also rises.

One way to reduce pollution is to reduce automobile use. Automobile use is closely related to population densities. As shown in Table 2-2, population density has an inverse relationship with automobile use.

Newman, Kenworthy and other researchers concluded that strong land use polices to increase urban densities are crucial in fostering viable alternatives to automobile dependence (Lowe 1990). The European system, which promotes compact development, is completely different from the U.S. where suburban planning has led to the "edge city" concept.

The term "edge city" applies to most North American cities that experienced rapid growth within the last 20 years. In Wisconsin this is especially true for the Milwaukee and Madison areas where there is a "leapfrogging" effect for new development. This takes place by allowing development of commercial and/or industrial parks on the outer fringes of a community. As these commercial areas develop, low to medium density housing will surround them, filling the edge. A new core

TABLE 2-2: URBAN DENSITIES AND COMMUTING CHOICES, SELECTED CITIES, 1980

CITY	Land Use Intensity	Private Car	Public Transportation	Walking and Cycling
	pop.+jobs/ha	percent of workers		
Phoenix	13	93	3	3
Washington D.C.	21	81	14	5
Toronto	59	63	31	6
Stockholm	85	34	46	20
Tokyo	171	16	59	25
Hong Kong	403	3	62	35

Source: Peter Newman and Jeffrey Kenworthy, 1989

Land use controls should do more than foster increased urban development.

of industrial/commercial development begins outside the edge of the older community, allowing the cycle of leapfrogging to continue. As a result of populations shifting to these edges, two-thirds of the U.S. voters now live in these developments. As edge cities increase, so does traffic density from commuters.

One way to solve this edge city phenomenon is to apply more uniform local land use controls. Land use controls should do more than foster urban development. They should optimally mix different land uses within a given area. Because of the shift from heavy smokestack industry to office parks and other "clean" industries, residential development can and should be incorporated into these office parks and other areas. With residential areas incorporated into commercial areas, commuters can walk or bike to work instead of taking an automobile.

Best Management Practices and Site Design

Where land is undergoing development, certain measures can help reduce the impact, but no BMP will totally mitigate past development. While peak flows may be controlled, volumes from these sites will always increase, and the volume of water will increase the potential damage to the water resource. There are many different ways to approach BMP site design, and this is most easily done within developing areas.

Developing areas allow for unique opportunities to incorporate BMPs into the site design. The BMPs can be incorporated into natural areas serving as open spaces for community enjoyment. This idea was expanded into a fingerprinting concept that requires each development to duplicate BMPs to some extent at each site (Schueler 1991). The requirements of fingerprinting ensure a minimum set of controls for each site.

Another technique is for a community to purchase land next to a water resource and create a buffer strip around the area. Wisconsin has a unique stewardship program with funds to purchase land around waterbodies. The program can be used to acquire land around water resources for preservation. In certain cases, this may be the only way to protect a sensitive waterbody from further degradation, even with BMPs in place.

Stormwater Financing

There are three alternatives for funding stormwater controls:

- Taxation
- Bonding
- Stormwater Utilities

Taxation

Local governments historically funded stormwater management services with *ad valorem* property tax revenues.

The rationale for government involvement (taxation) are the public benefits to managing runoff. The rationale for the financing mechanism, taxes, is either (1) that higher-valued properties benefit more or (2) that owners of higher-valued properties can pay more for a public good (the benefits available to everyone that cannot be quantified). Unfortunately, this means stormwater expenditures must compete with other government services, and consequently, funding is highly variable. With this disparity, officials often give low priority to maintenance of drainage infrastructure.

With property tax as a financing mechanism, equity of funding is a concern. Residential and commercial property owners are better served under a charge or utility system (see utility structures on the next page), industrial and property owners, in general, are better served under a property tax system. Commercial property owners might be better off with the user charge system. Owners of agricultural and exempt parcels will be better off under the tax system.

If property values reflected the benefits of stormwater management, the property tax system could be more equitable.

Bonding

Long-term borrowing can effectively finance stormwater projects within a municipality. A municipality can use bonding authority to issue long-term bonds for water systems. Issuing bonds is cheaper than financing a project with a bank loan because it eliminates the "middle man" when borrowing money.

A long-term municipal bond is characteristically exempt from federal taxation. The federal government does not tax the interest on local securities through income taxation. State and local governments may tax their own securities, although most do not exercise this right.

When a municipality wants to issue a bond, it must go through a rating process to learn how secure the city is from defaulting on this security. A higher rating makes it easier for the city to sell bonds. In some cases the municipality must find an underwriter to help secure the financing if there is a lower rating.

In Wisconsin, there are limits on the amount a municipality can borrow. The indebtedness of a municipality can not exceed five percent of the taxable property value within its boundaries. This limit ensures some proper fiscal management when borrowing. Certain types of bonding must also go through a referendum, giving the public a chance to vote on issuing bonds.

A Wisconsin municipal bond can be issued for 20 to 50 years. For more information on long-term bonding and legal requirements, see Wisconsin State Statues Chapter 66: Municipal Law, and Chapter 67: Municipal Borrowing.

Stormwater Utility

In the past few years, the concept of a stormwater utility became popular. The utility approach redefines how people think about runoff and stormwater management. A basic premise in the utility approach is that runoff is a man-made problem, and property owners are responsible for it. This approach designates property owners as stormwater generators with a government authority controlling these discharges. To finance government activities, property owners pay user charges or fees proportional to their discharges. This utility approach uses the "polluter pays" principle. The American Public Works Association (APWA) concludes:

A basic premise in the utility approach is that runoff is a man-made problem, and property owners are responsible for it.

> "The user charge and the utility concept are the most dependable and equitable approaches available to local governments for financing stormwater management."

Care must be taken when forming utilities. Listed below are 13 steps to consider during formation:

1) Document the need for a stormwater utility program.

This should include historic flooding problems and locations, and local pollution problems and possible causes. Use Priority Watershed Plans if available.

2) Educate administrative staff.

Stormwater management utilities with user charges can be a new concept to both administrative staff and elected officials. The staff should realize that on average, it will take one and one-half to two years to develop this program. All advantages and disadvantages must be presented.

3) Establish a steering committee.

Establish a steering committee to help advance the idea of a stormwater utility. This committee should include representatives of local Realtors, developers, large property owners, the public, the chamber of commerce, civic groups, churches, and schools. This committee should work with the local administrative staff to develop an ordinance for stormwater quality and quantity control. The committee should make a recommendation that the city council/local government can use a stormwater utility program with certain stipulations.

4) Develop a public participation program.

While the public might be aware of flooding problems, they usually do not participate in water quality issues. Information programs must convince citizens that the problems are best solved citywide, and that a new user fee will correct many of these problems. Public information programs typically include public meetings, slide shows and mailings of information brochures. The steering committee should suggest how best to handle public participation.

5) Develop a comprehensive implementation plan.

This plan should include all program activities and phases. Create a timeline to decide task sequence, assign responsibilities, establish billing procedures, estimate costs and schedule events.

6) Calculate current stormwater program costs.

Community costs should include stormsewer and catch basin maintenance, repair and reconstruction, ditch maintenance and other associated costs. Also consider street sweeping and leaf collection costs.

7) Estimate the stormwater revenue needs.

Estimate costs with operation and maintenance costs, proposed capital projects, master planning and other costs. Include construction site erosion controls if no other funding mechanism exists. The state can help with these costs, paying up to 70 percent for certain stormwater quality controls associated with the Priority Watershed Plans.

8) Prioritize needs and projects.

All problems will not be solved immediately. Set forth timelines to take these projects one by one. It is much easier to tackle non-structural practices first. These practices include catch-basin cleaning, street sweeping, construction site erosion controls, and leaf pickup. After establishing these items, consider the structural practices.

All problems will not be solved immediately.

9) Establish a preliminary budget.

Establish a budget for the first fiscal cycle (usually 1-2 years). This budget should include a complete and detailed stormwater management plan, information of a stormwater user charge, and needed personnel, equipment, and materials.

10) Create a rate structure.

Stormwater utility charges are typically determined from parcel size and a rate factor, which is a coefficient that relates estimated amounts of runoff per parcel to parcel charges. These rate factors can be based on actual measures of impervious area, runoff coefficients based on land use, or a combination of both. Listed below are systems to assess charges. Each system obtains a coefficient differently. The following pages describe each in detail.

Units for assessing charges:

- Equivalent Runoff Units - (ERU)
- Percent Impervious
- Special User Fees
- Simple Family Equivalent - (SFE)
- Billable Hydrologic Acreage

Equivalent Runoff Units (ERU)

Equivalent runoff units represent runoff from a parcel. These units calculate and levy stormwater charges by multiplying a rate factor by a parcel area. The following equation determines the charge for an ERU: C/ERU = R/ [S(F_i * A_i)] where:

C/ERU = Charge per equivalent runoff unit

R = Utility revenue requirement

S = Sum

F_i = the rate for each land use category i rate base. The rate can be based on runoff coefficients, such as the rational method, or based on parcel measurements obtained in the field or through a GIS.

A_i = the total acreage for each land use category i.

An example would be a municipality that needs to generate $350,000 annually for a stormwater program. The municipality has two land uses: industrial areas of various sizes and residential areas 0.5 -1.0 acres large. Let the rate factor be .70 (assumes 70 percent of the land is impervious) for industrial lands, and 0.23 of residential lands. The calculation is as follows:

Land Use	Rate Factor	Total Acres	ERU	Total Parcels
Industrial	.70	2,600	1820	24
Residential	.23	5,200	1196	6940

$350,000/(1820 + 1196) = $116.05

The charge per ERU necessary to generate $350,000 would be $116.05, if all parcels are charged. The industrial sector would pay approximately $211,211 per year. The residential sector would pay approximately $138,795 per year. This breaks down to an average of $733.37 per month for industrial users (based on the number of parcels), and an average $1.66 per month for residential users.

Single Family Equivalent (SFE)

Single Family Equivalents (SFE) is a variation of the ERU system. In essence, the equivalent runoff is scaled to represent single-family equivalents. Two ways to compute SFEs are:

1) Adjusting all factors equally so the product of the average residential area and the residential rate factor is one; or

2) Dividing the amount of impervious area on all non-single family residential parcels by the average amount of impervious area on single family residential parcels.

Planners use SFEs because they believe the public can understand the user charge concept easier when expressing runoff as an amount generated by a typical family residence. Over half the major cities throughout the nation use the SFE concept in stormwater utility systems.

Billable Hydrologic Acreage

The Billable Hydrologic Acreage method is based on hydrological response factors. Weighted factors assigned to each land parcel account for the runoff rate, rainfall intensity, and the runoff rate modified by retention. Ann Arbor, Michigan, uses this system with these factors:

0.20 for pervious land surface

0.95 for impervious land surface with no retention

0.30 for impervious land surface with retention

Multiplying the appropriate hydrologic factor by the acres in that category and adding the results determines a parcel's billable hydrologic acreage. A standard billing rate is applied by hydrologic acre. Table 2-3 shows how this system would charge for a 1-acre site.

TABLE 2-3: HYDROLOGIC BILLING ACRES

Area in Acres Factor	X	Hydrologic Response Acreage	=	Hydrologic
0.26		0.2		0.05
0.84		0.95		0.8
0		0.3		0
			total	0.85

0.85 total hydrologic acres x standard dollar rate = service charge per period

Single family and two family residences received a hydrologic acreage of 0.93 in Ann Arbor. All other parcels were measured individually to determine impervious versus previous areas.

Over half the major cities throughout the nation use the SFE concept in stormwater utility systems.

Percent Impervious Acreage

The Percent Impervious Acreage system is another variation of the ERU system. This system uses a standard coefficient of imperviousness to land uses. Listed below in Table 2-4 are the coefficients used by the Cincinnati Stormwater Management Utility.

TABLE 2-4: DEVELOPMENT FACTORS BY LAND USE

Land Use	Coefficient
Commercial	0.85
Industrial	0.75
Multifamily	0.6
Transportation	0.5
Institutional	0.4
Residential	0.25
Agriculture	0.08
Park	0.05

These coefficients are really the amounts of imperviousness associated with each land use. This coefficient is then multiplied by the number of acres to derive the amount of billable acreage per parcel. The key difference in this approach is that a higher percentage of impervious area gives a higher unit rate. This system is a progressive rate charge that considers more impervious areas are related to more water quality problems.

Credit and Surcharges:

Special use fees are common within stormwater utility districts. These fees can either reward or punish the parcel holders for good or bad stormwater practices. Utilities can enact many special features including an appeal process that can charge individual parcels differently. Listed below are some special features for utility rate structures. This list is hardly complete, and each municipality will deal with its own credit and surcharge system. This issue should be handled in the planning stages with specific guidelines on what is and is not covered under these special features.

Special features of utility rate structures:

- Separate charges for capital improvements and operations and maintenance
- Credits for on-site management
- Surcharges for parcels in floodplains
- Rebates for the elderly
- In kind payment by schools that provide education on stormwater management.

Special use fees are common within stormwater utility districts.

In general, these criteria should be considered with any of the discussed systems:

- The charge should be based on a reasonably accurate, technically defensible measure of runoff.
- The database used to determine charges and prepare the billing system should be accurate.
- Users in different classes should pay in proportion to the runoff their classes generate to others.
- Users within a class should pay in proportion to their contribution to the total runoff generated by the class.
- The rate structure should be legal and politically acceptable.
- The structure should be flexible.
- The structure should generate adequate revenues.
- The initial costs of carrying out the structure should not be exorbitant.

Utility Formation Steps (continued from page 21)

11. Refine budget and user charges.

After establishing a user charge, the operating budget may need refinement to reflect the willingness of the property owner to pay. Sometimes, a community is willing to pay a higher monthly fee, which may require more projects to be undertaken.

12. Prepare a stormwater utility and user charge ordinance.

Draft an ordinance that explains the need for a stormwater utility and establishes a user charge and land use classification. The steering committee should approve this ordinance before it goes to a municipal council for action.

13. Develop a billing system.

Many billing systems can be used. The key is to decide what system is optimal for the community. Table 2-5 lists options for billing systems.

TABLE 2-5: OPTIONS FOR STORMWATER UTILITY BILLING

Option	Frequncy	Advantages	Disadvantages
Add to existing utility bill	Quarterly or or bimonthly	Minimize cost of new system; frequent billing may improve cash flow; reinforce idea that charge is a service fee, not a tax	Confusing between sewer charge and stormsewer charge; more frequent billing may cost more
Add to property tax bill	Annual	Tax assessor's files usually include parcel size and land use, annual billing may minimize cost	May not be legal; annual billing results in poor cash flow; confusing between stormsewer charge with property tax
Create new system	As determined	Complete flexibility in designing system	High cost to develop and maintain

Elements of a Stormwater Ordinance

A stormwater ordinance provides the legal framework to require suitable management practices to reduce flooding and damage to water resources. An ordinance gives performance or construction guidelines and promotes consistency with a best management practice (BMP).

Stormwater ordinance elements to be considered include:

- Findings of fact/purpose and objectives
- Authority/jurisdiction
- Definitions
- Applicability
- Plan review
- Enforcement
- Performance standards
- Off-site management facilities
- Maintenance
- Performance bond
- Appeals
- Variance procedure

Consider several approaches to a stormwater ordinance. The ordinance may specify performance standards, runoff detention, specific BMPs, or limit peak flow. A companion document with the ordinance should contain standards or specifications for BMP installation.

Ultimately, a stormwater management ordinance concludes the stormwater planning effort for a municipality. The ordinance is the municipality's first step towards implementing the plan.

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Chapter Three: Stormwater Legal Issues

This Chapter Discusses:

Wisconsin state statutes

Federal statutes

The stormwater permit program

State and Federal Laws

Over the past 30 years, state and federal laws were enacted to mitigate stormwater problems. These laws were designed to protect humans and improve water quality. This chapter will attempt to identify laws that directly affect stormwater within Wisconsin.

Listed below are summaries of state and federal statutes that directly impact stormwater.

Wis. State Statute Section 23.19 - Menomonee River Conservation Project

This section targets the acquisition of land next to the Menomonee River within the City of Milwaukee. State dollars are available at a 50 percent cost-share rate totaling $500,000. The land acquired with this money can be used for 1.) Recreational and community facilities, 2.) Improved river access, 3.) Nonpoint source pollution abatement, and 4.) Restoration of wetlands.

Wis. State Statute Section 30.19 - Enlargement and Protection of Waterways

While this section does not directly relate to stormwater, it will affect BMP construction near waterbodies. If a BMP is built within 500 feet of a navigable waterbody, a permit may need to be obtained before construction begins. The DNR Bureau of Water Regulation and Zoning issues the permit. There are exceptions to this rule, the most notable are waterbodies that affect agricultural land and Milwaukee County.

Wis. State Statute Section 30.195 - Changing of Stream Courses

This section directly impacts stormwater discharges if a stream channel needs alterations because of increased flows or possibly if stream repair work, such as rip-rap, gabions, etc., are needed to stabilize the streambanks. The DNR Bureau of Water Regulation and Zoning issues the permit.

Wis. State Statute Section 59.974 - Construction Site Erosion Control and Stormwater Management Zoning - County

Under this section, a county may enact a construction site erosion control and stormwater management zoning ordinance to all of its unincorporated areas. The county has the authority to set stormwater and construction site standards for local developers. The county has the power to enforce these standards. If a city or village annexes part of the county land, the county ordinance supersedes the city or village until they adopt an ordinance at least as restrictive as the county's. In addition, the county may also delegate this enforcement authority to a Regional Planning Commission, and in Dane County, to the Lakes and Watershed Commission.

Wis. State Statute Section 61.345 - Construction Site Erosion Control and Stormwater Management Zoning - Village

Under this section, a village may enact a construction site erosion control and stormwater management zoning ordinance applicable to all of its incorporated area. The village has the authority to set stormwater and construction site standards that local developers must meet. The village has the power to enforce these standards. The village may also delegate this enforcement authority to the Regional Planning Commission, and in Dane County, to the Lakes and Watershed Commission.

Wis. State Statute Section 62.234 - Construction Site Erosion Control and Stormwater Management Zoning - City

Under this section, a city may enact a construction site erosion control and stormwater management zoning ordinance for all of its incorporated areas. The city has the authority to set stormwater and construction site standards for local developers. The city also has the power to enforce these standards. In addition, the city can delegate this enforcement authority to a Regional Planning Commission, and in Dane County, to the Lakes and Watershed Commission.

The city has the authority to set stormwater and construction site standards for local developers.

Wis. State Statute Section 66.072 - Utility Districts

A town, village and city can form a stormwater utility district along with other service districts. The local government must hold public hearings before it votes on the utility district. In towns, a majority of the governing body must support the utility district. In villages and cities, a three-fourths vote of all members of the governing body is required to establish a utility district.

Wis. State Statute Section 66.076 - Sewerage System, Service Charge

This section allows rate setting for sewerage collection, both for sanitary and stormwater systems.

Wis. State Statute Section 85.19 and 101.653 - Construction Site Erosion Control - Statewide

Created in 1992, these sections enact a statewide construction site erosion control ordinance administrated by the Wisconsin Department of Industry, Labor and Human Relations. It targets two areas for control. The first is highway and bridge construction funded in part or whole by state or federal funds, and the second controls one and two family dwellings. There is also a provision for training and certification in the preparation and review of erosion control plans and inspection of construction sites.

Wis. State Statute Sections 87.30-87.31 - Floodplain Zoning

The DNR Bureau of Water Regulation and Zoning administers the floodplain zoning section. This section delineates floodplain zones to protect people in these areas. The DNR and the municipality go through a hydrologic modeling and mapping process to delineate these areas. After delineation, it is possible no further development may be allowed within this floodplain zone. In addition, all structures in the floodplain may be removed.

Wis. State Statute Chapter 88 - Drainage of Lands

This chapter refers to creating drainage districts and maintaining drainageways adjacent to these districts. This chapter affects stormwater only on very small developments not under the jurisdiction of a town, village, or municipality. The district has the power to levy fees for the maintenance and improvement of drainage ways. In essence, a drainage district is the agricultural equivalent to municipal stormwater utility district.

Wis. State Statute Section 92.11 - Regulation of Local Soil and Water Resource Management Practices

This section promotes soil and water conservation and nonpoint source water pollution abatement. A county, city or village may develop ordinances to regulate land use, land management and pollution management practices. This section gives power to local governments to adopt and enforce stormwater and construction site ordinances. This section does not set performance or design standards. This section also encourages countywide adoption of these ordinances.

A county, city or village may enact a shoreland management ordinance.

Wis. State Statute Section 92.17 - Shoreland Management

Created in 1992, this section establishes standards for activities related to maintaining and improving surface water quality. A county, city or village may enact a shoreland management ordinance.

Wis. State Statute Section 144.235 - Financial Assistance Program; Local Water Quality Planning

This section allows for funding of water quality and stormwater planning under the supervision of the DNR Bureau of Water Resources Management. Cost-share dollars are available to designated planning agencies to develop stormwater and construction site erosion control plans.

Wis. State Statute Section 144.25 - Financial Assistance; Nonpoint Source Water Pollution Abatement

This statue authorizes cost-share dollars for planning and implementation of nonpoint source Priority Watershed Projects. The DNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection jointly administer this program. Cost-share dollars are available to develop and implement construction site erosion control and stormwater plans. Cost-share dollars are also available for BMP installation.

Wis. State Statute Section Chapter 147 - Pollution Discharge Elimination

This chapter gives authority to the DNR to issue Wisconsin Pollutant Discharge Elimination System (WPDES) permits for point source discharges of stormwater. The DNR used this authority in the past to bring selected stormwater discharges under permit, primarily at industrial sites. Authority comes, in part, from the federal stormwater permit program (40 CFR parts 122-124) enacted under the 1987 Clean Water Act Amendments. The DNR will issue two general permits for stormwater associated with industrial activity. One permit covers discharges from construction sites that disturb more than five acres. Administration of the permit complements existing construction site erosion control regulation administered by the Wisconsin Department of Industry, Labor, and Human Relations. The other DNR general permit covers all other stormwater discharges associated with industrial activity. In addition, the DNR is developing WPDES permits that cover the stormwater discharges from municipal stormsewers in Madison and Milwaukee.

Wis. State Statute Chapter 160 - Groundwater Protection Standards

This chapter sets standards for groundwater quality. It applies to all facilities, practices and activities that may affect groundwater quality and are regulated by state agencies. It establishes groundwater quality standards for substances that may be present in groundwater. It specifies procedures to determine if a numerical standard was exceeded. The chapter also provides standards for evaluating monitoring data, responding to exceedances and providing exemptions.

The stormwater permit program is a two-phased program...

Federal Statute - Section 6217 of the Costal Zone Act Reauthorization Amendments

Section 6217 address inputs of nonpoint source pollution on coastal water quality. The Lake Michigan and Lake Superior drainage areas will require a Coastal Nonpoint Control Program (CNPCP) in place by July 1995. The CNPCP will include regulatory provisions to control urban and rural nonpoint sources in the coastal zone, including stormwater runoff from new developments. Stormwater discharges covered under the NPDES permits are exempt from these requirements.

The Stormwater Permit Program

The stormwater permit program is a two-phased program enacted by Congress in 1987 under section 420(p) of the Clean Water Act. Under Phase I, National Pollution Discharger Program (NPDES) permits are required for municipal separate storm sewer systems serving large and medium sized populations (greater than 250,000 or 100,000 people, respectively) and for stormwater discharges associated with industrial activity. Permits are issued case-by-case if the EPA or the state determine that a stormwater discharge contributes to waters that already violate water quality standards or if the discharge significantly contributes pollutants to waters of the U.S. The EPA published a rule implementing Phase I on November 16, 1990.

Under Phase II, the EPA prepares two reports to Congress that assess remaining stormwater discharges. The EPA determines, to the maximum extent practical, the nature and extent of pollutants in such discharges and it establishes procedures and methods to control stormwater discharges necessary to mitigate impacts on water quality. The EPA then issues regulations designating stormwater discharges for regulation to protect water quality. It also establishes a comprehensive program to regulate those designated sources. The program is required to establish: 1) priorities, 2) requirements for state stormwater management programs, and 3) expeditious deadlines. (USEPA, Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, 1993).

The DNR Bureau of Wastewater Management has the responsibility of carrying out this program in Wisconsin under the Wisconsin Pollution Discharge Elimination System (WPDES) program.

For more information on the Stormwater Permit Program, Contact:

Wisconsin Department of Natural Resources

Bureau of Wastewater

101 S. Webster St.

Box 7921

Madison, WI 53707

Chapter Four: Pollution Prevention

This Chapter Discusses:

Information and education

Non-structural best management practices

Construction site erosion controls

Information and Education

Changing urban stormwater management will require investments in information and education as well as in engineering and construction. A carefully conceived and administered information and education strategy is essential for several reasons.

First, few people are aware of the problems caused by pollutants in urban stormwater runoff or the common sources of these pollutants. Before the public will support changes in stormwater management, they must understand the need for these changes.

Stormwater treatment methods such as detention, infiltration and biofiltration are unfamiliar, and are therefore not widely accepted by many urban residents, local government officials and developers.

Design, construction and maintenance techniques for stormwater treatment devices are evolving as these devices gain wider use. Therefore, both government and construction industry staff regularly need to share experiences and learn about the latest developments in this field.

City construction originally designed urban stormwater systems for drainage, not pollution control. Public expectations and engineering practices must change to expand stormwater management and include detention, infiltration and pollution prevention. Because pollutant sources in urban stormwater runoff are so widespread, the public needs to cooperate to carry out pollution prevention, the most effective control.

Changing Attitudes and Behavior

Changes in human behavior seldom occur overnight. From an individual perspective, there are three basic steps to change: awareness, acceptance and implementation. First a person must recognize a problem exists and understand what causes that problem. Then the person must overcome any resistance and accept the solutions. The person is then ready to learn how to carry out the solutions only after completing these steps.

However, societal change is more than an individual process, it is also a group process. People adopt new practices at different rates. Some people are more willing to experiment and take the lead. Others will wait until the "bugs are worked out" and adopt the practice after they have proof that it works. Some will resist until they are forced to change. Thus societal change also has three basic steps: innovation by a few, voluntary adoption by the leaders, and mandatory compliance by the rest.

To be effective, an information and education strategy for urban stormwater management must adapt to these different stages of individual and societal change. First you must build a basic awareness of the impacts of urban stormwater runoff with an understanding of the sources of urban pollutants. Then you need to overcome the public's resistance to pollution prevention and control practices by encouraging those who are willing to try them. Information from the experience of these innovators must be used to improve the practices and their successes must be shared with others to encourage leaders adopting new stormwater management techniques. Once a solid foundation of awareness, acceptance, voluntary adoption and feedback is built, support will be required for widespread implementation of stormwater controls.

Assessing Attitudes and Behavior

Where are Wisconsin residents in terms of changing urban stormwater management attitudes and practices? According to recent surveys, not very far. Most urban residents are still working on the first stage of change – awareness of the problem and its causes. Surveys done in Wisconsin suggest that most people do not realize the impact of urban stormwater runoff. Despite the progress made in cleaning up industrial discharges, many people (55%) still believe that industry is the leading source of water pollution (Nowak et al. 1990).

Surveys done in Wisconsin suggest that most people do not realize the impact of urban stormwater runoff.

In addition to being uninformed about the problem, many residents are leery of the solutions (Figure 4-1). Most people (67%) do not know what an infiltration basin is and consequently many (39%) express uncertainty about requiring these devices in new development. Almost half (47%) are not familiar with detention ponds and are unsure whether these runoff controls should be required in new development (33%). More people (58%) are familiar with grass swales, but a significant number (31%) are still unsure whether to require swales in new development (Nowak et al. 1990).

Despite these uncertainties, most urban residents use water resources for recreation and support pollution cleanup programs. More than half (57%) would support water quality programs by paying more taxes. Even more (74%) are willing to carry out pollution prevention practices at home (Figure 4-2) by using fewer chemicals on their yards, recycling used oil (74%) or separating hazardous waste from other trash (92%) (Nowak et al. 1990).

Developing a Strategy

The overwhelming temptation in developing an information and education program is to use a "shot gun" approach – planning to do a little bit of everything with the hope that something will work. When faced with the day-to-day demands of the public to provide good service while holding down the tax levy, most communities invest little in information and education. The best approach lies somewhere between these two extremes. Strategies should achieve specific objectives by educating key audiences whose actions or support is needed to carry out change.

Figure 4-1: Familiarity with Stormwater Controls

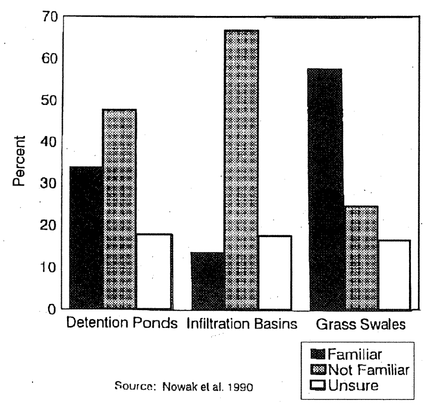
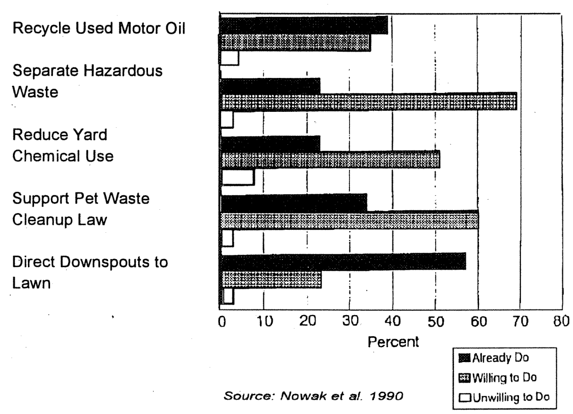


Figure 4-2: Pollution Prevention Practices



The first step in developing an information and education strategy is to decide what needs to be done and why. Which audiences need to receive what information to achieve a certain change. These decisions can be summarized in a list of long-term goals supplemented by a list of more specific objectives for each year. After completing this, select appropriate activities to accomplish each objective.

Targeting Audiences

Ideally, an information and education program for urban stormwater would reach all audiences. But limited dollars and staff makes ranking audiences and targeting messages especially important. The ability to change the way they manage urban stormwater is one way to group and rank audiences:

1) Those who must act:

- Government officials, both elected and appointed
- Developers and others in the construction industry
- Owners/managers of commercial and industrial property
- Urban residents, both homeowners and renters

2) Those who can actively support change:

- Local government associations
- Civic and service groups
- Conservation and environmental groups
- Fishing, boating and other water resource user groups
- Concerned citizens

3) Future actors and supporters:

- Youth, including teachers and youth group leaders
- General public

Each of these audiences has different backgrounds, preferences, needs, values and prejudices. Each can be reached in different ways, with different messages and modes of learning and assigned a different priority depending on what stage the community reached in changing stormwater management practices.

Identifying Issues

Besides targeting audiences, setting priorities requires narrowing the list of potential topics by identifying key issues to cover each year. The list of potential topics is quite long, but some of most important ones include:

1) Urban runoff:

- Impacts on water quality, fish habitat and recreation
- Sources of pollutants
- Effective solutions

2) Pollution prevention practices:

- Dumping of used oil and other materials in storm sewers
- Pesticide and fertilizer misuse
- Pet waste cleanup and disposal
- Sweeping streets and large parking lots
- Keeping leaves and grass clippings out of the street

3) Stormwater management practices:

- Effectiveness in pollutant removal and flow control
- Planning and design
- Construction
- Maintenance
- Financing and administration
- Neighborhood acceptance

...issues selected each year should build on topics covered in previous years...

The issues selected each year should build on topics covered in previous years and, where appropriate, should be tied to specific implementation projects. For example, if a city decides to change leaf collection practices to keep leaves out of the street, the information and education strategy for that year would focus on messages for the public about new leaf collection policies. These messages might build on previous messages about weed problems in local lakes. Other messages might emphasize alternatives to city leaf collection including specific "how to" information on using leaves for mulch and compost.

Setting Goals and Objectives

The goals for a stormwater information and education strategy might be broadly defined in terms of the stages of change, target audiences and key issues discussed above:

- *Awareness*: Increase awareness and understanding among all audiences of urban stormwater runoff impacts and the most common sources of pollution.
- *Acceptance*: Foster acceptance of stormwater treatment and pollution prevention methods among government officials, developers, owners and managers of industrial and commercial property, and urban residents.
- *Implementation*: Develop the skills of government and industry staff in designing, building and maintaining stormwater treatment devices. Increase the adoption of pollution prevention practices by urban residents by providing specific information on methods to reduce pollutants in runoff from residential property.
- *Evaluation*: Increase the effectiveness of stormwater treatment and pollution prevention by providing feedback about experiences with various techniques to government officials, developers and other construction industry staff, and urban residents.

The objectives developed for each goal would be more specific in terms of subjects, audiences and measurements of change. For example, objectives for the first goal might include:

To be effective, activities must reach the target audiences when they are receptive.

- 75 percent of 5th grade students will understand that storm sewers discharge untreated water to lakes and streams.
- All dog owners will be aware that leaving pet waste on the sidewalk or street causes water pollution and the city recently adopted a "pooper scooper" ordinance.

Because resources are usually limited, the list of objectives for each year should be kept short and focused on the most important issues and audiences. Objectives will vary from one community to another depending on local problems and needs. Within a community, objectives will also change from year to year.

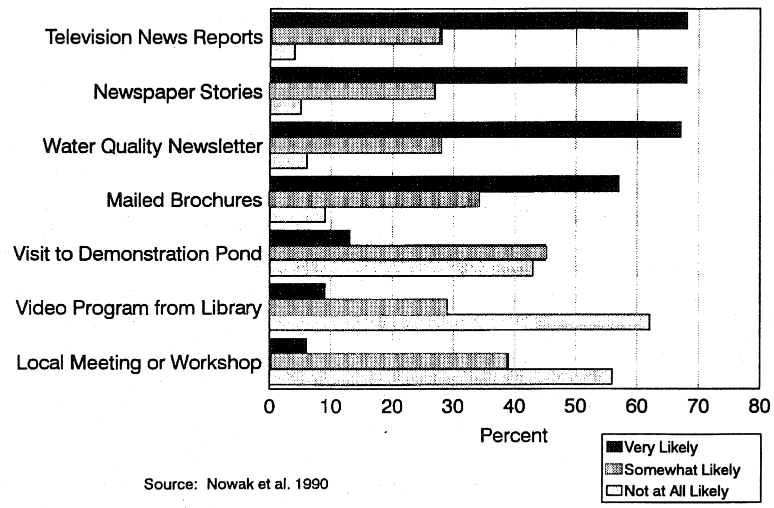
Selecting Appropriate Activities

After setting goals and objectives, the next challenge is to select activities that will reach the targeted audiences. To be effective, activities must reach the target audiences when they are receptive. While meetings, workshops and tours effectively convey detailed information to highly motivated, well-defined groups such as public works directors, programs for the public must rely heavily on the media. Surveys suggest that citizens are very likely to learn about something by watching television news reports, reading stories in the newspaper, or reading a newsletter or brochure received in the mail. They are much less likely to visit a demonstration project, check out a video cassette from the library or attend a meeting or workshop (Figure 4-3).

Also keep in mind that most people must hear a message several times before they remember it. They must hear it even more before they will act. Therefore, one newspaper publication of the official notice of a new "pooper scooper" ordinance will not achieve the objective of increasing compliance with the new ordinance by 75 percent.

A more effective information program might include news coverage in all the media, a notice mailed with pet license renewals, posters at veterinary clinics and

Figure 4-3: Sources of Information about Water Quality



Source: Nowak et al. 1990

pet supply stores, a handout featuring a cartoon for school children, and 60 days of "warning" tickets before issuing citations.

Measuring Success

No educational program is complete without an evaluation component. Evaluate individual activity success, but more importantly, periodically evaluate the whole program for its effectiveness in achieving the objectives set out in the strategy.

Individual activities are usually evaluated by these indicators:

- The number of people reached
- Their immediate reactions to the activity
- What they learned
- Whether they acted on that knowledge
- How long they maintained any changes in behavior

Participants evaluate most activities and record their actions on an evaluation form collected during the event. Better evaluations measure what participants learned (often through a pre/post test or skill demonstration). But the best evaluations measure changes in behavior. This can also be the most difficult and expensive evaluation to conduct. They may require follow-up surveys, interviews or long-term observation.

Evaluating the success of the whole stormwater information and education program may be an even greater challenge. One technique would measure changes in community attitudes and knowledge through periodic surveys. To yield accurate results, surveys should be based on random samples that represent all parts of the population. Telephone surveys are fairly accurate because they usually have a higher response rate. Mail surveys, give more people an opportunity to participate in the survey, but they usually have a much lower response rate. Results could be challenged unless there are steps to increase the number of people who return a mail survey.

Like evaluations of individual activities, evaluations of the total program are best when they measure changes in behavior, not just knowledge and attitudes. Unfortunately, surveys are not a good way to measure changes in behavior because people tend to over-report "good" behavior. Other indicators must be used. For example, asking people what they do with used oil may give an overestimate of the amount actually recycled. A more accurate measure of changes in oil disposal practices could be measured by comparing the amount of oil purchased at retail outlets to the amount received at recycling centers.

Surveys and statistics are not the only ways to evaluate an information and education program. Carefully designed research projects with control groups probably yield the most accurate hard data about behavior change. However, focus groups and case studies may be more effective in exploring the reasons behind people's attitudes and behavior. Regardless of the method, use information from periodic evaluations to make the information and education program more effective.

Summary

Information and education programs are a vital part of urban stormwater management and pollution prevention programs. Currently few leaders or citizens understand why changes are needed or how to carry out these changes. A well designed information and education program will develop awareness of urban stormwater problems, support the needed changes, and develop skills to implement those changes. A strategy that identifies key issues and targets audiences will also help focus limited resources on the most effective information and education activities.

Ten Tips for an Information and Education Program

1) Designate responsibility to someone to design and implement the information and education program. Information and education is often neglected because it is a shared responsibility.

2) Keep your program well focused. Choose a few important topics for each year and do a thorough job with them. You will overwhelm yourself and the audience if you try to cover every topic related to urban stormwater.

3) Target the audiences you need to reach. Think about when and where they will be most receptive to your message.

4) Lay the groundwork. People must first understand the problem, its causes and the consequences of their actions. Then they need specific information on what, where, when and how they can participate.

5) Insist on high quality. Grab attention with color, interesting graphics, or compelling sound. Double check your spelling, grammar and facts. If your staff lacks the necessary expertise, train someone or contract with a private consultant.

6) Use what's available. Many high quality materials on urban water quality are available from the University of Wisconsin-Extension and the DNR.

7) Keep your messages for the public simple. Messages should be concise, easy to understand and consistent. Be careful to avoid jargon and to explain any technical terms. If materials are too long or hard to understand, the message will be ignored.

8) Be positive. Positive messages are more effective than negative messages when getting people to adopt something new. People need to believe that their individual actions will make a difference in solving a significant problem. They also need to believe that participating will not sacrifice their standard of living or cause them to lose control of their environment.

9) Repeat the message. Remember that people must hear a message many times from sources they consider credible before they will act.

10) Give feedback. Tell people what was done, preferably by local people they know. Build on past achievements in your messages. Remember to get feedback. Give people the chance to tell you how to improve the program.

Non-Structural Best Management Practices

Leaf and Lawn Waste Disposal

Proper disposal of leaf and lawn waste is a simple and effective way to improve water quality. Small efforts by citizens can control sources of debris and phosphorus loadings. Past monitoring studies show increased levels of phosphorus in stormwater during the fall. This increase results from falling leaves and other debris that end up in the curb and gutter. The goal here is to keep leaves and grass clippings off these impervious areas.

Here are proper leaf disposal methods:

- Sweep leaves off curbs, sidewalks, driveways, and storm sewer openings.
- As an alternative to bagging, consider composting or mulching.
- If a municipality has a leaf collection system, place the leaves on the lawn terrace next to the curb. Do not put the leaves in the curb gutter or on the sidewalk.

Lawn waste disposal procedures are essentially the same as leaf disposal. Both composting and mulching are recommended for proper disposal of these wastes.

One quart of oil can contaminate two million gallons of drinking water.

For more information on proper disposal methods of lawn and leaf wastes, contact:

The Wisconsin Department of Natural Resources
Bureau of Water Resources Management
Nonpoint Source and Land Management Section
Box 7921
101 S. Webster St.
Madison, WI 53707

Waste Oil and Solid Waste Disposal

Improper disposal of waste oil and other materials can result in poor water quality. One quart of oil can contaminate two million gallons of drinking water.

Proper disposal of waste oil and other materials can improve water quality. With recycling now mandatory in many Wisconsin communities, most citizens already employ this best management practice. While this practice is not really pollution prevention, it is as close as most citizens get to this concept.

The best way to describe this BMP is by using common sense. Less oil and trash in the water means cleaner water resources.

Collection points at a municipal or county garages or a gas station is the proper way to dispose of waste oil. Do not dump waste oil down a stormsewer drain since they drain directly into a lake or stream. Make citizens aware of this by labeling storm drains with a stencil. The DNR Nonpoint Source and Land Management Section supplies stencils for a small fee.

Other wastes also need proper disposal. Larger municipalities have collection points or curbside collection. For smaller communities, hauling the waste to the nearest licensed landfill may be the only solution for proper disposal.

Clean Sweep programs are another way to dispose of toxic wastes that frequently accumulate within a household. For more information on Clean Sweep and other solid waste disposal programs, contact:

The Wisconsin Department of Natural Resources
Bureau of Solid and Hazardous Waste
101 S. Webster St.
Box 7921
Madison, WI 53707

Salt and Deicer Use on Winter Streets

Excessive sand and salt use can impact the surrounding environment. There is nationally documented evidence that excessive salt use can cause both groundwater and surface water problems. With public safety as the top concern, this chapter will explore the uses of salt and deicers on winter roadways.

...research shows high sodium levels in groundwater across Dane County from rock salt use.

Studies have recorded elevated levels of sodium where road salt is used. For example, Lake Wingra in Madison, Wisconsin, has higher than normal levels of sodium in its system because of road salt use. In addition, research shows high sodium levels in groundwater across Dane County from rock salt use. Pollutants associated with road salt include sodium, calcium and cyanide (from anticaking agents). Many studies show how road salt increases the decay rate of roads, streets and bridges.

Wisconsin administrative code Trans. 277 regulates storage of highway rock salt piles. This regulation requires covering salt piles and placing them on impervious pads. However, many salt piles fail to meet these minimum requirements.

Municipalities use many different materials to deice streets. The following section describes the advantages and disadvantages of some of these materials. This partial list gives an overview of different materials currently in use.

Road salt is still the most widely used deicer in the nation. Recommended application rates range from 300 to 800 pounds of salt per mile. This application can translate into immediate sodium chloride concentrations of 36,500 ppm or higher from the roadway. But in Wisconsin, these application rates are typically much higher. In a survey of seven Dane County municipalities, salt use per application ranged from 3.1 to 14.0 tons per mile of road, or 6,000 to 28,000 pounds per mile. This suggests that excessive salt use occurs for most applications.

An anticaking material is also used with salt for easier application. A common anticaking material used in the Midwest is sodium ferrocyanide. This substance produces cyanide when exposed to ultraviolet light. Typically, 1/4 to 1/2 pound of sodium ferrocyanide is added to each ton of salt. It is unclear how this amount of cyanide from anticaking agents affects the aquatic community.

Lower cost is the main advantage of road salt. Road salt costs approximately $25 a delivered ton, while other deicers can cost as much as $650 a ton.

In the late 1970s the Federal Highway Administration developed calcium magnesium acetate (CMA) to replace road salt as an environmentally safe alternative for road deicing. It is also much less corrosive than conventional deicing materials. In fact, CMA is no more corrosive than tap water.

Many parts of North America and Canada have used CMA successfully during the last five years. Most municipalities use CMA on new structures, such as bridges where replacement costs can be extremely high. Because of CMA's high cost ($650 a ton) citywide application is not feasible, but CMA may be an option with new structures.

CMA has reduced sodium levels in groundwater. In Freetown, Massachusetts, the Department of Public Works used CMA and sodium levels in private wells decreased from 52 to 26 mg/l in only two years.

The only potential impact of CMA on surface waters is related to acetate ion biodegradation. This can cause locally increased levels of biological oxygen demand (BOD) in waterbodies. Because acetate rapidly decomposes, impacts from CMA applications have not been detected.

CG-90 Anticorrosive deicer (CG-90) is an additive used with rock salt. When CG-90 dissolves, it forms a protective barrier on metal surfaces. Zinc ions reacting with hydroxide and phosphate ions produce the barrier on the metal surface, forming an insoluble thin film preventing oxygen diffusion and corrosion. The Richard I. Bong Memorial Bridge connecting Duluth, MN and Superior, WI uses this material.

The recomended application rate for rock salt is 300-800 pounds per mile.

This product is somewhat less expensive than other non-salt deicers. It has a mid-range cost of $200 a ton. Other additives for rock salt include sodium monofluorophosphate, magnesium oxide and lignon sulfonate derivatives.

In sum, rock salt remains the least expensive snow and ice control product. Evidence suggests rock salt is over-applied. The recommended application rate for rock salt is 300-800 pounds per mile.

Other deicers are as effective as rock salt, but the cost prohibits municipal-wide applications. Where sensitive water bodies and high groundwater tables are common, non salt deicers may be the only alternative to prevent degradation of the ground water and surface water resources.

Controlling Pet Waste

Micro-organisms (bacteria) are a common contaminant of urban stormwater. The major concern with bacteria found in stormwater is the potential for the spread of waterborne diseases among humans. Rather than trying to detect specific human pathogens in water, public health microbiologists use fecal coliforms as indicator organisms. These bacteria commonly live in the intestines of warm-blooded animals. The presence of fecal coliforms in water suggests fecal contamination and the possibility of pathogenic bacteria that also live in the intestinal tract.

If a watershed contains many animals, the runoff is likely contaminated with fecal material. An urban watershed may contain squirrels, rodents, rabbits, opossums, raccoons, pigeons, deer, birds, and domestic pets as sources of feces. Under the favorable conditions following a rain, bacteria can multiply rapidly until they utilize all available food. This results in high bacteria counts in urban runoff. The bacteria in feces are less of a health concern than the parasites. Although the transmission of any disease from animal to human is rare, when it does occur, the disease or parasite can be serious. Diseases that can be transmitted include *toxoplasmosis* (cats), *leptospirosis* (dogs), *visceral larval migrans* (dogs), and *giardiasis*.

Local units of government enact ordinances to minimize nuisance conditions from pets or undesirable wild animals. Usually the ordinance or control measure has more than one goal. For example, requiring dog owners to pick up pet droppings not only reduces contamination of stormwater, but it also removes an annoyance for pedestrians and a potential breeding material for flies.

Since enforcement of a pet waste ordinance is likely to have low priority with animal control or law enforcement officers, compliance depends on social pressure. A responsible pet owner will clean up after a pet to reduce the chance of cross-infection from other pets. Well maintained areas where occupants know one another is the most likely place for voluntary compliance. Public education is an essential part of an effective program.

The recommended disposal for pet waste is to flush fecal material down the toilet. Pet waste will then receive the same treatment as human waste. Waste from pets free of parasites may be buried in soil around ornamental plants. Although some individuals dispose of cat litter and dog droppings along with household garbage, landfill operators do not want these materials.

Construction Site Erosion Control

Although erosion is a natural process, human activity can greatly increase erosion rates resulting in harmful effects to the environment. Construction and agricultural activities normally remove vegetation from a land surface, allowing the erosive forces of wind and water to carry the sediment to surface waters more easily. This sediment clogs water conveyance systems, produces turbid water, and acts as a nutrient that increases algae and weed growth.

More sediment comes from agricultural areas than from construction sites. However, the amount of soil eroded per acre from individual construction sites is often greater than the same area of agricultural land. Agriculture typically produces one to three tons per acre every year, while construction sites typically produce 10 to 30 tons per acre per year. Construction erosion can produce dramatic effects downstream years after the construction ends.

Because construction site erosion produces such a heavy concentration of sediment, small areas can have profound effects on surface water. Controlling stormwater runoff from these sites can accomplish large reductions in sediment pollutant load. To guide runoff control from these sites, the DNR created the *Wisconsin Construction Site Best Management Practice Handbook*. This handbook provides builders, contractors, developers, government officials and others with guidelines to control sediment from construction sites. Seven subject areas divide the handbook in the following manner:

1) The introduction and purpose of the handbook

2) The basic principles of construction site erosion control

3) A description of the individual best management practices by category
    A. Diverting flow
    B. Managing overland flow
    C. Trapping sediment in channelized flow
    D. Establishing permanent drainageways
    E. Inlet protection
    F. Trapping sediment during site dewatering
    G. Preventing tracking
    H. Others
4) A list of selected guide books, manuals and references
5) Samples of checklists for review in erosion control plans and samples of plans
6) A description of procedures for calculating runoff
7) Aids for implementing and enforcing erosion control of construction sites.

Appendix A of the Wisconsin Construction Site Handbook includes the Wisconsin Model Construction Site Erosion Ordinance. Appendix B includes the Soil Conservation Service tables for designing grassed waterways.

There are plans to periodically review and update the handbook. If you have comments, questions or suggestions, please contact Terry Donovan at:

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Chapter Five: Best Management Practices

This Chapter Discusses:

Wet detention ponds

Constructed wetland

Infiltration basins

Infiltration trenches

Porous pavement

Street sweeping

Catchbasin cleaning

Wet Detention Ponds

Introduction

Wet detention ponds are the most commonly used best management practices for control of urban stormwater. They are reliable and attractive systems that help control stormwater pollutants.

These systems consist of a single permanent pool of water that treats incoming stormwater. Wet detention ponds usually have three to seven feet of standing water, allowing pollutants to settle, with a defined forebay and outlet structure.

Stormwater Control Effectiveness / Positive Impacts

Many studies show these systems consistently remove suspended solids. Removal rates vary from 50 to 90 percent, depending on the size and shape of the system. Wet detention ponds can also control pollutants such as heavy metals, phosphorus, and bacteria, but at lower removal rates than suspended solids. Pollution control rates will vary depending on the construction of the system, but in general, the following rates apply:

Pollutant	Percent Reduction
Suspended Solids	50-90
Phosphorus	12-79
Nitrogen	6-62
Chemical Oxygen Demand	7-76
Lead	8-84
Copper	7-65
Zinc	13-87

Wet detention ponds can also be an attractive environmental asset for wildlife and humans if properly designed. The systems can be integrated with green space areas to provide park-like settings, while also controlling stormwater pollutants.

Negative Impacts

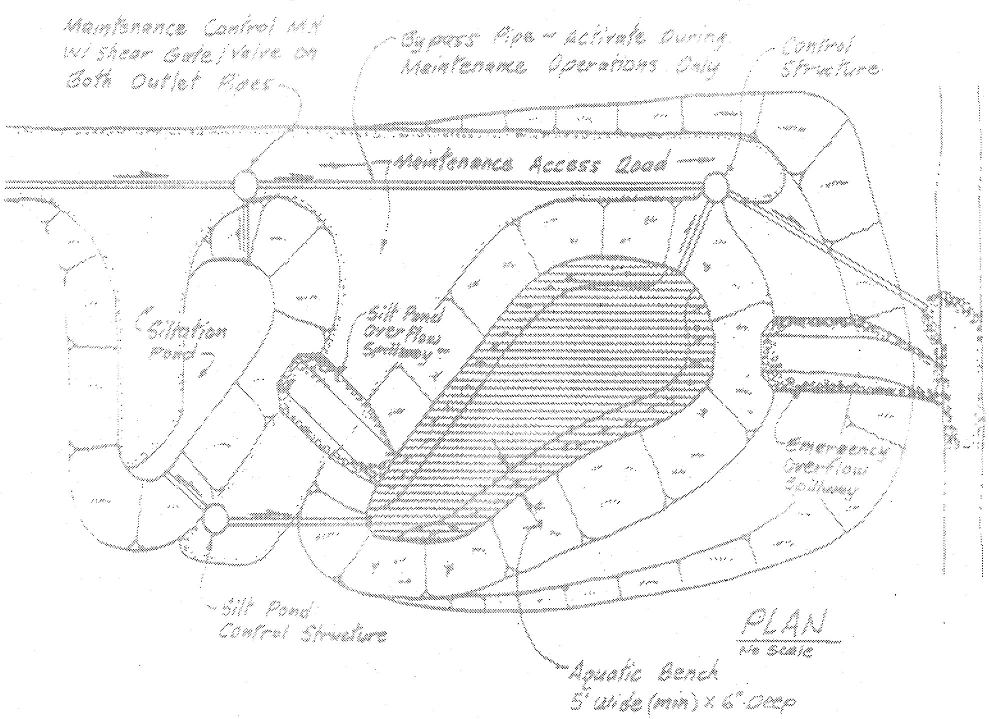
Wet detention ponds have limited negative impacts on water resources. One impact can be the downstream warming from thermal discharges. Another concern is the long-term maintenance requirement associated with the system. Concerns are also raised about child safety around standing pools of water.

Design Considerations

Sediment settling is the most important function of this BMP. Design considerations should include soil type, slope of the system, depth to groundwater and bedrock, pretreatment and control of sediment input, size and depth of system, hydrological impact downstream and maintenance.

For a complete listing of design considerations on wet detention ponds, please refer to Part Two – Technical Design Guidelines for Stormwater BMPs.

Wet detention ponds can also be an attractive environmental asset for wildlife and humans if properly designed.



Constructed Stormwater Wetlands

Introduction

Constructed stormwater wetlands can be used as a BMP to control urban stormwater. The idea of constructed wetlands is not new. Point source dischargers have used these structures for years. However, there are many questions regarding exactly how wetlands remove pollutants.

Constructed stormwater wetlands are shallow pools that enhance growing conditions for marsh plants to maximize pollutant removal. These wetlands differ from artificial wetlands since they do not reproduce the ecological diversity found in natural wetlands.

Stormwater Control Effectiveness / positive Impacts

Constructed stormwater wetlands can effectively remove most pollutants from stormwater. This takes place by the diverse treatment mechanisms of sedimentation, infiltration, chemical precipitation, adsorption, microbial interactions and uptake by vegetation (Hammer 1989).

Pollution control rates can vary depending on the construction methods and the vegetation associated with the wetland. In general, constructed wetlands will have the following removal efficiencies:

Pollutant	Percent Reduction
Suspended Solids	14-98
Phosphorus	0-97
Nitrogen	23-30
COD	22-79
Iron	43-92
Lead	68-82
Zinc	34-50

Constructed stormwater wetlands are designed for pollutant removal and differ from natural wetlands in many ways. The most obvious difference is that constructed wetlands may not fulfill the requirements associated with wetland mitigation action, since they are not designed to replace existing wetlands.

Negative Impacts

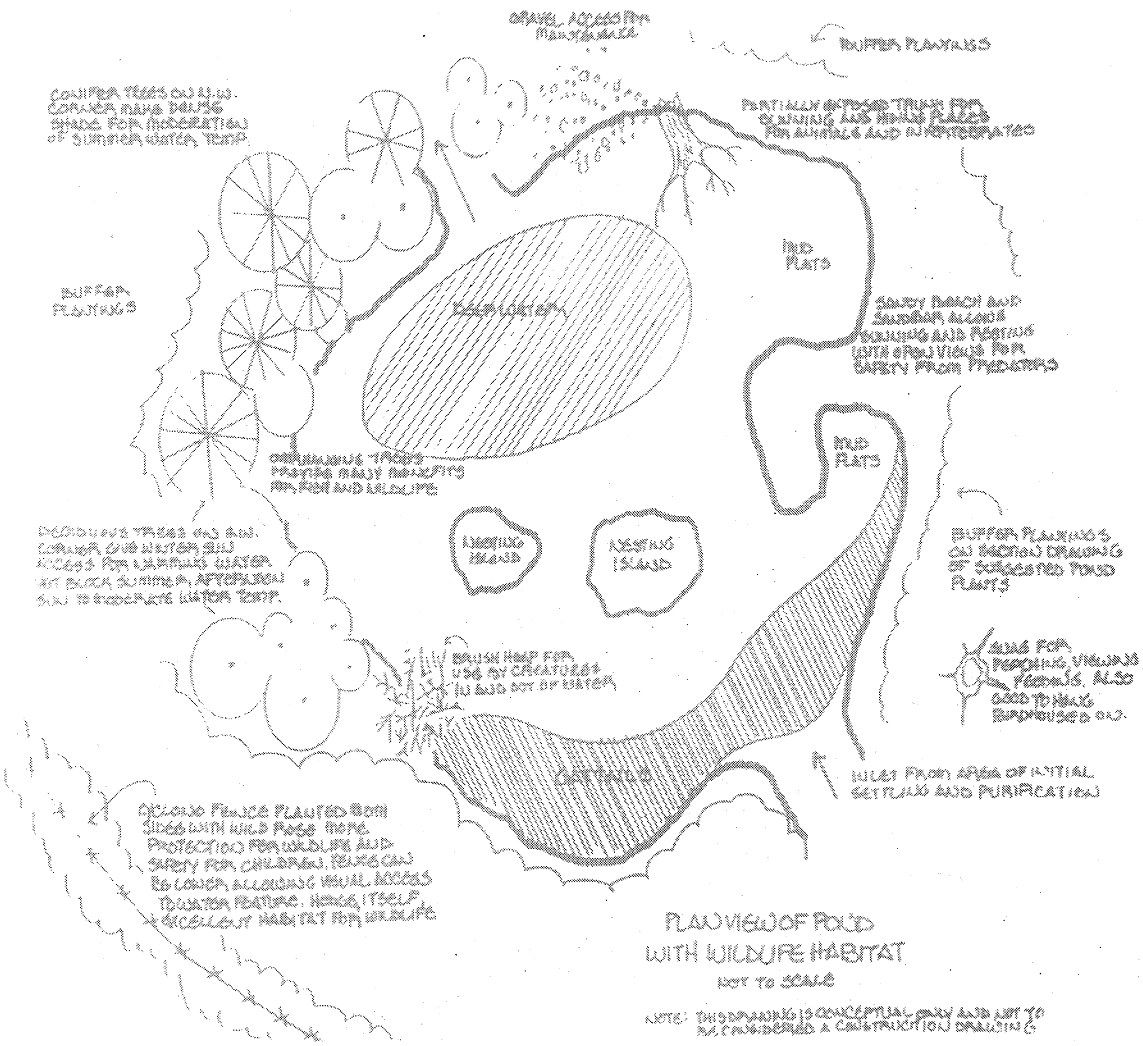
Constructed wetlands may have negative impacts on land and water resources. Listed below are impacts that Schueler(1992) associates with constructed wetlands:

- Possible impact on wetland biota from trace metal uptake
- Discharges are warmer than inflows
- Possible takeover by invasive aquatic nuisance plants such as loosestrife, cattails, etc.
- Construction may adversely impact existing wetland or forest areas

Design Considerations

Design considerations for constructed wetlands can be numerous. Site selection, wetted surface area, water depth, wetland plantings and maintenance all play important roles. Constructed wetlands are normally not located within natural wetlands.

For a complete listing of design considerations on constructed stormwater wetlands, refer to Part Two – Technical Design Guidelines for Stormwater BMPs.



Infiltration Basins

Introduction

Infiltration basins are large open depressions that stores incoming stormwater runoff while percolation occurs through the bottom and sides. Soils, slope, geology, and hydrogeology restrict the use of these basins.

Stormwater Control Effectiveness / Positive Impacts

Infiltrating stormwater allows groundwater recharge to maintain stream baseflow and colder stream temperatures. Infiltrating also controls streambank erosion by reducing runoff. Dissolved pollutants in stormwater can be removed if site soil conditions are right. Unfortunately, limited performance data exist on infiltration basins.

Negative Impacts

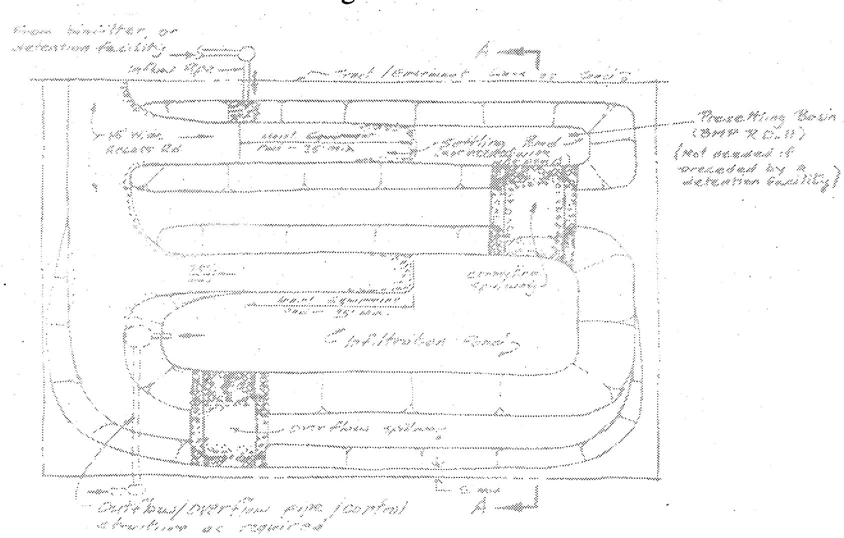
Infiltration basins have a limited life span. They require maintenance to keep a vegetative cover and prevent clogging or sealing of the structure. They also require retreated runoff with removed sediment. Infiltration of runoff could raise the groundwater table and cause flooding. Contaminants in stormwater could negatively affect groundwater quality.

...limited performance data exist on infiltration basins.

Design Considerations

Infiltration basins are normally designed to store runoff long enough to let it percolate within 24 hours of the storm event. Depth to high seasonal groundwater and bedrock must be greater than five feet below the bottom of the structure. Basins cannot be located in groundwater discharge zones or high traffic areas. Care must be taken during construction to prevent compaction of soils in the basin. Minimum separation distances to wells, foundations and septic drain fields are needed. Infiltration basins are generally not effective for areas contributing more than 50 acres or if one-half of the contributing area is impervious. Infiltration basins must be large enough to store snowmelt until spring thaw.

For a complete listing of design considerations on infiltration basins, please refer to Part Two – Technical Design Guidelines for Stormwater BMPs.



Infiltration Trenches

Introduction

Infiltration trenches are shallow, excavated trenches filled with coarse aggregate and covered with a pervious soil layer. The trench serves as an underground reservoir. Stormwater runoff diverted into the trench exfiltrates from the bottom through the subsoil to the water table where an underdrain carries it to a stormwater conveyance system.

Stormwater Control Effectiveness / Positive Impacts

The advantages of using infiltration trenches for stormwater disposal are maintenance of groundwater recharge, stream baseflow and colder stream temperatures. Some pollutant removal may occur in correctly sited trenches. However, only limited performance data on infiltration trenches are available.

Negative Impacts

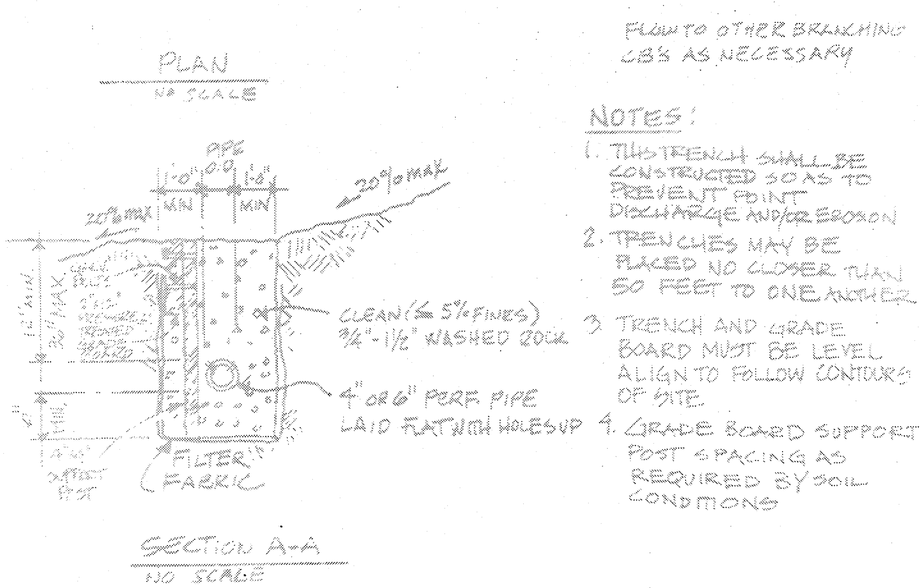
Infiltration trenches do not perform well in cold climates with deep freeze/thaw levels. If installed in cold climates, trenches may provide storage for snowmelt. Pretreatment of runoff is needed to prevent clogging. Over half the trenches in North America failed within five years of installation from clogging.

Infiltration trenches do not perform well in cold climates...

Design Considerations

Infiltration trenches drain small areas. Their efficiency depends on the aggregate in the reservoir and the subsoil type. Depth to groundwater and bedrock must be more than five feet and separation distances from foundations, septic systems, and wells should be considered. Pretreatment of runoff to control sediment input is also a factor. Preventing soil compaction during construction is also important.

For a complete listing of design considerations on infiltration trenches, please refer to Part Two – Technical Design Guidelines for Stormwater BMPs.



Porous Pavement

Introduction

Porous pavement is an alternative to conventional pavement. Porous pavement diverts runoff through a porous asphalt layer and into an underground reservoir constructed of crushed stone or gravel. The stored runoff gradually infiltrates into the subsoil and water table.

Stormwater Control Effectiveness / Positive Impacts

Porous pavement allows the groundwater to recharge, preserving stream baseflow and cold-stream temperatures. Dissolved pollutants may be removed from runoff if the subsoils can adsorb pollutants. However, there are limited performance data on porous pavement.

Negative Impacts

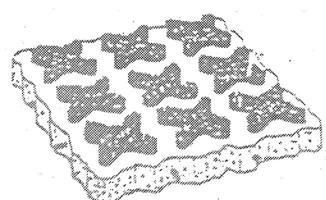
Maintenance of porous pavement involves vacuuming or jet hosing to prevent clogging by sediments, oil and grease. It can only be used in low traffic areas with restrictions on heavy truck access. Pretreatment of off-site runoff water is necessary to reduce sediments. Deicing chemicals and sand must be restricted.

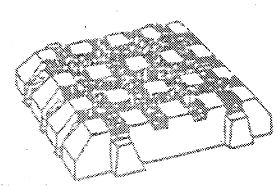
Porous pavement can only be used in low traffic areas...

Design Considerations

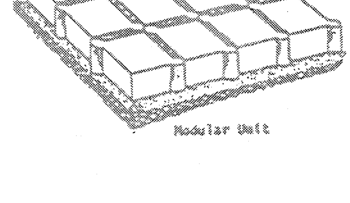
Construction methods must not compact subsoils. Traffic on porous pavement must be light so the surface isn't compacted, reducing infiltration. Subsoils must be permeable and depth to high seasonal groundwater and bedrock must be greater than five feet. A monitoring well can be installed to monitor groundwater quality and insure that water stored in the crushed stone reservoir is infiltrating within 24 to 48 hours. An overflow pipe should be installed to prevent flooding if a storm exceeds the design. The bottom of the porous pavement reservoir should have a sand or fabric filter and the sides should be lined with filter fabric. Porous pavement should be located in recharge areas with sufficient separation from wells and septic drain fields.

For a complete listing of design considerations on infiltration trenches, please refer to Part Two – Technical Design Guidelines for Stormwater BMPs.


Poured-in-Place Slab


Castellated Unit


Lattice Unit


Modular Unit

Street Sweeping

Introduction

Street sweeping can have limited success as a BMP on existing urban land uses. Street sweeping can be used with other BMPs to control urban stormwater. Beyond cleaning urban stormwater pollutants, street sweeping is highly visible and can be used as an information and educational tool to promote awareness of urban stormwater pollution.

Stormwater Control Effectiveness / Positive Impacts

Typical mechanical street cleaners remove much (about 70 percent) of the large particles in the path of the street cleaner, but remove very few small particles (Sartor and Boyd 1972; Pitt 1979). Rains, however, remove a few large particles, but can remove considerable quantities (about 50 percent) of the fine particles (Bannerman et al. 1983; Pitt 1984; Pitt and McLean 1985).

Factors significantly affecting street cleaning performance include street dirt sizes and loadings, street texture, moisture, parked car conditions and equipment operating conditions (Pitt, Ugelow, and Sartor 1976; Pitt 1979).

Many street cleaning performance tests were conducted in Milwaukee with street dirt accumulation and urban runoff monitoring as part of the Milwaukee Urban Runoff Project (Bannerman et al. 1983). Other Nationwide Urban Runoff Program (NURP) projects have also completed street cleaning monitoring. The main factors affecting street cleaning productivity are street texture, street dirt particle size and street dirt loading.

Street cleaning can be more effective in industrial areas...

Typical predicted control at the residential outfalls varies from 1 to 11 percent. Street cleaners are more effective for small rains. For small 0.1 inch rains, street cleaning in residential areas may remove up to 30 percent of the urban runoff pollutants. During these small events, most pollutants originate from connected impervious areas (streets).

Street cleaning can be more effective in industrial areas, especially if paved parking/storage areas are effectively cleaned. Up to a 70 percent reduction of pollutants can occur. However, more common industrial street cleaning programs would be less than 10 percent effective because of limited parking and street sweeping.

Negative Impacts

Street sweeping has few, if any negative impacts.

Design Considerations

A regenerative-air street cleaner increases performance, especially at low loadings. The improved performance is much greater for fine particle sizes, where a mechanical street cleaner cannot remove any significant quantities of this material. Both kinds of street cleaners remove larger particles with about the same effectiveness. Other tests of vacuum street cleaners (Pitt 1979), and regenerative-air street cleaners (Pitt and Shawley 1981) showed very few differences in performance when compared to more standard, mechanical street cleaners. For heavy loadings, first clean with a mechanical street cleaner to remove the large particles, followed by a regenerative-air cleaner to remove the finer particles.

For more detailed information on street sweeping criteria, please refer to Part Two – Technical Design Guidelines for Stormwater BMPs.

TECHNICAL DATA

PERFORMANCE
Maximum travel speed 16mph (25kph).
Sweeping performance up to 20,000m^2/hr.
Turning circle 13'2" (4m)

ENGINE
Perkins 4.108 water cooled diesel engine 1760 cc.
45 bhp @ 3,000rpm: Max. torque 112Nm @ 2250rpm.

FUEL TANK
14 gallons (55 litres). Sufficient for more than ten hours' work.

WHEELS AND TIRES
Four 200/75 R9-Michelin tires on 5-hole steel disc wheels.

HOPPER
The hopper has a volume of 2.3yd^3 (1.8m^3) and is raised to its discharge position by means of two rams. A hand pump is fitted in order to raise the hopper in the event of engine failure. Hopper discharge height is 4' 11½" (1500mm). 45° discharge angle.

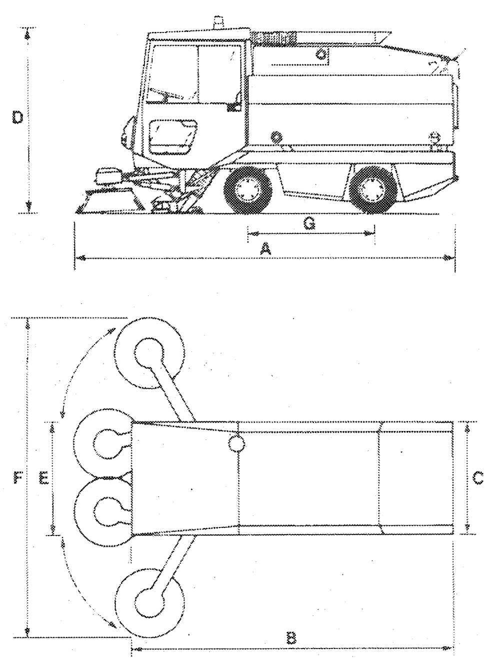
BRUSHES
Two 33 inch (850mm) diameter polypropylene, variable speed front brushes are fitted as standard The brushes are positioned by means of hydraulic rams.

BRAKES
Rear wheels hydrostatic with mechanical parking brake. Front wheels hydraulically actuated drum brakes by foot pedal.

TRANSMISSION
Fully hydrostatic to motors on rear wheels.

WATER SPRAY SYSTEM
Tank capacity 41 gallons (155 litres). Water sprays on brushes via an electrically driven diaphragm pump.

DUST SUPPRESSION IN HOPPER
Tank capacity 49 gallons (185 litres). Water recirculation system via a hydraulically driven pump.



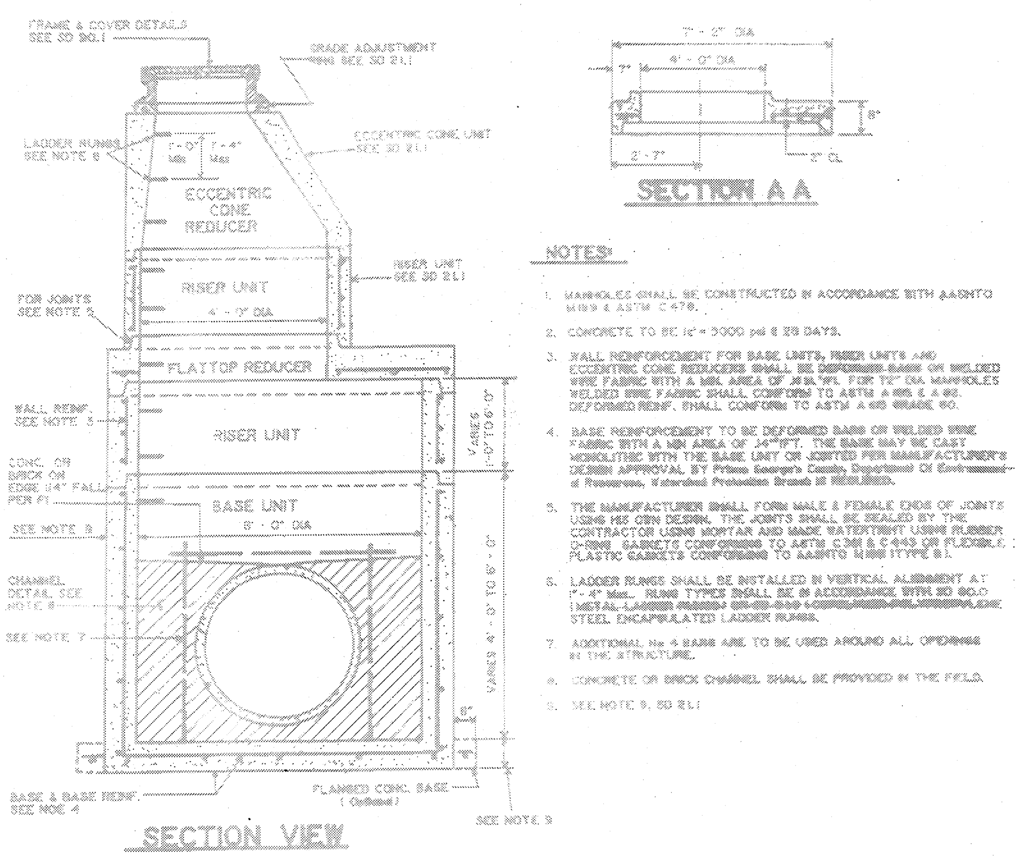
Catchbasin Cleaning

Pitt (1979) investigated the mobilities of catchbasin sediments during a research project sponsored by the U.S. EPA's Storm and Combined Sewer Section. This project used particulate fluorescent tracers mixed with catchbasin sediment. The study concluded that the amount of catchbasin sediment was very large in comparison with storm runoff yields, but was not very mobile. Cleaning the sediments reduces the potential for very large discharges during rare scouring rains.

Further research by Pitt (1984) in Bellevue, Washington investigated the accumulation rate of sediment in storm runoff and the effects of stormsewer cleaning on runoff discharges. The sediments found in the catchbasins were the largest particles washed from the streets. Erosion sediment from steep hillsides next to the storm sewer inlets was predominate in a few unusual locations. The runoff and catchbasin sediments had a much smaller median particle size than the street dirt and therefore had more potential to pollute than the particulates that can be removed by street cleaning. If the catchbasins are full, they also cannot remove any additional particulates from the runoff.

Catchbasin particulates can be conveniently removed to eliminate this potential source of urban runoff pollutants. Cleaning twice a year allows the catchbasins to capture particulates for most rains. This cleaning schedule reduced the total solids and lead loads in urban runoff yields by 10 and 25 percent. It reduced loads of COD, total Kjeldahl nitrogen, total phosphorus, and zinc by between 5 and 10 percent (Pitt 1979,1984).

Cleaning twice a year allows the catchbasins to capture particulates for most rains.



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Glossary

Acute toxicity: Any poisonous effect produced by a single short-term exposure to a chemical that results in a rapid onset of fatal symptoms.

Best management practice (BMP): A practice or combination of practices that are determined to be the most effective and practical (including technological, economic, and institutional considerations) means of controlling point and nonpoint pollutants levels compatible with environmental quality goals.

Chronic toxicity: The effects of long-term exposure of organisms to concentrations of a toxic chemical that are not lethal, but are injurious or debilitating to an organism in one or more ways. An example of this effect is reduced reproductive success.

Composting: A controlled process to degrade organic matter by microorganisms.

Critical habitat: A habitat determined to be important to the survival of a threatened or endangered species, to general environmental quality, or for other reasons designated by state or federal government.

Drainage basin: A geographic and hydrologic subunit of a watershed.

EPA: United States Environmental Protection Agency.

Erosion: Wearing away of the land surface by running water, winds and waves. The term erosion is usually preceded by a definitive term denoting the type or source of erosion such as gully erosion, sheet erosion, or bank erosion.

Groundwater: Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the water table.

Heavy metals: Metallic elements with high atomic weights, e.g. mercury, cadmium and lead. They can damage living organisms at low concentrations and tend to accumulate in the food chain.

Impervious surface: Hard surface that prevents and retards the entry of water into the soil mantle as natural conditions prior to development and/or a hard surface area that causes water to runoff the surface in greater quantities or at increased flow rates from the flow present under conditions prior to development. Common impervious surfaces include, but are not limited to: rooftops, walkways, patios, driveways, parking lots, storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam, or other surfaces that similarly impede the natural infiltration of urban runoff.

Infiltration: The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

Land conversion: A change in land use, function, or purpose.

Local government: Any county, city, or town having its own incorporated government for local affairs.

Micron (ug/l): Micrometer; one-one millionth (0.000001) of a meter.

NPDES: National Pollutant Discharge Elimination System. A permitting system for point source polluters regulated under section 402 of the Clean Water Act.

Nonpoint source pollution: Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe.

Pollution prevention: A management measure to prevent and reduce nonpoint sources loadings generated from a variety of everyday activities within urban areas. These can include turf management, pet waste control and proper disposal of oil.

Post-development peak runoff: Maximum instantaneous rate of flow during a storm, after development is complete.

Riparian area: Vegetated ecosystems along a waterbody through which energy, materials and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding from the adjacent waterbody.

Removal efficiency: The capacity of a pollutant control device to remove pollutants from wastewater or runoff.

Retrofit: The modification of an urban runoff management system in a previously developed area. This may include wet ponds, infiltration systems, wetland plantings, streambank stabilization, and other BMP techniques for improving water quality and creating aquatic habitat. A retrofit can consist new BMP construction in a developing area, enhancing an older runoff management structure, or a combining improvements and new construction.

Runoff: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. Runoff can carry pollutants from the air and land into receiving waters.

Watershed: A drainage area or basin where all land and water areas drain or flow toward a central collector such as a stream, river or lake at a lower elevation.

WPDES: Wisconsin Pollutant Discharge Elimination System. A permit system to monitor and control point and some nonpoint source dischargers in Wisconsin.

Notes

Notes

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