BMP EFFECTIVENESS REPORT
18-9001-15
FAIRBANKS, ALASKA

February 2006

Submitted To:
Alaska Department of Environmental Conservation
Water Quality Program
610 University Avenue
Fairbanks, Alaska 99709

By:
Shannon & Wilson, Inc.
2355 Hill Road
Fairbanks, Alaska 99709-5326

31-1-11262-002

TABLE OF CONTENTS

Page

LIST OF TABLES

Table No.

LIST OF APPENDICES

Appendix

BMP EFFECTIVENESS REPORT
18-9001-15
FAIRBANKS, ALASKA

1.0 INTRODUCTION

1.1 Purpose and Scope

This report presents our interim findings in support of the Fairbanks Stormwater Best Management Practice (BMP) Development project. The work is being conducted under our term agreement with the Alaska Department of Environmental Conservation (ADEC), contract 18-9001-15 and notice to proceed (NTP) 18-9001-15-1A. The project was authorized by a written NTP dated March 7, 2005, and issued by Remie Doyle of the ADEC.

This report presents our initial findings and a preliminary discussion on some of the factors we have identified as being important for BMP effectiveness in the Fairbanks area. We also present our recommendations for BMPs that will be evaluated for their effectiveness and development of long-term monitoring plans.

It is our intent that upon review of this report, we will have a framework for discussion of stormwater effectiveness with ADEC and the owners/operators of municipal stormwater systems in the Fairbanks area. Additional input may be solicited from the engineering community and the public.

1.2 Project Understanding

The purpose of this project is to identify the effectiveness of stormwater BMPs for use in the Fairbanks Area. Major objectives for this phase of study include:

1. identifying the stormwater BMPs in use in the Fairbanks area,
2. identifying other BMPs that may be of use in the Fairbanks area,
3. evaluating the likely effectiveness of the BMPs, and
4. developing a strategy for monitoring the effectiveness of the BMPs.

A fifth objective, entering results of the project into the International Stormwater BMP Database, is likely not appropriate for this phase of the study, as sampling and analysis of stormwater data have been specifically excluded from the scope of services.

The BMP investigation is primarily limited to good housekeeping/maintenance nonstructural BMPs and permanent, post-construction BMPs. The effectiveness of BMPs involving public education and involvement is generally difficult to quantify, particularly with water quality data. In addition, this study does not address temporary construction BMPs, as these are generally project-specific.

1.3 General Fairbanks Community

The Fairbanks North Star Borough (FNSB) is a 7,361-square-mile, local government jurisdiction in the interior of Alaska, with the city of Fairbanks being the main population and commerce center. The borough is the second largest population center in the state with approximately 85,000 residents. City, Borough, State, and Federal government agencies, including the military, provide over one-third of the employment in the Borough. The Borough School District and the University of Alaska Fairbanks are the primary public employers. Approximately 6,000 residents are military. Retail services, gold mining, tourism, transportation, medical, and other services are the primary private sector activities. The economy of the Fairbanks area is generally service-based, as presented in the table below.

TABLE 1
FNSB DISTRIBUTION OF WORKFORCE

Industry	Percent of Workforce
Producing Goods	11.9%
Providing Services	88.1%
Natural Resources and Mining	2.6%
Construction	7.7%
Manufacturing	1.6%
Trade, Transportation, and Utilities	19.8%
Information	1.6%
Financial Activities	3.7%
Professional and Business Services	11.4%
Leisure and Hospitality	11.6%

Industry	Percent of Workforce
Other Services	3.7%
Federal Government	9.0%
State Government	13.8%
Local Government	7.9%

Source: *Fairbanks Community Research Quarterly*, Fall 2005

Limited industrial activities are present within the developed portion of the Fairbanks area. Stormwater generating sources are primarily pavements for roads and parking areas. Industrial activities include transportation-related functions (airports, automobile, maintenance, and cleaning), landfills, and power facilities. Mining and petroleum processing generally occurs in remote areas that are not served by municipal stormwater systems.

1.4 Geological Setting

The near-surface geology, high groundwater table, and depth of frost penetration are anticipated to impact BMP effectiveness in the Fairbanks area in a unique manner. The primary urban development area in the Fairbanks is the Tanana Lowlands physiographic province, which forms a large arcuate band of alluvial sediments between the Alaska Range and the Yukon-Tanana Uplands. The lowlands consist of vegetated floodplains and low benches cut by the Tanana River, and sloughs and oxbow lakes representing former channel positions of the Tanana or Chena Rivers. Soils in the lowlands typically consist of interbedded alluvial sand and gravel covered by silty overbank deposits. Former slough channels are commonly filled with organic silt and peat deposits. These deposits are laterally discontinuous and vary in thickness.

The Fairbanks North Star Borough also occupies a portion of the Yukon-Tanana Uplands north, west, and southeast of the city of Fairbanks. Outlying communities located within the Borough include: Eielson Air Force Base, Ester, Fox, North Pole, Salcha, and Two Rivers. Development in these areas is primarily single-family residential but also includes businesses related to general services. The uplands in the vicinity of the Fairbanks area are comprised of rounded ridges and hills consisting of Precambrian schist bedrock with areas of intrusive granitic bedrock. Windblown silt mantles portions of the middle and upper slopes, and silt is generally thin to absent on the highest ridges and hills. The silt slopes are generally well drained.

Groundwater in the lowland areas has generally been observed at depths between 5 to 20 feet below the ground surface. The Tanana River and the Chena River influence the groundwater table in the Fairbanks area. Highest groundwater levels should be anticipated in the late spring after breakup, and during the summer when rainfall combined with melting snow in the headwaters normally results in higher groundwater levels. Groundwater levels are expected to drop throughout the late fall and winter months and should reach their lowest levels before spring breakup; higher groundwater elevations should be anticipated during the summer. The magnitude of the fluctuations may be on the order of 2 to 5 feet. A high groundwater table may restrict the ability of soils through which percolation occurs to effectively treat stormwater before it reaches the groundwater table.

The Fairbanks area is in a subarctic zone underlain by discontinuous permafrost. Permafrost is defined as ground that has remained at a temperature of 32°F or less for two or more years. The maximum depth of permafrost measured in the Fairbanks area is in excess of 200 feet. The thickness of the "active layer," the portion of the ground at or near the surface that undergoes an annual freeze-thaw cycle, is largely dependent upon the type of ground cover and the snow depth. Seasonal frost penetration commonly exceeds 10 feet beneath roads or parking areas kept free from snow during winter; whereas, in areas covered by thick mats of tundra or organic material, the thickness of the active zone is often 2 feet or less. The magnitude of the seasonal frost penetration and the potential for permafrost in the may have a significant impact on the performance and effectiveness of infiltration-based and subsurface BMPs.

1.5 Fairbanks Climate

Fairbanks is in the central part of Alaska in an area of subarctic climate. According to National Weather Service records collected at the Fairbanks International Airport (September 1949 to June 2005), the average maximum daily temperature is approximately 36.9°F, and the average minimum daily temperature is 17.0°F. Ground freezing typically begins in October, and near-surface soils generally remain frozen into May.

The average annual precipitation in Fairbanks is approximately 10.5 inches. In general, only the months of June (1.31 inches), July (1.90 inches), August (1.83 inches), and September (1.06 inches) have average monthly precipitation values of more than one inch. Included in this annual precipitation is approximately 67.4 inches of snowfall. The months with the highest average snowfall are November (13.2 inches) and December (12.7 inches). According to the National Weather Service average monthly snow depth records, there is snow on the ground between October and April.

Structural BMPs are often designed based on rainfall intensity-duration-frequency curves for the area. For the Fairbanks area, Armstrong and Carlson (2002) have developed these curves for precipitation events that may be used during the summer storm season. However, the use of rainfall intensity-duration-frequency curves for loading of a potential structural stormwater BMP during the spring breakup event has limited functionality. The amount of snowmelt is a function of many variables that are difficult to quantify, and include the amount and moisture content of the winter season's snowfall, whether the snow is left on pavement areas or plowed and stockpiled on pavement areas (shopping center parking lots), and the intensity and length of the warm spell. Daily temperatures with both high and lows above freezing have the potential to generate greater snowmelt and sheetflows. Localized street flooding is not uncommon due to frozen and under-capacity storm collection systems.

The climate of Fairbanks and interior Alaska differs from the climates of most other places in the United States in ways that impact the design and performance of stormwater treatment BMPs. The most significant difference between the climate of Fairbanks and that of most other locales is the long and uniformly cold winter in Fairbanks. Other populated areas generally do not have a winter that approaches the length of a Fairbanks winter. Snow that accumulates in October will typically not melt until the following April or May, allowing up to seven months of pollutants to accumulate on pavement surfaces.

Breakup is a dominant runoff event in Fairbanks, and it occurs at a time when many BMPs will not be functioning properly because they remain partially frozen. Surface water from snowmelt in Fairbanks begins with the melting of roadside snow. During warm days in April significant surface water may accumulate in ditches along the edges of major roads, which are typically plowed free of snow, and sheet flow can develop on local streets and parking lots, which may not have been plowed. This early snowmelt may contain a significant portion of the pollutants (oils, grease, sediment, debris) from the snowpack and pavements. During this early period of spring breakup, the ground; most small water bodies such as ditches, swales, and ponds; and many underground stormwater infrastructures are still frozen. This frozen condition may render many standard stormwater treatment BMPs ineffective.

ADOT&PF personnel thawing stormwater system inlet during 2005 breakup

Another concern regarding BMP performance in cold climates is that many standard BMPs tend to be frozen or partially filled with ice that will not melt until after most of the street runoff occurs in the spring. This may be particularly prevalent in the Fairbanks area because late summer is the wettest portion of the year, potentially causing many BMPs to be partially filled with water in October when freezing temperatures set in. Underground pipes may be filled with ice during spring snowmelt, resulting in localized flooding, and may remain frozen after most surface water has thawed because of the insulation afforded by the ground. Many storm inlet catch basins require steam thawing to deal with the local flooding, which may include several thousand gallons of water. This thawing may result in a peak discharge of sediment and pollutant laden water to the receiving water body. However, we were not able to identify storm outlet discharges as a function of steam thawing. Significant maintenance costs are incurred thawing the pipes in the spring.

2.0 BMP EFFECTIVENESS IN FAIRBANKS

2.1 Types of BMPs

> "Effective stormwater management is often achieved from a management system approach, as opposed to an approach that focuses on individual practices. That is, the pollutant control achievable from any given management system is viewed as the sum of its parts, taking into account the range of effectiveness associated with each single practice, the costs of each practice, and the resulting overall cost and effectiveness." (EPA, 2000).

BMPs can be divided into two major groups: source control and stormwater treatment. Source control BMPs are activities designed to prevent potential pollution from entering the stormwater system. These are nonstructural practices that include public education and outreach campaigns, watershed management plans, good housekeeping including proper storage of chemicals and trash, street sweeping, and catch basin cleaning. Catch basin cleaning in the fall may reduce ice blockage from forming due to standing water in the system and prevent sediment-laden water discharges during steam thawing. Stormwater Treatment BMPs are designed to control the rate and volume of stormwater runoff, release of pollutants to receiving waters, and/or remove pollutants once they are incorporated into the stormwater runoff. These structural BMPs include detention ponds, grassed swales, constructed wetlands, infiltration basins or dry wells, and catch basin inserts. These all have the primary function of reducing downstream peak storm runoff and subsequently provide pollutant control. Controlling the rate of stormwater runoff to receiving waters from developed lands will also mitigate potential downstream impacts of channel scour and sedimentation.

The combination of source control and stormwater treatment BMPs that is effective for a particular community is a function of numerous factors, such as the size and urbanization of the community, climate, economic activities, and potential contaminants. A BMP that functions well in one community under a particular set of circumstances (temperature, flow, variation in the concentration of potential contaminants, etc.) may not necessarily function in another community or under different circumstances. Therefore, methodologies must be developed to identify which BMPs are appropriate for the community and under what conditions. This identification is referred to as the BMP effectiveness. The effectiveness should be evaluated for existing BMPs and other BMPs that might be used in the Fairbanks area.

2.2 Measurement of BMP Effectiveness

BMP effectiveness can be determined either by quantifying or qualifying BMP performance and efficiency. The first step in quantifying BMP effectiveness is to clearly identify the goals the BMP is designed to accomplish. For example, is the objective to reduce downstream impacts associated with peak flows or control sediment at the source before it enters the water body? A measure of how well the BMP achieves the goals it was designed to accomplish will determine its performance.

The next step in assessing BMP effectiveness is to identify the pollutants of concern and determine the maximum allowable effluent concentrations or volume reduction of stormwater required. A measure of how well the BMP removes or controls pollutants of concern will determine efficiency. Monitoring BMP performance and efficiency data will allow for the calculation of effectiveness.

Measurement methods used to evaluate BMP performance differ between the two main groups of BMPs. Stormwater treatment BMPs (structural) are amenable to direct measurement of inflow and outflow variables, permitting a comparison of measured values to performance goals of the BMP. For example, measuring the amount and pollutant concentrations of the inflow and comparing the results to a similar set of measurements taken at the BMP outlet can evaluate the performance of a dry detention pond, where the goal is to reduce pollutants in the outflow as compared to the inflow

Source control BMPs (nonstructural) is generally not amenable to direct measurement, and therefore must be evaluated qualitatively. Street sweeping is a common source control BMP. Determining the effectiveness of street sweeping by evaluating performance and efficiency in reducing pollutant loads in runoff can be done in several ways, none of which is as simple as the approach described above for the dry detention pond. One method to evaluate street sweeping is to measure the amount of pollutants collected within the sweeper. Unfortunately, the amount of material collected in the sweeper does not correlate directly with a reduction in the amount of pollutant delivered to receiving waters, as not all of the pollutants present on a street will be carried off by runoff. Another approach to evaluating street sweeping is to conduct wash-off measurements before and after street sweeping. A wash-off measurement consists of artificially watering a paved surface and collecting and analyzing the resulting runoff. This approach provides a direct measurement of the impact of street sweeping on runoff, but uses artificial irrigation, which may not simulate natural precipitation or pollutant transport processes. A third approach is to study two or more watersheds, some with street sweeping and some without. This approach is susceptible to random differences in the amount and types of pollutants that are present in developed watersheds. Thus, it is often difficult to evaluate the effectiveness of stormwater BMPs in ways that support the comparison of results between several BMPs.

Even with BMPs that lend themselves to evaluation of pollutant removal rates, the measurements are often highly variable, requiring repeated measurements to produce a reliable estimate of typical performance. Most BMP performance measurements are designed to examine pollutant removal rates in full-scale BMPs in realistic field conditions. This approach ensures that the data collected will be indicative of actual pollutants, precipitation patterns, and other environmental variables that may be impossible to replicate. However, field studies of BMPs typically yield pollutant loadings and removal rates that vary widely between runoff events. This variability requires that repeated measurements be made in order to obtain reliable average results. Therefore BMP field trials are costly and time consuming. In a climate with short summers and limited rainfall, such as Fairbanks, a BMP study may take several years to generate acceptable results.

One option that might reduce the quantity of data required for the calculation of effectiveness is to evaluate if the effluent from a BMP or BMP system is statistically below the regulatory limit. This analysis would be consistent with an effectiveness goal of meeting regulatory requirements. However, it does not address if the influent was also below the regulatory limit, and whether the BMP or BMP system was actually providing any benefit. As such, we do not recommend this analysis.

EPA guidance (2002) recommends that an effluent probability method be used to quantify BMP effectiveness for studies where water quality data are used to determine BMP effectiveness. This method provides a statistical view of effluent and influent quality that leads to defensible results. Two analysis methods, the efficiency ratio (ER) and summation of loads (SOL), have been used to analyze BMP efficiency. These methods are not recommended as stand-alone analysis tools, but may be used to provide a preliminary simple analysis of what is happening in the BMP system. In both these cases the EPA (2002) recommends conducting nonparametric (or parametric, if applicable) statistical testing to identify if differences in the influent and effluent concentrations are statistically significant.

3.0 LITERATURE SEARCH AND DATA REVIEW

3.1 Scientific Literature

Several library search engines were used to identify research documents that may be applicable to this investigation. These searches included the Environmental Protection Agency (EPA) National Library Catalog, the American Society of Civil Engineers (ASCE) Civil Engineering Database (CEDB), and the Transportation Research Information Service (TRIS). These searches have yielded over 300 hits using the keyword terms “Best Management Practice” or “BMP.” However, if the term “cold” is added to the search, only three relevant hits are reported, indicating a general lack of available research regarding BMP effectiveness in cold regions or cold climates.

In addition to these online databases, we have used the web search engines clusty.com, firstgov.com, and mooter.com. Finally, we used the dialog.com search engine that searches the following databases: EI Compendex (1970-2005), Inside Conferences (1993-2005), NTIS (1964-2005), SciSearch – a cited reference science database (1974-1989), GEOBASE (1980-2005), and Enviroline (1975-2005). Using the Dialog database search, 4,126 articles were identified that were associated with the key words of either “BMP” or “Best Management Practice.” After the keywords of “storm water” or “stormwater” were added to the search, the total was reduced to 517 unique items. For initial screening this dataset was further reduced to 466 by eliminating works that were associated with Florida, southeastern United States, or California. Selecting articles that included Canada, Alaska, Minnesota, Michigan, or Sweden, limited the search to 19 hits. These articles among others were reviewed for their applicability to this effectiveness study and cited in the reference section as appropriate.

Published works continue to be reviewed for applicability for the report and for the individual effectiveness monitoring plans.

3.2 ADEC Data Search

The Anchorage ADEC maintains a record of engineering plans that have been submitted for review and approval prior to constructing, altering, modifying, or operating a nondomestic wastewater system (including stormwater) in Alaska. On September 14 and 15, 2005, Jessa Tibbetts, an Environmental Scientist with our Anchorage Office, reviewed plans the ADEC has on record for construction projects in the Fairbanks North Star Borough. A summary of her findings is tabulated below. Twenty plans were reviewed, which included descriptions for 152 BMPs. However, most of the BMPs were associated with the construction of the project, and data on post-construction BMPs were more limited. The following tables summarize the type and category of BMPs identified in our record review based on categories used to organize the studies listed in the International Stormwater BMP Database.

TABLE 2A
FAIRBANKS AREA BMP SUMMARY BY TYPE

BMP Type	Number of BMPs
Total Structural	121
Total Nonstructural	31
Total BMPs	152

TABLE 2B
FAIRBANKS AREA BMP SUMMARY BY CATEGORY

BMP Category	Occurrence of BMPs
Biofilter	26
Detention Basin	11
Hydrodynamic Device	0
Infiltration Basin	17
Maintenance Practice	65
Media Filter	30
Percolation Trench/Well	0
Porous Pavement	0
Retention Pond	1
Wetland Basin	0
Wetland Channel	0
Other	2

For purposes of this document, and being consistent with EPA documentation (EPA, 1999), descriptions of the BMPs listed in Table 2B are summarized below.

Biofilter - Vegetated systems such as swales and filter strips designed to convey and treat either shallow flow (swales) or sheet flow (filter strips) runoff designed to mimic the functions of a natural ecosystem for treating runoff.

***Detention Basin* -** Captures a volume of runoff and temporarily retains that volume for subsequent controlled release. Detention systems do not retain a significant permanent pool of water between runoff events.

***Hydrodynamic Device* -** A “drop-in” system that can incorporate some combination of filtration media, sediment removal, or oil and grease removal.

***Infiltration Basin* -** Captures a volume of runoff and infiltrates it into the ground over a period of days.

***Maintenance Practice* -** Maintenance programs are necessary in order to reduce the pollutant contribution from the urban landscape and to allow the collection and treatment systems to operate as designed, which include catch-basin cleaning and street and parking lot sweeping.

***Media Filter* -** Use some combination of granular filtration media such as sand, soil, organic material, carbon, or a membrane to remove constituents found in runoff.

***Percolation Trench/Well* –** Gravel-filled trench or well designed to infiltrate stormwater into the ground.

***Porous Pavement* -** An infiltration system where runoff is infiltrated into the ground through a semi-permeable layer of pavement or other stabilized permeable surface.

***Retention Pond* -** Captures volume of runoff and retains that volume until it is displaced in part or in total by the next runoff event. Retention systems maintain a significant permanent pool volume of water between runoff events.

***Wetland Basin* -** Similar to retention and detention systems, except a major portion of the BMP water surface area (basin) contains wetland vegetation and may be designed with or without open water.

***Wetland Channel* -** Similar to retention and detention systems, except a major portion of the BMP water surface area (channel) contains wetland vegetation designed to convey runoff very slowly.

3.3 EPA Class V Injection Well Registration

One structural BMP that meets the definition of an EPA Class V injection well observed being used in Fairbanks area projects includes an infiltration gallery, vertical French drains, or dry well. Underground injection wells are defined as any bored, drilled, or driven shaft, a hole deeper than its widest dimension, an improved sinkhole, or a subsurface fluid distribution system (EPA, 2003). These do not include surface systems that allow for infiltration, such as infiltration trenches or surface impoundments and ditches.

Under federal requirements, stormwater drainage wells, characterized as Class 5 wells by 40 CFR 146.5(e)(4), are "authorized by rule" rather than requiring a specific permit. The Underground Injection Control (UIC) program regulations requires owners or operators to submit injection well inventory information to the EPA; construct, operate, and close the well in a manner that does not potentially damage the groundwater aquifer; and comply with additional prohibitions or requirements of the ADEC or the EPA.

Several states have developed and maintained State UIC programs. Seventeen states have adopted "authorized by rule" regulations (EPA, 2005). These include wells in Wisconsin that are constructed prior to 1994 and are less than 10 feet deep, and wells in Idaho that are less than 18 feet deep. Eleven states maintain an individual permit/registration system for stormwater drainage wells. This group includes wells in Idaho that are greater than 18 feet deep. Four states (North Carolina, Georgia, and Wisconsin, if constructed since 1994 or are greater than 10 feet deep, and Minnesota, if the well reaches groundwater) ban the use of stormwater drainage wells. Alaska is one of the remaining states that does not have a Class V UIC program.

According to the EPA, there are approximately 71,000, documented, stormwater drainage wells and 248,000 stormwater drainage wells estimated to exist in the United States (EPA, 2005). Of the registered wells, approximately 81 percent are located in the western/mountain states of Arizona, California, Washington, Oregon, Idaho, Montana, and Utah. Fifteen percent of the total are in Ohio, Florida, Michigan, Maryland, and Hawaii.

In August 2005 we contacted Thor Cutler and Peter Magolske of the EPA's Region 10 Underground Injection Control (UIC) program regarding the use of Class V Injection wells as a stormwater BMP in the Fairbanks area. Although Mr. Magolske did not want to release details regarding the specific Class V injection wells used for stormwater in the Fairbanks area, he stated that there were records for two wells. It is our opinion that this underestimates the number of Class V stormwater wells in the Fairbanks area.

If designed correctly, stormwater drainage wells may be appropriate for use in the Fairbanks area. These systems are considered to be wastewater disposal systems and need to be treated accordingly. Specific design standards have not been developed by the EPA or ADEC, although the ADEC does require (18 AAC 72.600) that engineering documents be submitted to them for approval prior to construction. This review considers items as anticipated water quality, amount of suspended solids, groundwater and soil conditions, as well as other factors; but it generally leaves flexibility to the design engineer. A professional engineer must stamp the documents that are submitted.

Direct injection of stormwater may lead to degradation and contamination of the local aquifer. The relatively high (typically less than 15 feet) groundwater table may not allow for proper treatment of the water, particularly if the base of the infiltration system is in or near the water table.

In addition to regulatory and environmental considerations, the use of infiltration galleries may be of limited use in the spring, as cold temperatures settling into the system inlets during winter may result in freezing the soils near the infiltration system. The freezing of the soil may result in the system becoming ineffective during spring rains and breakup.

3.4 International Stormwater BMP Database

We reviewed the contents of the International Stormwater BMP Database for BMP studies in the Fairbanks area and in Alaska. The database project, which began in 1996 under a cooperative agreement between the ASCE and the EPA, now has support and funding from a broad coalition of partners, including the Water Environment Research Foundation, ASCE Environmental and Water Resources Institute, EPA, Federal Highway Administration, and the American Public Works Association. Wright Water Engineers, Inc., and GeoSyntec Consultants are the entities maintaining and operating the database clearinghouse.

We have reviewed the summary records for the database (Appendix A) and identified the following contents of the system. Please note that some of the studies involve BMPs that fit into multiple categories, and some duplicity of information may be present. The subtotals and totals on the following table do not include duplicity. For example, 28 street-sweeping BMP studies were reported for street cleaning. Of these 28, twelve BMP studies also addressed catch-basin cleaning. However, the total number of nonstructural BMPs evaluated in the database was 28. Summaries of the data contained in the International Stormwater Database are organized by BMP Category and presented in Appendix A.

TABLE 3
BMP OCCURANCES IN THE INTERNATIONAL DATABASE

Structural BMP Category	BMP Effectiveness Studies	Nonstructural BMP Category	BMP Effectiveness Studies
Biofilter – Grass Strip	6	Catch Basin Cleaning	12
Biofilter – Grass Swale	26	Street Cleaning	28
Biofilter – Wetland Vegetative Swale	2		
Detention Pond – Dry, Empties After Storm	22		
Detention Pond – Dry, Lined	6		
Detention Pond – Underground Vault or Tank	3		
Filter – Combination Media or Layered Media	6		
Filter – Other Media	8		
Filter – Peat Mixed with Sand	5		
Filter – Sand	11		
Filter – Geotechnical Fabric, Vertical	6		
Hydrodynamic Devices	14		
Infiltration (Percolation)	1		
Oil – Water Separators	5		
Porous Pavement	2		
Porous Pavement – Poured Concrete	1		
Porous Pavement – Modular Concrete Block	2		
Retention Pond – Wet	42		
Wetland – Basin with Open Water Surfaces	16		
Wetland – Channel With Wetland Bottom	20		
Wetland – Basin Without Open Water – Wetland Meadow	2		
Total Structural BMP Studies	**176**	**Total Nonstructural BMP Studies**	**28**
Total BMP Effectiveness Studies			**204**

No BMP studies are identified in the International Stormwater Database for the Fairbanks area or Alaska. Limited data are available in semiarid, cold, continental climates. A retention pond study in Ontario contains limited information. BMP studies conducted in cold, continental states consist of seven studies conducted in Minnesota. Four of these studies involved wet, permanent retention ponds, and the remaining three studies were conducted on channels with wetland bottoms. The summaries generated by the database may be useful as reference for BMP performance background information, but care must be taken if using the information for decision-making when considering BMP performance in arctic or subarctic conditions. Table 4 summarizes the locations of the studies included in the database.

TABLE 4
LOCATIONS OF BMP EFFECTIVENESS STUDIES
IN THE INTERNATIONAL DATABASE

Study Locations	BMP Effectiveness Studies
Alaska	0
Canada, Russia, Sweden, Norway, Finland, Ukraine	1
Cold, Continental U.S. (MT, ND, SD, MN, WY, UT, ID)	7
Cold U.S. (WI, MI, NY, VT, NH, ME, CO)	19
Temperate Continental U.S. (NE, IA, MO, KS, IL, IN, KY, OH, TN, WV, PA)	6
Warm Continental U.S. (TX, AZ, NM, NV, OK, AR)	19
Temperate Coastal U.S. (WA, OR, MA, RI, CT, DE, MD, VA, NJ)	59
Warm Coastal U.S. (CA, GA, FL, AL, MI, LA, HI, NC, SC)	86

4.0 DISCUSSSION

4.1 Stormwater Characteristics and Regulatory Compliance

BMPs are often selected to achieve goals that will meet regulatory requirements for stormwater. Regulatory requirements are often molded by characteristics specific to the local stormwater conditions. Characteristics of stormwater unique to Fairbanks are largely defined by the long and uniformly cold winters. As presented in Section 1.5, snow accumulates in September and October and does not typically melt until the following April or May; therefore, breakup is one of the dominant runoff events in Fairbanks and occurs at a time when many structural BMPs are not functioning properly because they remain partially frozen. During the summer months, however, stormwater characteristics are expected to be similar to those in temperate climates.

Regulatory compliance requirements for stormwater in Fairbanks influence selection of BMPs to achieve goals that will meet or exceed these regulatory requirements. Table 5 summarizes regulatory compliance standards applicable to stormwater in Fairbanks.

TABLE 5
REGULATORY REQUIREMENTS APPLICABLE TO STORMWATER IN FAIRBANKS

Regulation	Identifies Water Quality Standards	Identifies Permit Process	Monitoring may be Required for Compliance
ADEC 18 AAC 70 – Water Quality Standards	✓		✓
Alaska Water Quality Manual for Toxic and other Deleterious Organic and Inorganic Substances	✓		✓
TMDL – Total Maximum Daily Load			
Chena River	✓		✓
Chena Slough	✓		✓
Noyes Slough	✓		✓
NPDES – National Pollution Discharge Elimination System 40 CFR 122		✓	
Local ordinances and regulation	(under development)		
ADEC 18 AAC 72 – Waste Water Disposal	✓	✓	✓

There have been a few studies conducted on stormwater in the Fairbanks area. In 1994 the City of Fairbanks conducted a study on runoff from a snow dump near the Carlson Center (Martin, 1994). In 2002, Gould, Barnes, and Carlson conducted stormwater sampling at several locations in Fairbanks for selected metals and oil and grease. Table 6 summarizes the compounds that were detected in their studies. The potential regulatory standard values were taken from Tables I and V of *Alaska Water Quality Criteria Manual For Toxic and Other Deleterious Organic and Inorganic Substances* (2003). If the substance is listed in reference and a federal maximum contaminant level exists, it is presented. If the compound is not present in either document, no potential regulator standard is presented.

TABLE 6
DETECTED COMPOUNDS IN STORMWATER RUNOFF IN FAIRBANKS

Compound	Potential Regulatory Standard (µg/L)	Detected Concentration (µg/L)	
		Martin Snow Dump Study	Gould Stormwater Study
Arsenic*	10	7	<4 – 13
Barium	2000	100	—
Beryllium	4	0.4	—
Cadmium	5	0.1	<0.6 – 0.8
Chromium	100	3	<2 – 12
Copper	—	—	<0.9 – 1140
Iron	—	—	780 – 10,100
Lead	15	—	<4 – 110
Zinc	—	—	<40 – 4610
Nitrate-N	10,000	60	—
Oil and Grease	—	—	<2220 – 37,700
Benzene	5	0.44	—
Ethylbenzene	3100	0.22	—
Naphthalene	—	0.87/0.18	—
Toluene	6800	0.66	—
1,1,1-Trichloroethane	200	0.22	—
1,2,4-Trimethylbenzene	260	1.1	—
1,3,5-Trimethylbenzene	—	0.32	—
m,p-xylene	Total 10,000	0.87	—
o-xylene	Total 10,000	0.54	—
Phenol	—	0.74	—
Benzyl alcohol	—	1.55	—
2-Methylphenol	—	0.34	—
4-Methylphenol	—	1.14	—
2,4-Dimethylphenol	—	0.42	—
Benzoic acid	—	36.5	—
2-Methylnaphthalene	—	0.39	—
4-Nitrophenol	—	1.52	—
Dibenzofuran	—	0.13	—
Fluorine	—	0.26	—
Phenanthrene	—	1.54	—

Compound	Potential Regulatory Standard (µg/L)	Detected Concentration (µg/L)	
		Martin Snow Dump Study	Gould Stormwater Study
Di-N-Butylphthalate	2700	0.86	—
Flouroanthene	300	0.71	—
Butylbenzylphthalate	—	0.40	—
Benzo(a)anthracene	—	0.40	—
Bis(2-Ethylhexyl)phthalate	—	6.92	—
Chrysene	—	0.86	—
Di-N-octylphthalate	—	0.48	—

(—) Not Sampled, or no identified potential regulatory standard at this time
*Arsenic potential regulatory standard is federal drinking water standards effective January 23, 2006.

In general, the concentrations of the compounds in the samples were well below the potential regulatory standard. We anticipate that many of the identified compounds in the table above will be primarily present in the spring runoff resulting from snowmelt. In the summer and fall the primary runoff constituent of concern will likely be sediment from exposed surface soils. These exposed surface soils may be the result of construction or other activity. Additional toxicological consideration may be given to contaminants that are adhering to the sediment.

4.2 Preliminary Goals for BMPs in Fairbanks

Establishing priorities for BMP goals are a vital part of the equation when attempting to determine BMP effectiveness. Identifying BMP goals specific to the stormwater cycles of Fairbanks is being accomplished by reviewing engineering plans submitted for review and approval at the ADEC, ADOT&PF, and by surveying design professionals and interested parties. The engineering plans on file at the ADEC provide descriptions of BMPs and their proposed use for construction projects. The ADOT&PF maintains BMP guidance manuals, and they review construction contracts to assure that stormwater protection is adequately addressed, and allow each respondent to comment on commonly used BMPs and rank the five most important potential goals.

The EPA guidance (2002) provides descriptions of common BMPs and their purpose and goals. This guidance is being used as the platform for generating a preliminary list of goals for BMPs in

Fairbanks. The results of our file review and survey will mold this information provided by EPA (2002) to generate a list of goals specific to Fairbanks.

Table 7, which was generated from EPA guidance (2002), provides our platform for identification of preliminary goals for BMPs used in Fairbanks.

TABLE 7
POTENTIAL GOALS FOR BMPS IN FAIRBANKS

BMP Purpose	BMP Goal
Hydraulics	Improve flow characteristics upstream and/or downstream of BMP
Hydrology	Mitigate floods; improve runoff characteristics (peak shaving)
Water Quality	Reduce downstream pollutant loads and concentrations of pollutants
	Improve/minimize downstream temperature impact
	Achieve desired pollutant concentration at outfall
	Remove litter and debris
Toxicology	Reduce acute toxicity of runoff
	Reduce chronic toxicity of runoff
Regulatory	Comply with NPDES permit
	Meet federal, state, or federal water quality criteria
Implementation Feasibility	For nonstructural BMPs, function within management and oversight structure
Cost	Provide capital, operation, and maintenance costs
Aesthetic	Improve appearance of site
Maintenance	Operate within maintenance and repair schedules and requirements
	Ability of system to be retrofit, modified or expanded
Longevity	Long-term functionality
Resources	Improve downstream aquatic environment/ erosion control
	Improve wildlife habitat

In order to evaluate potential goals of interest to Fairbanks, we prepared a brief survey that we submitted to the owners and operators of the municipal stormwater systems. This survey was submitted to the municipal representative and their citizen representative on the Fairbanks co-permittees, stormwater management committee, the personnel working with the NPDES stormwater program with the Fairbanks North Star Borough, and the stormwater manager for Fort Wainwright Public Works. To date, approximately a third of the responses have been received (although it should be noted that the submission to the members of the co-permittees stormwater management group was relatively recent). The responses that have been returned to date are included in Appendix B of this report.

In order to evaluate the surveys, we assigned the highest ranking goal a score of five points, the second highest ranking goal four points, the third highest ranking goal three points, and so on. Two of the responses were filled out on a relative scale and are suitable for scoring. Another response presents goals that the owner identified as important. Table 8 presents a summary of the ranking of the importance of the goals.

TABLE 8
RELATIVE IMPORTANCE OF OWNER SURVEY GOALS

Total Points	Type of Goal	BMP Goal
15	Regulatory	Compliance with NPDES Permit
9	Water Quality	Reduce downstream pollutant loads and concentrations of pollutants
8	Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts
5	Cost	Capital, operation, and maintenance costs
5	Safety, risk, and liability	Function without significant risk or liability
2	Maintenance	Operate within maintenance and repair schedules and requirements
1	Longevity	Long-term functionality

The most important goal for a BMP identified in the survey was regulatory, specifically to meet the requirements of the NPDES permit. This goal is an administrative goal for which a standard for effectiveness cannot be measured, but rather implies that a BMP works as long the requirements of the permit are met.

The reduction of downstream pollutant loads and concentrations of pollutants was the second highest rated goal in the survey to date. This goal is one of the common ways that structural BMP effectiveness can be measured. The BMP effectiveness is based on a statistical approach that compares whether the effluent coming out of the BMP is statistically cleaner that the influent. This goal to reduce downstream pollutant loads and concentrations of pollutants will be one of the primary areas of focus for the development of monitoring plans that can be used to determine BMP effectiveness in Fairbanks.

Public perception, although potentially quantifiable through the use of surveys, is another goal for which measuring the effectiveness of a potential BMP is difficult and of limited value. Effectiveness could be potentially measured by conducting pre- and post-event surveys within a group involved in BMP activity. However, the significance of the survey may be more of a function of the survey composition and dynamics rather than a measurement of the public perception of a BMP.

The effectiveness of a BMP in terms of costs, functioning in a manner to reduce liability and maintenance requirements, is generally not related specifically to water quality, but water quality should be incorporated into a comparison between different BMPs to ensure that a relative comparison is made on an equitable basis. A specific structural BMP may cost significantly less than an alternative BMP. However, if the alternative BMP has a significantly higher removal efficiency of a particular compound of interest than the initial BMP, a straight cost comparison may not be an effective way to quantify cost.

Finally, the longevity of a BMP can be monitored to evaluate if the performance of the BMP decreases with time. For example, a critical value may be determined for a BMP effluent parameter such that the BMP will not be considered to be functioning if the parameter falls below (or rises above) this critical value. A longevity comparison could be made between the period of time that it takes the BMP to reach this critical value. Longevity is often tied to maintenance of the BMP. Debo and Reese (2003) state that the longevity of some BMPs is limited to such a degree that their use is encouraged only under certain circumstances. “Of particular concern are the infiltration practices, such as basins, trenches, and porous pavement…Very often, the lifespans of BMPs can be increased to acceptable lengths if local communities adopt enhanced designs and commit to strong maintenance and inspection programs.”

We propose to develop effectiveness testing methodologies based primarily on the goals of improving water quality; that is, the effluent (or downstream water quality) is statistically cleaner than the influent (or upstream water quality). Whether this improvement in the water quality results in the BMP being effective from the regulatory or other criteria can then be evaluated. Structural BMPs that are not effective in improving water quality will be considered ineffective overall, even if the effluent is less than regulatory levels. Nonstructural BMPs may be evaluated using a basis (or goal) that is not directly related to water quality.

4.3 Preliminary Discussion of BMPs Suitable for Fairbanks

For a structural BMP to be considered suitable in Fairbanks, we propose the following criteria:

- The BMP is able to perform in freezing and/or snowy conditions.
- The BMP is effective in controlling downstream transported silt-sized sediment (generally 0.05 to 0.002 mm in diameter) as well as sand and gravel.
- The BMP is not anticipated to release toxic compounds at concentrations above regulatory limits.
- The BMP is effective at low to medium flows (less than 3 cubic feet per second).
- The BMP is not anticipated to require high levels of maintenance

The following presents a preliminary list of structural BMPs that may be effective in Fairbanks.

- Dry, extended detention pond
- Vegetated strips
- Vegetated swales
- Infiltration trenches
- Infiltration basins

Several other structural BMPs are anticipated to be effective in treating stormwater in the summer and fall after the systems are thawed. As previously stated, the primary goal of stormwater BMPs that function during the summer and fall months would be to improve water quality by removing sediment. Some of the structural BMPs that may be suitable for use in the summer and fall, but are not anticipated to be fully effective in the spring are listed below.

- Hydrodynamic devices
- Infiltration drain fields
- Sand filters
- Stormwater wetlands
- Water quality inlets
- French drains
- Dry wells or roof downspout systems
- Oil/grit separators

Several BMPs will likely operate at reduced efficiency during the initial spring break-up event. For example, it is unknown if hydrodynamic devices will function if they are coated with ice.

Snow, snowdrifts, and dead vegetation may impact the effectiveness of vegetated swales and vegetated barriers.

Maintenance and good housekeeping BMPs that may be effective in the Fairbanks area include the following.

- Catch basin cleaning
- Street sweeping
- Buffer zones
- Infrastructure planning
- Urban forestry
- Pet waste collection
- Vehicle washing restrictions
- Illegal dumping control
- Landscaping and lawn care

4.4 Preliminary Discussion of BMPs Not Suitable for Fairbanks

Several types of BMPs may not be suitable for use in Fairbanks due to freezing or freeze-thaw conditions, such as those in the following list.

- Porous pavements
- Wet ponds
- Sediment filters
- Green parking areas
- Alternative pavers

Note that subsurface storm sewers, such as those incorporated in Fairbanks and operated by the City of Fairbanks and Northern Region ADOT&PF, are not anticipated to be effective in the Fairbanks area. We have observed significant maintenance expense and manpower are spent in the spring attempting to thaw the inlets of the stormwater system. Although not practical in highly developed areas of downtown Fairbanks, consideration may be given to using surface swales to convey stormwater, similar to the stormwater system on Fort Wainwright and in south Fairbanks. This may include using median swales in areas of divided traffic, such as those on Airport Way.

4.4.1 Porous Pavements

Porous pavements allows stormwater to infiltrate through the asphalt and pavement section into the underlying soils and thus reducing the runoff from the ground surface. Research has shown that this technique is appropriate for areas where the temperature of stormwater runoff is a concern for fish habitat (EPA, 2000); the EPA guidance states that removal efficiencies of 82 to 95 percent for total suspended solids (TSS) has been observed in areas using porous pavements.

Although the EPA guidance (2000) suggests that porous pavements have been successfully used in Norway, our concerns regarding the use of porous pavements is the potential for freeze-thaw impacts, frost heave, and subgrade bearing reduction associated with the incorporation of freezing moisture in the pavement structure. It is not uncommon to receive significant precipitation in Fairbanks area just before the ground freezes. If the pavement is saturated during ground freezing, the expansion that occurs as water freezes may result in the surface concrete being damaged. In addition, water infiltrating through the pavement section may result in saturation or near-saturation of the subgrade. When these soils freeze they may exhibit differential movement due to frost heaving. This may particularly manifest itself near utilities (manholes, stormwater catch basins, etc.) where the use of nonfrost-susceptible backfill increases the differential movement. Finally, when these soils thaw in the spring, they may saturate or over saturate subgrade soils and result in increased pavement distress.

4.4.2 Wet Ponds

Wet ponds, also known as stormwater ponds, retention ponds, or wet extended-detention ponds, treat incoming stormwater using settling and algal or biological uptake. EPA (2000) identifies the ponds as being among the most cost-effective and widely used BMPs. Regular maintenance and inspection of the ponds are required, but major maintenance operations for a properly designed pond are generally limited to periodic sediment removal with a 5 to 50-year recurrence interval.

Many research studies have been conducted on wet ponds (EPA, 2000). These studies indicate that the removal efficiency of TSS for the ponds has been documented between 20 and 99 percent, with typical removal efficiencies of 65 to 95 percent. We anticipate the removal efficiency of oil and grease in vegetated ponds to be relatively high.

Wet ponds have two primary problems that we have identified as not efficient for Fairbanks. During the summer maintaining water in the pond to facilitate the biological activity may be difficult and require mechanical assistance. Unless the pond is below the groundwater table, it is likely that it will be dry for a significant portion of the year.

Another reason that wet ponds are not recommended is the potential for the ponds to serve as breeding areas for mosquitoes. Apperson, et al., sampled several stormwater retention facilities in North Carolina in 2004. They found mosquito larva and pupae in 34 percent of the structures sampled. However, a strong correlation was observed in the presence or absence of mosquito larva and pupae with the presence of mosquitofish in innovative ponds and wetland stormwater facilities. The correlation was not documented in standard retention facilities. The authors note that the 34 percent is significantly less than studies conducted in Florida and New Jersey, which found mosquito larva and pupae in 89 and 81 percent of wet retention structures. The likelihood that shallow, wet retention ponds constructed above the groundwater table would serve as mosquito breeding areas in the Fairbanks area is high.

It should be noted that discharging stormwater into existing gravel pits should not be considered a BMP. According to 40 CFR 122.2, “waters of the United States” includes intrastate lakes that are, or could be, used by interstate or foreign travelers for recreational or other purposes. A gravel pit would likely be classified as “waters of the United States” based on this definition; thus, the point where the stormwater discharges into the gravel pit would likely be considered a potential point of compliance. This would not allow the gravel pit to function as a BMP.

5.0 PRELIMINARY DISCUSSION OF BMPS SELECTED TO DEVELOP MONITORING PLANS

The selection of BMPs for the development of detailed monitoring plans is based on several factors, including whether the techniques have already been used in the Fairbanks area, the anticipated effectiveness of the BMP for potential contaminants of concern, and climatic conditions.

5.1 Nonstructural BMP

5.1.1 Street Sweeping

Several municipalities in the Fairbanks area conduct street sweeping. The type of street sweepers varies depending on the municipality. The ADOT&PF operates three, broom street sweepers with water-assisted dust control that physically pick up sediment/aggregate, and three single-broom cleaners used primarily for cleaning off surfaces. The City of Fairbanks and University of Alaska also operates street cleaning equipment.

Street-sweeping studies were conducted in Bellevue, Washington, in the early 1980s. Data were collected as part of this project to identify differences in runoff concentrations and yields caused by street cleaning operations (Burton and Pitt, 2002). The studies indicated that there was not a significant difference in runoff yields or concentrations during periods of intensive street cleaning versus times when no street cleaning was conducted. Burton and Pitt state this is because that intensive street cleaning only significantly reduces the larger particle sizes, which are not the particles typically mobilized during rain events. The study did note that for very small events, the impacts of street cleaning were increased.

Chocat, Barraud, and Alfakih (2001) identified recent studies that indicate that the use of newly developed sweepers can significantly reduce the pollutant input (particularly sediment and metals) into drainage systems. However, the effectiveness of the techniques in these tests was measured by the amount of material removed from the street surface. Mikkelsen, Viklander, Linde, and Malmqvist (2001) identify studies by German, 2001, that concluded that street sweeping with modern sweeping equipment can be an effective pollutant control measure, based on removed sediments and heavy metals in sediment.

However, even though material is removed from the pavement surface, others believe it has limited value as a treatment for improving stormwater quality. Chocat and other cite Balades and Petinicolas (2001) as confirming that sweeping performs poorly as a pollution control measure, but “remains indispensable in cities, because of its role in street cleaning. For pollution control, various BMPs are cheaper and provide better efficiencies.”

5.1.2 Catch-Basin Cleaning

Catch-basin cleaning is currently being conducted by the City of Fairbanks and the ADOT&PF on a periodic basis. The purpose of the cleaning is to remove sediment and other types of refuse and debris that may accumulate in the catch basin, primarily as a result of winter traction sanding.

Somewhat related to catch-basin cleaning is the use of extensions on the catch basins to trap sediment and debris. Except for very small flows, these extensions will primarily be effective in trapping gravel and sand; however, the usefulness of these extensions to trap fine sand and silt will be limited.

The studies in Bellevue, Washington (Burton and Pitt, 2002), also evaluated the impact of catch-basin cleaning. They reported that the rains preferentially removed the finer, more heavily polluted, and more available materials during the washout, and the sediments in the catch basins were mostly the largest particles that washed off the streets. Based on their studies, they found that semiannual street cleaning could be expected to decrease the lead and total solids in the runoff by between 10 and 25 percent. The chemical oxygen demand (COD), total Kjeldahl nitrogen, total phosphorus, and zinc were reduced between 5 and 10 percent with semiannual catch-basin cleaning.

Gould (2002) prepared a preliminary assessment of the use of a jet truck for cleaning catch basins in the Fairbanks area. However, the limited number and variability of the data did not allow for a statistical determination as to whether water quality improved as a result of the testing.

5.2 Structural BMP

5.2.1 Grass Strip Biofilter

Grassed filter strips are vegetated surfaces that treat stormwater flowing in sheet flow. The grass strips function by slowing runoff velocities, filtering sediment, and providing some infiltration (EPA, 2000). They are typically used near parking lots or other impervious structures to provide an initial treatment. For grass strips to be effective, water must flow in sheet flow. If concentrated flow occurs, the BMP becomes ineffective. As such, consideration should be given to curveless parking areas and other BMPs that tend not to concentrate flow.

Grass strips can be specified at the design permit level, once effective minimum distances and slopes are established. EPA guidance (2000) indicates that the minimum distance for a grass strip should be 25 feet.

In 2003 the California Transportation (CALTRANS) Division of Environmental Analysis conducted a study at several sites (generally slopes) along roadsides throughout the state. According to their research, a minimum vegetative cover of 65 percent is required for concentration reduction to occur; although, the report indicates that a rapid decline in performance was observed if the vegetation cover falls below 80 percent. Using a minimum section (based on their design criteria), they reported a drop in TSS concentration on the order of 77 to 97 percent at seven of eight test sites.

5.2.2 Grass Swale Biofilter

Vegetated or grass swales are extensively used in Fairbanks to convey and treat stormwater. Often these swales can also function as infiltration/evaporation trenches during low flow events. However, infiltration in the trenches is generally limited in the spring, when frozen soils with moderate to high moisture contents are relatively impermeable. Grass swales treat stormwater by filtering the water with vegetation and thawed, near-surface soils. Maintenance on grass swale is generally limited to maintenance of the vegetation in the swale and occasionally removing accumulated sediment.

Grass swales were selected for the development of an efficiency monitoring plan, due to their wide use in the Fairbanks area and their ability to convey flow without expensive thawing operations.

The EPA (2000) fact sheet for grass swales has identified several studies that present pollutant removal efficiencies. The removal efficiency for TSS generally ranges between 60 and 99 percent.

5.2.3 Hydrodynamic Devices

Hydrodynamic devices, also known as swirl separators, have been used throughout the nation in recent years (EPA, 2000). These devices are attached to the stormwater inlet. As water passes through this device, it begins to swirl, potentially freeing the sediment, oil, and grease from the water. According to EPA (2000), the hydrodynamic devices required frequent maintenance (catch-basin cleaning). Maintenance is generally involves cleaning the sediment chamber using a vacuum truck. The sediment removed from the device may require special disposal considerations.

According to one popular manufacturer (Stormceptor, whose products we understand have been installed in Fairbanks), the treatment chamber is always full of water (Stormceptor, 2000). During winter this chamber is likely to freeze, resulting in the BMP being ineffective until it can be thawed (either manually or naturally), and thus the effectiveness of the BMP will likely be limited during the initial spring breakup event. However, the BMP may be effective during the summer and fall months.

This BMP was selected for the development of a monitoring plan and effectiveness studies due to its use in the Fairbanks area.

Two studies of the removal efficiencies have been identified in the EPA (2000) fact sheet for hydrodynamic devices.   These studies indicate that the overall removal efficiency of TSS is about 21 to 52 percent.

Guo (2005) examined the removal efficiency of several hydrodynamic devices, including a Stormceptor device that is similar to the hydrodynamic devices that have been installed by the ADOT&PF. Using a sandy loam (d_{50} = 0.097 mm) at an influent suspended sediment concentration (SSC) of approximately 295 mg/L, removal efficiencies of 68 to 87 percent were observed over a range of flows ranging between 25 and 125 percent of the treatment flow rate. However, the study indicates that the removal efficiency is decreased as the amount of sediment in the lower chamber increases, creating a maintenance (catch-basin cleaning) consideration.

Nnadi, Al-Hamdan, and Romah (2005) conducted side-by-side testing of Baysaver, CDS, and Stormceptor hydrodynamic devices in Florida. In their studies, they identified load reduction efficiencies for total dissolved solids (TDS) and TSS ranging between -10 to 44 percent and 8 to 52 percent, respectively. These devices were found to be highly effective (generally greater than 65 percent) in the removal of sediment, leaves and twigs, and refuse.

5.2.4 Infiltration Basin Without Open Water

Various forms of detention and infiltration basins and channels have been identified in the literature. Detention basins are temporary stormwater storage and treatment areas that will eventually discharge the water on the surface, while infiltration basins functioning to reduce flow volumes by detaining stormwater runoff until it can either infiltrate or evaporate. We selected the infiltration basin without permanent open water based on the mosquito and climatic features discussed earlier. Infiltration basins have been incorporated into several of the recently constructed facilities in Fairbanks, including Home Depot, Wal-Mart, and other large retail stores in the Fairbanks area.

Infiltration basins may also serve as snow storage areas. However, as the snow melts in the spring, meltwater will likely be retained in the structure, as the underlying frozen soils will likely have a reduced permeability. EPA guidance (1996) suggests that infiltration basins must be located in soils with an infiltration rate greater than 0.5 inch per hour. In addition, water in the basin should infiltrate or evaporate within 72 hours of the storm event. This standard may be met in summer or fall, but it is unlikely to be met in the spring.

Infiltration basins have been found to have a high failure rate due to clogging. Failure rates of infiltration basins in the mid-Atlantic region range from 60 to 100 percent in the first 5 years (Schueler, et al., 1992). Preventive maintenance may include inspection, sediment removal, tilling, erosion control, and debris and litter removal. The frequency of the maintenance depends on whether the basin is vegetated, its capacity, sediment load, and other factors.

Since there is no anticipated discharge, the infiltration basins are considered efficient under normal operating conditions. Care must be taken so that there is enough separation from the basin bottom to the water table to allow for adequate treatment.

6.0 REFERENCES

Armstrong, R. and R.F. Carlson. 2002. Analysis of rainfall frequency data for Fairbanks, Alaska. *ASCE Proceedings of the Eleventh International Conference of Cold Regions Engineering,* Anchorage, Alaska. pp. 838-843.

Apperson, C.S., W.F. Hunt, S. Kennedy, B.A. Harrison, and W.G. Lord. 2005. Occurrence and relative abundance of mosquitoes in stormwater retention facilities in North Carolina. *ASCE Proceedings of the 2005 World Water and Environmental Resources Congress*, May 15-19. Anchorage, Alaska.

Balades, J.D. and F. Petitnicolas. 2001. Strategies of wet weather pollution control at source – a technical and financial approach. *Proceedings of the 4th international conference on innovative technologies in urban storm drainage*, June 25-26. Lyon, France.

Burton, G.A. and R.E. Pitt. 2002. *Stormwater effects handbook. A toolbox for watershed managers, scientists, and engineers*. Lewis Publishers, Washington D.C.

California Transportation Division of Environmental Analysis. 2003. *Final report, roadside vegetated treatment sites (RVTS) study*. CTSW-RT-03-028. November.

Chocat, B., S. Barraud, and E. Alfakih. 2001. Development of BMPs: Progress in France and Western Europe. *ASCE, Proceedings of the 2001 Engineering foundation conference on Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation*, August 19-24. Snowmass Village, Colorado.

Debo, T.N. and A.J. Reese. 2003. *Municipal stormwater management*. Second edition. Lewis Publishers, New York.

Environmental Protection Agency. 2005. *Class V UIC study fact sheet – storm water drainage wells.*

___. 2003. *When are storm water discharges regulated as Class V wells?* Fact sheet EPA 816-F-03-001.

___. 2002. *Urban Stormwater BMP Performance Monitoring.* EPA-821-B-02-001.

___. 2000. *National menu of best management practices (BMPs) for NPDES Stromwater Phase II.*

___. 1996. *Protecting natural wetlands. A guide to stormwater best management practices.* EPA-843-B-96-001. October.

Fairbanks North Star Borough. 2005. *Fairbanks community research quarterly*. Community Research Center, Fairbanks, Alaska, vol. 28, no. 3.

German, J. 2001. *Stormwater sediments, removal and characteristics*. Licentiate thesis, Department of Water Environment Transport, Chalmers University of Technology, Goteborg, Sweden.

Gould, S. 2002. *Preliminary analysis of stormwater quality parameters for the City of Fairbanks, Alaska.* Masters thesis prepared at the University of Alaska at Fairbanks.

Guo, Q. 2005. Development of adjustment and scaling factors for measured suspended solids removal performance of stormwater hydrodynamic treatment devices. *ASCE, Proceedings of the 2005 World Water and Environmental Resources Congress.* May 15-19. Anchorage, Alaska.

Martin, M. 1994. *Fairbanks snow dump contamination study*. Memorandum from D. Jacoby to M. Boyer, P. Cole, and B. Kleven. June 17.

Mikkelsen, P., M. Viklander, J. Linde, and M. Per-Arne. 2001. BMPs in urban stormwater management in Denmark and Sweden. *ASCE, Proceedings of the 2001 Engineering foundation conference on Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation*, August 19-24. Snowmass Village, Colorado.

Nnadi, F.N., A.Z. Al-Hamdan, and S.M. Romah. 2005. Side by side evaluation of stormwater proprietary BMPs. *ASCE, Proceedings of the 2005 World Water and Environmental Resources Congress*. May 15-19. Anchorage, Alaska.

Schueler, T.R., P.A. Kumble, and M.A. Heraty. 1992. *A current assessment of urban best management practices: techniques for reducing non-point source pollution in the coastal zone*. Prepared for the Metropolitan Washington Council of Governments, Washington DC.

Stormceptor. 2000. *Owner's Manual*.

APPENDIX A

Summary of the Data in the International Stormwater Database Organized by BMP Category

BMP Test Site Summary Information

Test Site Name 29 South Buffer Strip

BMP Name	29 S Buffer Strip	**Watershed Name**	U.S. Route 29 S Buffer
BMP Type	Biofilter - Grass Strip	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	0.81 ac
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	66		
Minimum Flow Volume	7.27		
Maximum Flow Volume	7.27		

Comments

This study monitored both a buffer strip and a swale. Monitoring results for the swale are entered into the Database under the BMP Test Site Name "29 South Swale." Results for the buffer strip are entered under the name "29 South Buffer Strip."

The 29 South Swale is located in the median of U.S. Route 29, south of Charlottesville, VA. The swale was constructed in the early 1970s. Lateral inflow barriers were installed at this swale site so that a mass balance could be performed between the inflow and outflow sampling points. However flow measurements showed an increase in flow from the inlet to the outlet, indicating that the barriers were not working properly. If flow is ignored, and only pollutant concentration is examined, the percent decrease in concentrations at this site were: 29%, -6%, -0.4%, and 11% for TSS, COD, TP and Zn, respectively. At least 7mm of rainfall was required to generate runoff into the swale at this site.

After monitoring eight storms at the swale, it was observed that pollutant concentrations in the runoff entering the swale were consistently lower than expected values determined from a literature review of edge of pavement studies. This suggested that significant pollutant removal was occurring before the stormwater reached the swale. Therefore, this project's focus was switched to examine the vegetated buffer strip through which the runoff from the roadway must flow before entering the swale. The following removal percentages were obtained for the buffer strip: TSS (63.9%), COD (59.3%), TP (21.2%), and ZN (87.6%).

Water quality values for this study are currently entered as discrete grab sample values. Data is available to calculate EMCs and can be obtained from the project team. Values may be flow-weighted and updated at a later time.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Altadena (strip)

BMP Name	Altadena Strip	**Watershed Name**	Altadena strip
BMP Type	Biofilter - Grass Strip	**Watershed Type**	Test
City	Altadena	**Total Watershed Area**	1.70 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	24	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	476		
Minimum Flow Volume	26.26 ac ft		
Maximum Flow Volume	468.35 ac ft		

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Carlsbad Biofiltration Strip

BMP Name	Carlsbad strip	**Watershed Name**	Carlsbad strip
BMP Type	Biofilter - Grass Strip	**Watershed Type**	Test
City	Carlsbad	**Total Watershed Area**	2.40 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	30	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	331		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	202.89 ac ft		

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-605/SR-91 Strip

BMP Name	605/91 strip	**Watershed Name**	605/91 strip
BMP Type	Biofilter - Grass Strip	**Watershed Type**	Test
City	Cerritos	**Total Watershed Area**	0.50 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	56		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	51.00 ac ft		

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name US 183 at MoPac

BMP Name US 183 at MoPac Grass Filter Strip

BMP Type Biofilter - Grass Strip

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 23

Number of Water Quality Records 1994

Minimum Flow Volume 13.75 ac ft

Maximum Flow Volume 551.54 ac ft

Watershed Name US 183 MoPac Grass Filt. Strip

Watershed Type Test

Total Watershed Area 3.21 ac

Watershed Area Disturbed 0.00 ac

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The study investigated the efficiency of vegetated buffer strips for removing 14 constituents in highway runoff in the Austin, TX area. Two different sites with different characteristics (e.g., vegetation, slope) were monitored for 34 and 36 storm events, respectively.

A pilot test was also performed to evaluate the efficiency of a constructed grass swale by modifying swale length, water depth and season. However, these data are not included in the database.

In general, the monitoring results demonstrate good to excellent (often greater than 75%) removal efficiency of suspended solids and metals, good (60-70%) removal efficiency of organics, moderate (25-60%) removal efficiency of nutrients, and poor (no removal) efficiency for removing bacteria. The two different buffer strips that were investigated had different vegetative composition and slope; however, removal efficiencies were comparable between the two sites.

This is a relatively comprehensive field study; however, some important data have been excluded (i.e., rainfall amount and flow rate). In addition, the pilot scale grassy swale investigation has some useful information on BMP performance. Although, there is no correlation of sample identifications for the monitoring data included in the appendix to the discussion in the text which makes the data unusable.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Walnut Creek

BMP Name	Walnut Creek Veg. Buffer Strip	**Watershed Name**	Walnut Creek Watershed
BMP Type	Biofilter - Grass Strip	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	25.85 ac
State/Country	TX /US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	22	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	2664		
Minimum Flow Volume	4.86 ac ft		
Maximum Flow Volume	1,377.63 ac ft		

Comments

The study investigated the efficiency of vegetated buffer strips for removing 14 constituents in highway runoff in the Austin, TX area. Two different sites with different characteristics (e.g., vegetation, slope) were monitored for 34 and 36 storm events.

A pilot test was also performed to evaluate the efficiency of a constructed grass swale, by modifying swale length, water depth and season. However, these data are not included in the database.

In general, the monitoring results demonstrate good to excellent (often greater than 75%) removal efficiency of suspended solids and metals, good (60-70%) removal efficiency of organics, moderate (25-60%) removal efficiency of nutrients, and poor (no removal) efficiency for removing bacteria. The two different buffer strips that were investigated had different vegetative composition and slope; however, removal efficiencies were comparable between the two sites.

This is a relatively comprehensive field study; however, some important data have been excluded (i.e., rainfall amount and flow rate). In addition, the pilot scale grassy swale investigation has some useful information on BMP performance. Although, there is no correlation of sample identifications for the monitoring data included in the appendix to the discussion in the text which makes the data unusable

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name 29 North Swale A

BMP Name 29 N Swale Sect 1

BMP Type Biofilter - Grass Swale

City Charlottesville

State/Country VA /US

BMP Installation Date

Number of Flow Records 24

Number of Water Quality Records 185

Minimum Flow Volume

Maximum Flow Volume

Watershed Name U.S. Route 29 N A

Watershed Type Test

Total Watershed Area 1.48 ac

Watershed Area Disturbed

Avg Annual Rainfall 38.26 Inches

Avg Annual Storm Duration 10.90 Hour(s)

Comments

This swale, located in the median of U.S. Route 29 south of the intersection with Hydraulic Rd, receives runoff from a heavily traveled urban highway. The swale was divided into four sections based on length and slope geometry. Sampling stations were located at four lengths starting 25 m from the edge of the asphalt at the intersection: 0 m, 33 m, 68 m, and 100 m. The following table gives the drainage areas and slopes for each swale sections:

STATION, DRAINAGE AREA, SLOPE
0 m, 0.05 ha, 0 m to 33 m: 3.2%
33 m, 0.11 ha, 33 m to 68 m: 3.8%
68 m, 0.19 ha, 68 m to 100 m: 6.5%
100 m, 0.25 ha

A study of the quality of stormwater runoff that immediately exits the highway was conducted at the intersection of U.S. 29 and Hydraulic Rd, immediately adjacent to the swale study site. Grab samples were taken from the discharge flume of a VDOT standard curb inlet located at the edge of pavement during the first 30 min of four storms. Care was taken to ensure that the water samples reflected only highway pavement runoff and that no other mixing occurred in the storm sewer system. Care was also taken to ensure that the runoff sampled did not come into contact with any part of the vegetated-lined channels. Lateral inflow into the swale was not blocked, therefore limiting the accuracy of flow and mass balance calculations.

This database entry ("29 North Swale A") describes Phase I of a two part study. In this first phase, the entire length (128 m) of the swale was examined. Phase II (entered into the database under the BMP Test Site Name "29 North Swale B") focused on the lower 30 m of the swale after lateral flow barriers were installed.

Water quality values for this study are currently entered as discrete grab sample values. Data is available to calculate EMCs and can be obtained from the project team. Values may be flow-weighted and updated at a later time.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

%

Test Site Name 29 North Swale B

BMP Name	29 N Swale B	**Watershed Name**	U.S. Route 29 N B
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	0.86 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	10	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	172		
Minimum Flow Volume	0.29 ac ft		
Maximum Flow Volume	45.68 ac ft		

Comments

This swale, constructed in the early 1970s, is located in a highway median at the intersection of U.S. Route 29 and Hydraulic Road. In Phase I of the study (entered into the database under the BMP Test Site Name "29 North Swale A"), the entire length (128 m) of the swale was examined. However, Phase II (described here under the name "29 North Swale B") focused on the lower 30 m of the swale. For Phase II, lateral barriers were installed to divert inflow from the sides of the swale away from the study area. 5 mm of rainfall were required to generate runoff into this swale. Removal efficiencies for the first two of the five monitored storms showed negative removal rates. These were caused by higher flows leaving the swale than entering the swale, indicating the barriers failed to stop flow from entering the swale laterally. Therefore, for the rest of the monitoring, a plastic liner was placed along the lateral barrier to improve its performance.

At this site, a significant amount of stormwater is ponded behind the downstream weir, creating a small detention area where pollutants are allowed to settle and runoff is allowed to infiltrate. Therefore, the weir functions as a berm or checkdam. Percent decrease in pollutant concentrations at this site were as follows: TSS (49%), COD (3%), TP (33%), and Zn (13%).

Water quality values for this study are currently entered as discrete grab sample values. Data is available to calculate EMCs and can be obtained from the project team. Values may be flow-weighted and updated at a later time.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name 29 South Swale

BMP Name	29 S Swale	**Watershed Name**	U.S. Route 29 S Swale
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	0.81 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	268		
Minimum Flow Volume	0.69 ac ft		
Maximum Flow Volume	62.48 ac ft		

Comments

This study monitored both a buffer strip and a swale. Monitoring results for the swale are entered into the Database under the BMP Test Site Name "29 South Swale." Results for the buffer strip are entered under the name "29 South Buffer Strip."

The 29 South Swale is located in the median of U.S. Route 29, south of Charlottesville, VA. The swale was constructed in the early 1970s. Lateral inflow barriers were installed at this swale site so that a mass balance could be performed between the inflow and outflow sampling points. However flow measurements showed an increase in flow from the inlet to the outlet, indicating that the barriers were not working properly. If flow is ignored, and only pollutant concentration is examined, the percent decrease in concentrations at this site were: 29%, -6%, -0.4%, and 11% for TSS, COD, TP and Zn, respectively. At least 7mm of rainfall was required to generate runoff into the swale at this site.

After monitoring eight storms at the swale, it was observed that pollutant concentrations in the runoff entering the swale were consistently lower than expected values determined from a literature review of edge of pavement studies. This suggested that significant pollutant removal was occurring before the stormwater reached the swale. Therefore, this project's focus was switched to examine the vegetated buffer strip through which the runoff from the roadway must flow before entering the swale. The following removal percentages were obtained for the buffer strip: TSS (63.9%), COD (59.3%), TP (21.2%), and ZN (87.6%).

Water quality values for this study are currently entered as discrete grab sample values. Data is available to calculate EMCs and can be obtained from the project team. Values may be flow-weighted and updated at a later time.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Alta Vista Planned Unit Development

BMP Name	Alta Vista Planned Development Detention w/ swales	**Watershed Name**	Alta Vista Det. Pond w/ Swales
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	4.00 ac
State/Country	TX / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	38	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	603		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	219.48 ac ft		

Comments

This report summarizes the precipitation, streamflow, and water quality data collected from September 1982 to September 1984 upstream and downstream from a grass-swale control in the Alta Vista Planned Unit Development, a multiple-family housing area in northwest Austin. The report also analyzes and presents the effects of this runoff control on streamflow and the quality of runoff water.

The Alta Vista Planned Unit Development covers less than 4 acres and is drained by grass channels along the east and west side of the basin. Rain gage, streamflow and water quality stations were established and operated at the principle points of inflow and outflow from the pond. Hydrologic analysis was not performed at this site due to the inaccuracies of discharge at the outflow station and variations in the ungaged drainage area with the size of the storm. Water quality data were analyzed by comparing the discharge-weighted, peak concentrations and loads of selected constituents computed at the inflow station with values computed at outflow stations.

Discharge-weighted concentration of total phosphorus were larger in the outflow than in the inflow for most of the storms analyzed. Discharge-weighted concentrations of dissolved solids, volatile dissolved solids, BOD, COD and TOC were larger in the outflow than in the inflow for majority of the storms analyzed. Discharge-weighted densities of fecal-streptococci bacteria were decreased between the inflow and outflow sites.

Discrete concentrations or densities of most constituents were not decreased. Peak concentrations of dissolved solids in the outflow exceeded peak concentrations in the inflow for all five of the storms analyzed with discrete samples. Peak concentration of TSS, NH3+organic N, NO2+NO3, total N, and dissolved iron were larger in the outflow than in the inflow for most of the storms. Load-removal efficiencies of water-quality constituents could not be determined because of inaccuracies in measuring discharge at the outflow site.

A quantitative hydrologic analysis of the effects of the swale could not be made due to the inability to calculate the outflow and the significant quantity of runoff from the ungaged drainage area.

Average Pollutant Removal Efficiencies *See notes at end of report.

LEAD, TOTAL (UG/L AS PB)		16 %
ZINC, TOTAL (UG/L AS ZN)		14 %
COD, .025N K2CR2O7	MG/L	-13 %
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L		-29 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)		19 %
BOD, 5 DAY, 20 DEG C	MG/L	-7 %
IRON, TOTAL (UG/L AS FE)		-10 %
CADMIUM, TOTAL (UG/L AS CD)		14 %
CARBON, TOTAL ORGANIC (MG/L AS C)		-24 %
PHOSPHORUS, TOTAL (MG/L AS P)		-84 %
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)		-11 %
NITROGEN, TOTAL (MG/L AS N)		-10 %
RESIDUE, TOTAL VOLATILE (MG/L)		-33 %

Test Site Name BES Bioswales - East Swale

BMP Name	Bioswale Native East	**Watershed Name**	City of Portland BES East Test
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Portland	**Total Watershed Area**	50.00 ac
State/Country	OR / US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	34.60 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	15.90 Hour(s)
Number of Water Quality Records	281		
Minimum Flow Volume	1.71 ac ft		
Maximum Flow Volume	18.16 ac ft		

Comments

The bioswale was constructed in conjunction with the Bureau of Environmental Services' (BES) WPCL facility during the spring of 1997. Due to multiple equipment and design problems with the original system, WCC and BES personnel reconfigured the system during December 1998. The swales were designed to fit in the limited area parallel to the eastern edge of the WPCL facility parking lot. Since the channel dimensions were fixed by the limited space, the design process was reversed to calculate the maximum flow rate given the fixed swale dimensions. The two parallel swales were constructed to be as similar as possible regarding design. The design flow rate of the swales is 0.118 cfs. Design parameters entered in the database are based on this flow rate not a 2-year storm event. Residence time 8.6 minutes for 0.118 cfs flow. Parameters for 0.04 cfs flow: residence time 12.8 minute, velocity 0.13 ft/s, flow depth 0.06 ft. Other general design parameters: width 1.5 feet, side slopes (H:V) 4:1.

In addition to the different vegetation, a significant difference between the two swales is that the west swale's non-native vegetation was routinely mowed and the native vegetation of the east swale has never been mowed. Mowing was terminated in the west swale during the fall of 1999. Thus, vegetation conditions during events 10/27/99, 02/16/99, and 04/19/99 ranged from 2 to 4 inches in the non-native (West) swale, while the vegetation height in the east swale ranged from about 12 to 60 inches. By the last event 06/10/00 vegetation height between the two swales was nearly the same, although the density of the vegetation in the native swale appeared greater.

Data Industrial non-magnetic flow sensors, for pressurized 1.5-inch diameter piping, are used at the swale inlets. These sensors use a paddle wheel that outputs a frequency directly related to the flow rate. A valve is installed at each inflow point to control the flow entering the swales. During events 02/99 to 10/99 the valves were adjusted so inflow rates to each swale were approximately 0.04 cubic feet per second (cfs). For events 02/00 to 06/00 the inflow rate was increased to 0.08 cfs to better simulate inflow volumes for swales of this size. Standard 0.8-foot Plasti-Fab HS-flumes equipped with an Instrumentation Northwest submersible pressure transducer mounted in the flume's stilling well measure outflow from each of the flumes.

Grab and time-paced composite water quality samples are collected at the west inflow the west outflow and the east outflow. Since the pumped stormwater is split by a tee immediately upstream of the two inflow locations, it is assumed that stormwater entering both swales is physically and chemically identical. Thus, only the west inflow is sampled with the assumption that the sample also represents the east inflow. Approximately 10 minutes after flow is observed at the swale inlets (to allow any stagnant water to be flushed from the piping), the inlet grab is collected at the west inlet by placing sample containers directly in the flow. Outflow grabs are collected at the flume exit channels as soon as outflow is observed.

Grab and composite duplicate samples are collected at the west inlet. Duplicate grabs are collected by lowering two bottles for each analyte into the flow at the same time. A composite duplicate sample is made in the laboratory by splitting the composite sample into two separate containers.

Grab samples are analyzed in the field for pH, specific conductance, and temperature using field analytical meters. Grab samples are submitted to the laboratory for Escherichia coli, fecal coliform bacteria, and oil and grease (total and nonpolar) analyses. The area is frequented by domestic animals and wildlife, and animal feces have been observed in the swales.

Composite samples are analyzed for chemical oxygen demand, hardness, nitrate-nitrogen, ortho-phosphate phosphorus, total dissolved solids, total Kjeldahl nitrogen, total phosphorus, total solids, total suspended solids, total and dissolved metals (cadmium, copper, lead, zinc) and particle size.

Three hours after flow begins through the second flume, the system is shut down by turning off the pump and removing the dam.

Event 6 was started in the middle of several days of light, scattered showers. During the hour preceding the start of the event (0900-1000 on June 10, 2000), 0.05 inches of rain fell, which filled the storm sewer enough so sampling activities could proceed.

During the event of 06/10/2000 rain intensity increased from 0.01 inches for the first hour of the event to 0.09 inches for the second hour of the event. Inflow was steady from 1008 to 1043 and then stopped due to lack of rain. Inflow started again at 1114 and then stopped at 1152 due to the pump becoming clogged with debris and shorting the electrical system. A total of 0.1 inches of rain was recorded during this two-hour event.

The average reduction in flow due to infiltration was 29%t for the West swale and 41% for the East swale over the six storm events from 02/99 to 06/22

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	BES Bioswales - West Swale

BMP Name	Bioswale Non-Native West	**Watershed Name**	City of Portland BES WestTest
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Portland	**Total Watershed Area**	50.00 ac
State/Country	OR /US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	34.60 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	15.90 Hour(s)
Number of Water Quality Records	282		
Minimum Flow Volume	2.17 ac ft		
Maximum Flow Volume	17.26 ac ft		

Comments

The bioswale was constructed in conjunction with the Bureau of Environmental Services' (BES) WPCL facility during the spring of 1997. Due to multiple equipment and design problems with the original system, WCC and BES personnel reconfigured the system during December 1998. The swales were designed to fit in the limited area parallel to the eastern edge of the WPCL facility parking lot. Since the channel dimensions were fixed by the limited space, the design process was reversed to calculate the maximum flow rate given the fixed swale dimensions. The two parallel swales were constructed to be as similar as possible regarding design. The design flow rate of the swales is 0.118 cfs. Design parameters entered in the database are based on this flow rate not a 2-year storm event. Residence time 8.6 minutes for 0.118 cfs flow. Parameters for 0.04 cfs flow: residence time 12.8 minute, velocity 0.13 ft/s, flow depth 0.06 ft. Other general design parameters: width 1.5 feet, side slopes (H:V) 4:1.

In addition to the different vegetation, a significant difference between the two swales is that the west swale's non-native vegetation was routinely mowed and the native vegetation of the east swale has never been mowed. Mowing was terminated in the west swale during the fall of 1999. Thus, vegetation conditions during events 10/27/99, 02/16/99, and 04/19/99 ranged from 2 to 4 inches in the non-native (West) swale, while the vegetation height in the east swale ranged from about 12 to 60 inches. By the last event 06/10/00 vegetation height between the two swales was nearly the same, although the density of the vegetation in the native swale appeared greater.

Data Industrial non-magnetic flow sensors, for pressurized 1.5-inch diameter piping, are used at the swale inlets. These sensors use a paddle wheel that outputs a frequency directly related to the flow rate. A valve is installed at each inflow point to control the flow entering the swales. During events 02/99 to 10/99 the valves were adjusted so inflow rates to each swale were approximately 0.04 cubic feet per second (cfs). For events 02/00 to 06/00 the inflow rate was increased to 0.08 cfs to better simulate inflow volumes for swales of this size. Standard 0.8-foot Plasti-Fab HS-flumes equipped with an Instrumentation Northwest submersible pressure transducer mounted in the flume's stilling well measure outflow from each of the flumes.

Grab and time-paced composite water quality samples are collected at the west inflow the west outflow and the east outflow. Since the pumped stormwater is split by a tee immediately upstream of the two inflow locations, it is assumed that stormwater entering both swales is physically and chemically identical. Thus, only the west inflow is sampled with the assumption that the sample also represents the east inflow. Approximately 10 minutes after flow is observed at the swale inlets (to allow any stagnant water to be flushed from the piping), the inlet grab is collected at the west inlet by placing sample containers directly in the flow. Outflow grabs are collected at the flume exit channels as soon as outflow is observed.

Grab and composite duplicate samples are collected at the west inlet. Duplicate grabs are collected by lowering two bottles for each analyte into the flow at the same time. A composite duplicate sample is made in the laboratory by splitting the composite sample into two separate containers.

Grab samples are analyzed in the field for pH, specific conductance, and temperature using field analytical meters. Grab samples are submitted to the laboratory for Escherichia coli, fecal coliform bacteria, and oil and grease (total and nonpolar) analyses. The area is frequented by domestic animals and wildlife, and animal feces have been observed in the swales.

Composite samples are analyzed for chemical oxygen demand, hardness, nitrate-nitrogen, ortho-phosphate phosphorus, total dissolved solids, total Kjeldahl nitrogen, total phosphorus, total solids, total suspended solids, total and dissolved metals (cadmium, copper, lead, zinc) and particle size.

Three hours after flow begins through the second flume, the system is shut down by turning off the pump and removing the dam.

Event 6 was started in the middle of several days of light, scattered showers. During the hour preceding the start of the event (0900-1000 on June 10, 2000), 0.05 inches of rain fell, which filled the storm sewer enough so sampling activities could proceed.

During the event of 06/10/2000 rain intensity increased from 0.01 inches for the first hour of the event to 0.09 inches for the second hour of the event. Inflow was steady from 1008 to 1043 and then stopped due to lack of rain. Inflow started again at 1114 and then stopped at 1152 due to the pump becoming clogged with debris and shorting the electrical system. A total of 0.1 inches of rain was recorded during this two-hour event.

The average reduction in flow due to infiltration was 29%t for the West swale and 41% for the East swale over the six storm events from 02/99 to 06/22

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Cerritos MS		
BMP Name	Cerritos	**Watershed Name**	Cerritos
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Cerritos	**Total Watershed Area**	0.40 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	19	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	310		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	246.60 ac ft		

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Dayton Swale

BMP Name	Dayton Biofilter - Grass Swale	**Watershed Name**	Dayton Biofilter - Grass Swale
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Seattle	**Total Watershed Area**	90.00 ac
State/Country	WA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	272		
Minimum Flow Volume	25.45 ac ft		
Maximum Flow Volume	1,041.20 ac ft		

Comments

The Dayton Avenue Swale Boifiltration Project was a three year water quality monitoring study designed to test seasonal variations in nutrient and contaminant uptake and measure pollutant removal for a grassy swale over time.

Located in northern Seattle WA, the swale was designed to treat the runoff from a 90 acre drainage basin, of which, 20% of the land area was impervious. The swale was parabolic in shape, 10 ft in total width by 570 ft in length. The bottom width was 5 feet and the design depth was 9 inches for a 2 year storm. H flumes were placed at each end of the swale and were equipped with Montedoro Whitney electronic flow meters and ISCO automatic samplers. Due to technical difficulties (ponding and low flows), the upstream H-flume was retrofit with a cutthroat flume which provided more representative data.

Total suspended solids (TSS), Fecal Coliforms, turbidity, nitrate nitrite (NO2+NO3), total phosphorous (TP), soluble reactive phosphorous (SRP), and biologically available phosphorous (BAP) were sampled for. In addition, the study looked at several total and soluble metals including: copper, lead, zinc, aluminum, cadmium, and iron.

Over the three year study period, 8 storms produced data that were useable for the project. The results showed that the swale achieved an average pollutant removal efficiency of: 67.8% for TSS, 44.1% for turbidity, 31.4% for NO2+NO3, 4.5% for TP, 35.3% for SRP, 21.9% for BAP, 41.7% for copper, and approximately 60-65% for lead, iron and aluminum. Fecal coliform levels actually increased from the intake to the outlet. Zinc levels were below the detection limit of the equipment used in the project. The pollutant removal efficiencies achieved by the swale were comparable to other swales evaluated in the Seattle area; however, this particular swale was much larger than those normally designed for similar drainages (570 ft in length as opposed to the more typical 200ft).

This project was well documented and contains a lot of good information. The project's swale is much longer than is typically recommended which may make comparison to other swales difficult.

Average Pollutant Removal Efficiencies *See notes at end of report.

RESIDUE, TOTAL NONFILTRABLE (MG/L)	69 %
LEAD, TOTAL (UG/L AS PB)	69 %
IRON, TOTAL (UG/L AS FE)	65 %
LEAD, DISSOLVED (UG/L AS PB)	23 %
OIL & GREASE (SOXHLET EXTRACTION) TOTAL,REC.,MG/L	-46 %
ZINC, TOTAL (UG/L AS ZN)	43 %
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	31 %
PHOSPHORUS, TOTAL (MG/L AS P)	-5 %
HARDNESS, TOTAL (MG/L AS CACO3)	3 %
CADMIUM, DISSOLVED (UG/L AS CD)	50 %
CADMIUM, TOTAL (UG/L AS CD)	35 %
COPPER, DISSOLVED (UG/L AS CU)	24 %
COPPER, TOTAL (UG/L AS CU)	46 %
ZINC, DISSOLVED (UG/L AS ZN)	33 %

Test Site Name EPCOT Swale

BMP Name EPCOT Swale

BMP Type Biofilter - Grass Swale

City Orlando

State/Country FL / US

BMP Installation Date

Number of Flow Records

Number of Water Quality Records 96

Minimum Flow Volume

Maximum Flow Volume

Watershed Name EPCOT Swale Watershed

Watershed Type Test

Total Watershed Area 0.00 ac

Watershed Area Disturbed

Avg Annual Rainfall 47.15 Inches

Avg Annual Storm Duration 5.90 Hour(s)

Comments

The EPCOT interchange was constructed during 1982-83 as a 0.8 mile multilane connector between the EPCOT entrance and SR 535. The interchange is approximately 1.5 miles southwest of the I-4/SR535 interchange and 2.4 miles northeast of the I-4/US 192 interchange, near Lake Buena Vistas in Orange County, Florida.

Watershed size is unknown.

The swale area selected for this study was a newly constructed swale along ramp A which connected the EPCOT Center Exit to the westbound lanes of I-4. Two experiments were conducted at this site, one in a predominately earthen state before the establishment of vegetation in the swale, and the other after vegetation had become established.

The experiments conducted at this site used a submersible pump placed at the downstream stormwater inlet. The water was spiked with a concentration of heavy metals (Pb, Cd, Zn, Cr, Cu, Ni, and Fe) and nutrients (P and N) in concentrations typical of highway runoff.

Occasional increases in dissolved highway contaminants were observed at intermediate stations during swale experiments particularly close to the inflow point. This may result from the initial flow resuspension and resolubilization of loosely bound contaminants. The removal of heavy metals, nitrogen, and phosphorous species on a mass basis was directly related to the infiltration losses through swales. Therefore, retention of as much water as possible on the swale area will reduce the highway contaminant loadings to adjacent receiving waters. Recommendations for the construction of roadside swales are presented. The information in the document is limited to a small number of storms and, thus, may provide only minimal data for the efficiency analysis of the swale in question.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Florida Aquarium Test Site - F4

BMP Name	Swale - F4	**Watershed Name**	Cement w/ Swale
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Tampa	**Total Watershed Area**	0.26 ac
State/Country	FL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	46.86 Inches
Number of Flow Records	64	**Avg Annual Storm Duration**	5.50 Hour(s)
Number of Water Quality Records	1050		
Minimum Flow Volume	0.02 ac ft		
Maximum Flow Volume	29.99 ac ft		

Comments

The parking lot design for the Florida Aquarium uses the entire drainage basin for lowimpact stormwater treatment. The study site is a 4.65 hectare (11.25 acre) parking lot serving 700,000 visitors annually. The research is designed to determine pollutant load reductions measured from three elements in the treatment train: Different treatment types in the parking lot, a planted strand with native wetland trees, and a small pond used for final treatment. Only data collected in the parking lot for the first year of a two year study are evaluated in this report. Sub-basins within the parking lot were evaluated using a statistical block design that tests four treatments with a replicate of each treatment. We have only included data for one replicate since all of these basins are exactly alike except for the treatments. The first treatment is no treatment (asphalt paving without a swale). The 2nd treatment is asphalt paving with a swale, the third is cement with a swale and the 4th is permeable with a swale. The basins with swales are all compared to the basin with no treatment, since this represents the quantity and quality of runoff that would occur if the parking lot if it was built in a traditional design. A full report with all the data is available. The principal meridian lies within the UTM Zone 17 and is a 1927 North American Datum.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Florida Aquarium Test Site - F6

BMP Name	Swale - F6	**Watershed Name**	Permeable w/ Swale
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Tampa	**Total Watershed Area**	0.26 ac
State/Country	FL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	46.86 Inches
Number of Flow Records	62	**Avg Annual Storm Duration**	5.50 Hour(s)
Number of Water Quality Records	944		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	29.99 ac ft		

Comments

The parking lot design for the Florida Aquarium uses the entire drainage basin for lowimpact stormwater treatment. The study site is a 4.65 hectare (11.25 acre) parking lot serving 700,000 visitors annually. The research is designed to determine pollutant load reductions measured from three elements in the treatment train: Different treatment types in the parking lot, a planted strand with native wetland trees, and a small pond used for final treatment. Only data collected in the parking lot for the first year of a two year study are evaluated in this report. Sub-basins within the parking lot were evaluated using a statistical block design that tests four treatments with a replicate of each treatment. We have only included data for one replicate since all of these basins are exactly alike except for the treatments. The first treatment is no treatment (asphalt paving without a swale). The 2nd treatment is asphalt paving with a swale, the third is cement with a swale and the 4th is permeable with a swale. The basins with swales are all compared to the basin with no treatment, since this represents the quantity and quality of runoff that would occur if the parking lot if it was built in a traditional design. A full report with all the data is available. The principal meridian lies within the UTM Zone 17 and is a 1927 North American Datum.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Florida Aquarium Test Site - F8

BMP Name Swale - F8

BMP Type Biofilter - Grass Swale

City Tampa

State/Country FL/US

BMP Installation Date

Number of Flow Records 64

Number of Water Quality Records 977

Minimum Flow Volume 0.76 ac ft

Maximum Flow Volume 29.99 ac ft

Watershed Name Asphalt w/ Swale

Watershed Type Test

Total Watershed Area 0.26 ac

Watershed Area Disturbed 0.00 ac

Avg Annual Rainfall 46.86 Inches

Avg Annual Storm Duration 5.50 Hour(s)

Comments

The parking lot design for the Florida Aquarium uses the entire drainage basin for lowimpact stormwater treatment. The study site is a 4.65 hectare (11.25 acre) parking lot serving 700,000 visitors annually. The research is designed to determine pollutant load reductions measured from three elements in the treatment train: Different treatment types in the parking lot, a planted strand with native wetland trees, and a small pond used for final treatment. Only data collected in the parking lot for the first year of a two year study are evaluated in this report. Sub-basins within the parking lot were evaluated using a statistical block design that tests four treatments with a replicate of each treatment. We have only included data for one replicate since all of these basins are exactly alike except for the treatments. The first treatment is no treatment (asphalt paving without a swale). The 2nd treatment is asphalt paving with a swale, the third is cement with a swale and the 4th is permeable with a swale. The basins with swales are all compared to the basin with no treatment, since this represents the quantity and quality of runoff that would occur if the parking lot if it was built in a traditional design. A full report with all the data is available. The principal meridian lies within the UTM Zone 17 and is a 1927 North American Datum.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Goose Creek Swale

BMP Name Goose Swale Sect 1

BMP Type Biofilter - Grass Swale

City Leesburg

State/Country VA /US

BMP Installation Date

Number of Flow Records 8

Number of Water Quality Records 56

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Route 7/ Goose Creek Overpass

Watershed Type Test

Total Watershed Area 0.76 ac

Watershed Area Disturbed 0.76 ac

Avg Annual Rainfall 37.46 Inches

Avg Annual Storm Duration 10.00 Hour(s)

Comments

The Route 7/Goose Creek overpass has an average daily traffic of approximately 39,000 vehicles per day. Swale and check dam systems were constructed in the highway median on the eastern and western sides of the overpass. The swale on the west side of the overpass was chosen as the study swale. The swale is bordered by an intersection on the west side and the overpass on the east side. The swale inlet point is approximately 575 ft upgrade of a temporary siltation fence, which served as a check dam (check dam 1) for this study. It is approximately 205 ft from the siltation fence to the permanent rock check dam (check dam 2) and approximately 120 ft from the permanent rock check dam to the stormwater drainage inlet grate. Wet weather grab sampling was conducted downgrade from the silt fence, downgrade from the permanent rock check dam, at the outlet grate, and at the edge of pavement (EOP). Sample concentrations from the EOP site represent the raw highway runoff concentrations before any treatment by the swale. Storm samples were collected June 18, July 22, and August 4, 1997. For each storm event monitored, sampling began after 0.1 in of rainfall accumulation, provided runoff was generated. For every 0.1 in of accumulation thereafter, samples were taken at each site where runoff occurred and the time was recorded. During the June storm, the rain gage tipped over, which led to inaccurate measurements for the last half of the storm. Therefore, the total precipitation recorded at Dulles International Airport (approximately 7 miles from the study area) was substituted for the on-site data collection. The high intensity of the June storm caused "short-circuiting" of the swale. The soil infiltration rate was much lower than the rainfall rate, and as a result, there was very little detention of the stormwater. The check dams were not effective because the runoff depth and flow rate were very high. The July storm was small (0.1 in) yet generated highway runoff. However, this runoff was completely infiltrated in the swale, and therefore no swale runoff or flow was observed. The August storm produced more consistent patterns than those obtained for the June storm, indicating that the swale was performing effectively. Results show that there was very little runoff at the beginning of the storm, as evident by sample collection only at the edge of the pavement and check dam 1 locations. For later sampling occasions, higher pollutant concentration at check dam 1 compared to EOP indicate the possible resuspension of pollutants within the swale. The general trend of decreased pollutant concentration over the length of the swale for each time period demonstrates the treatment enhancement gained by increased length and the presence of check dams. Runoff from the August storm never reached the swale outlet.

Runoff at the EOP site was considered representative of the runoff into the swale upgrade of the inlet as well as of the lateral sheet flow into the entire length of the swale. To allow a mass balance analysis, the swale was broken up into sections based on the check dam locations. The section from the swale inlet to the first check dam received flow from the intersection in the median of the highway and the sheet flow from the roadways for the length of the section (the contribution from the east and westbound lanes of Route 7 was assumed to be half of each lane (18 ft) for the length of each swale section). Each of the second and third sections received flow from its upstream check dam and from the roadways for the road length spanning that section. The flows for the roadways were calculated using the rational formula and the flows in the swale, just downgrade of each check dam and at the swale outlet, were calculated Manning's formula. (The results of these flow calculations are not available, however the mass removal efficiencies are including in the published report.)

Water quality values for this study are currently entered as discrete grab sample values. Data is available to calculate EMCs and can be obtained from the project team. Values may be flow-weighted and updated at a later time.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

Test Site Name I-5 North of Palomar Airport Road

BMP Name	Palomar Swale	**Watershed Name**	Palomar
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Carlsbad	**Total Watershed Area**	4.60 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	204		

Minimum Flow Volume 15.18 ac ft

Maximum Flow Volume 615.74 ac ft

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-5/I-605 Swale

BMP Name	5/605 swale	**Watershed Name**	5/605 swale
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Downey	**Total Watershed Area**	0.70 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	18	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	108		

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 143.43 ac ft

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-605 / Del Amo

BMP Name	Del Amo	**Watershed Name**	605/Del Amo
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Lakewood	**Total Watershed Area**	0.70 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	310		

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 133.81 ac ft

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-605/SR-91 Swale

BMP Name 605/91 swale

BMP Type Biofilter - Grass Swale

City Cerritos

State/Country CA /US

BMP Installation Date

Number of Flow Records 18

Number of Water Quality Records 54

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 39.94 ac ft

Watershed Name 605/91 swale

Watershed Type Test

Total Watershed Area 0.20 ac

Watershed Area Disturbed

Avg Annual Rainfall 8.97 Inches

Avg Annual Storm Duration 11.80 Hour(s)

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Maitland Swale

BMP Name	Maitland Swale	**Watershed Name**	Maitland Swale Watershed
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Orlando	**Total Watershed Area**	0.00 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	47.15 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	5.90 Hour(s)
Number of Water Quality Records	94		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	33.39 ac ft		

Comments

The site for this investigation is located at the intersection of Interstate 4 and Maitland Blvd., north of the City of Orlando in Orange County, Florida. Maitland Blvd. crosses over Interstate 4 by means of a bridge overpass created during the construction of the interchange in 1976. The traffic lanes on the interstate are separated by a 6 meter grassy median which widens to 13.5 meters through the interchange.

The Maitland Blvd. Bridge consists of two sections: one carrying two lanes of east bound traffic plus one exit lane and the other carrying two lanes of west bound traffic plus one exit lane. The section carrying west bound traffic spans 168 meters with a 16 meter roadway and a 16 meter horizontal clearance. The section carrying east bound traffic spans 163 meters and also with a 16 meter roadway and 16 meter horizontal clearance. The average annual daily traffic volume on Maitland Blvd is 15,000 vehicles per day. Interstate 4 has three lanes of traffic east and west bound through the Maitland Interchange. The traffic volume on Interstate 4 through the Maitland Interchange is approximately 45,000 ADT in each direction. A grassy swale along the eastern side of Ramp A was selected for this investigation. This swale was used because of its accessibility and the availability of a continuous source of runoff water from a drain located at the bottom of the swale. The drain connects to the west pond via a 36 inch diameter RCP.

The experiments conducted at this site used a submersible pump placed at the downstream stormwater inlet. The water was spiked with a concentration of heavy metal (Pb, Cd, Zn, Cr, Cu, Ni, and Fe) and nutrients (P and N) in concentrations typical of highway runoff. The spiked water traveled a distance of 175 ft.

From the results obtained, it appears that ionic species of metals, nitrogen and phosphorous species may be retained on the swale site by sorption, precipitation, co-precipitation and biological uptake processes. These processes can reduce pollutant concentration in highway runoff flowing over swales. Occasional increases in dissolved highway contaminants were observed at intermediate stations during swale experiments particularly close to the inflow point. This may result from the initial flow resuspension and resolubilization of loosely bound contaminants. The removal of heavy metals, nitrogen, and phosphorous species on a mass basis was directly related to the infiltration losses through swales. Therefore, retention of as much water as possible on the swale area will reduce the highway contaminant loadings to adjacent receiving waters. Recommendations for the construction of roadside swales are presented. The information in the document is limited to a small number of storms and, thus, may provide only minimal data for the efficiency analysis of the swale in question.

Watershed size is unknown.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Monticello High School

BMP Name Bioretention Area

BMP Type Biofilter - Grass Swale

City Charlottesville

State/Country VA /US

BMP Installation Date

Number of Flow Records 54

Number of Water Quality Records 230

Watershed Name Monticello High School Parking

Watershed Type Test

Total Watershed Area 0.78 ac

Watershed Area Disturbed

Avg Annual Rainfall 38.26 Inches

Avg Annual Storm Duration 10.90 Hour(s)

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 17.61 ac ft

Comments

This bioretention area consists of a grass buffer strip, ponding area, planting soil, sand bed, organic layer, and plant material. Runoff enters the BA via three evenly spaced riprapped channels, which prevent large debris from entering the BA. The BA has an approximate slope of 1%. Railroad ties are placed across the width at evenly spaced intervals to serve as check dams. A typical cross-section is described by a bed of a 4.0 ft layer of organic planting soil overlaying a 1.0 ft sand layer. The underdrain system is comprised of a 1.0 ft layer of #57 stone with two evenly spaced 0.5 ft perforated corrugated polyethylene pipes wrapped in filter fabric. Flow from the two pipes empties into a single storm sewer. The BA has an estimated 6 hour detention time as observed during field sampling. The minimum size storm to produce outflow from the BA during the monitoring period was 0.36 inches.

Total construction costs (materials and installation) were between $15,000 and $20,000.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name SR-78 / Melrose Dr

BMP Name	Melrose	**Watershed Name**	Melrose
BMP Type	Biofilter - Grass Swale	**Watershed Type**	Test
City	Vista	**Total Watershed Area**	2.40 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	407		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	106.13 ac ft		

Comments

Information for the following required grass filter design parameters were not provided because they were not considered or calculated for the design of this BMP. These fields include "Date of last rehabilitation", "Flow depth during 2-year Storm", "2-year peak flow velocity", "Manning's 2-year", " Depth to groundwater", "Saturated infiltration rate", and "Soil Group".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name University of Central FL Swale Bloc

BMP Name Univ. Central FL Swale Blocks

BMP Type Biofilter - Grass Swale

City Orlando

State/Country FL / US

BMP Installation Date

Number of Flow Records 24

Number of Water Quality Records 44

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 14.58 ac ft

Watershed Name Univ. Central FL Watershed

Watershed Type Test

Total Watershed Area 13.70 ac

Watershed Area Disturbed

Avg Annual Rainfall 47.15 Inches

Avg Annual Storm Duration 5.90 Hour(s)

Comments

This document examines erosion and sediment control of an existing highway system using swale blocks. Chapter 4 of the document provides a case study on a specific site on the campus of the University of Central Florida. Chapters 1-3 provide general information on erosion and sediment control and swale hydrology, hydraulics and design.

A site adjacent to a 4-lane highway located on the campus of the University of Central Florida was selected to determine the efficiency of a swale block system.

Sediment can be retained using off-line retention, on-line retention, detention systems and swale blocks. Swales and swale blocks within highway right-of-ways can be designed and operated to be as effective in the retention of solids as retention and detention systems. The use of swales and swale blocks decrease end-of-swale discharge volume and flow rates.

Only Chapter 4 provided information that would be useful. The constituent data is limited to TSS.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Mobile County Extension Service

BMP Name	8-Mile Wetland	**Watershed Name**	8-Mile Creek
BMP Type	Biofilter - Wetland Vegetation Swale	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	12.00 ac
State/Country	AL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	8	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	21		

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 0.00 ac ft

Comments

This study consisted only of grab samples with no flow measurements. Grab samples were collected using first-flush samplers.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name USA Brookley Golf Course

BMP Name	Moble Bay Constructed Wetland	**Watershed Name**	Mobile Bay
BMP Type	Biofilter - Wetland Vegetation Swale	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	2.50 ac
State/Country	AL /US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	14	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	47		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	0.00 ac ft		

Comments

Wetland is 100 ft away from Mobile Bay. Inflow samples were collected with a first flush sampler. No inflow or outflow measurements were taken for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Boeing Computer Services

BMP Name Boeing Detention Pond

BMP Type Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm

City Seattle

State/Country WA /US

BMP Installation Date

Number of Flow Records 7

Number of Water Quality Records 745

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Boeing Watershed

Watershed Type Test

Total Watershed Area 18.00 ac

Watershed Area Disturbed

Avg Annual Rainfall 34.31 Inches

Avg Annual Storm Duration 14.60 Hour(s)

Comments

This study was primarily concerned with the treatability of urban stormwater for oil and grease using a detention basin/coalescing plate oil separator treatment system. The project site was an 18 acre controlled and mostly impervious area (parking lot) which drained into a small pond (approximately 165,000 ft^3 in total volume). Data was collected during 3 natural storms and 4 synthetic storms. The synthetic storms were generated using the domestic water supply and irrigation sprinklers attached to fire hydrants on-site. The drainage area for the synthetic storms was approximately 1.0 acre. All samples were grab samples and the parameters analyzed were: Total Suspended Solids (TSS), Total Phosphorous (TP), Nitrate (NO3), Nitrate-nitrogen (NO3-N), Oil and Grease (O/G), Arsenic (AS), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb), and Zinc (Zn).

The detention pond at the Boeing site removed between -122 and 99% of the TSS, with removal efficiency being highest when influent concentrations were the highest. By eliminating the cases where influent TSS was < 7 mg/l, the removal efficiency for TSS increased to 77- 90%. Most of the lead, 25-33% of the total phosphorous and variable proportions of other metals were removed by the system. The oil and grease concentrations in the runoff were very low, and the capacity of the coalescing plate was not utilized. Materials in the separator added substantial quantities of Zinc to the runoff.

The major factor limiting the usefulness of this study is that its purpose was to evaluate the effectiveness of coalescing plate oil/water separator and the runoff from the site contained very low concentrations of oil and grease. There is a lot of water quality information provided in the study but it may be difficult to use. Samples were taken after the storm event for the 2 of the 3 natural events. For the other natural event, there was precipitation for four hours preceding the event and for 2 hours into the sampling period. For the synthetic events, sampling was done at the influent to the pond during the storm events and at the effluent and oil/water separator 4 to 24 hrs after the event. Composite samples were taken at all three sampling stations for the first 4 storms and only at station 1(the influent to the pond) for the other 3 storms.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Brooke Detention Basin and Wetland

BMP Name	Brooke Detention Pond	**Watershed Name**	Brooke Commuter Rail Parking L
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Brooke	**Total Watershed Area**	12.01 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	23	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	74		
Minimum Flow Volume	8.78 ac ft		
Maximum Flow Volume	730.36 ac ft		

Comments

The Brooke site consists of a 0.08 ha emergent detention pond and a 2.83 ha mitigated wetland in series. The site receives stormwater runoff from a commuter parking lot, a grassed area, and a railway. Conditions range from permanently flooded regions where deep (up to 1 m) pools exist to intermittently flooded regions where surface water is present during storm events and near-saturated to saturated soil conditions prevail during dry weather. The site has approximately 0.4 ha (14 % of total area) of open water. The detention basin is intermittently flooded with water levels rising as high as 2 m during large storm events. Like the rest of the site, the basin's soil is usually at or near saturation during dry periods. Vegetation density is moderate to dense in all but the open water area. Wool Grass, Cattail, and Soft Rush are the dominant emergent species and Black Willow is dense along the main channel of the wetland. Primary species in the detention basin are Wool Grass, Cattail, Goldenrod, and Soft Rush.

Flow volumes could not be recovered for the 10/19/1996 storm event.
A study of the relative abundance of various plant species in the Brooke wetland was conducted. A composite of one-meter plots was used to determine the overall composition of the wetland. The figures do not include woody species or floating aquatic plants that can not be easily counted individually, such as Duckweed. The composite composition of vegetation at the Brooke wetland is as follows: Soft Rush (34.06%), Stinking Marsh-Fleabane (0.39%), Cattail (22.24%), Broom sedge (0.39%), Sphagnum (21.46%), Buttonbush (0.39%), St. John's Wort (8.86%), Lurid Sedge (1.18%), Goldenrod (10.04%), and Spotted Joe Pye Weed (0.98%).

While minimal or negative removals are indicated for the Brooke wetland for TSS, OP, COD, and Zn, these figures must be viewed within the context of the system as a whole. A comparison of the detention basin inflow and the relatively lower wetland inflow (detention outflow) concentrations for the Brooke wetland indicate that a significant portion of removal at this site occurs in the detention basin rather than in the wetland. While effluent from the Brooke wetland may contain higher pollutant concentrations for some parameters than the wetland inflow, the concentration is still far lower than that in the inflow to the system, resulting in overall pollutant reductions.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Greenville Pond

BMP Name	Greenville Pond	**Watershed Name**	Greenville Pond Watershed
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Greenville	**Total Watershed Area**	200.15 ac
State/Country	NC/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.12 Inches
Number of Flow Records	19	**Avg Annual Storm Duration**	9.60 Hour(s)
Number of Water Quality Records	212		
Minimum Flow Volume	555.05 ac ft		
Maximum Flow Volume	35,163.17 ac ft		

Comments

In October 1989 the city of Greenville was awarded a grant to construct a 1.75 acre extended dry detention pond on a 3.5-acre site that is adjacent to the Tar River. Details of the project design, construction, and hydrologic characteristics are in the City of Greenville's report to APES prepared by Belk et al. (1992).

The field study included 8 storm events that occurred in the period between February 25 and August 17, 1992. Median pond treatment efficiencies were 71% for TSS, 45% for particulate organic carbon and particulate nitrogen, 33% for particulate phosphorus, and 26-55% for metals. Dissolved pollutant loads leaving the pond were about the same as the runoff loads, except for PO4-P which was 25%. For dissolved nitrogen and carbon ,the efficiency was small or negative. Treatment brought the copper levels below the standard, but zinc effluent levels were 2 times the standard. Typically, the first 20% of total storm runoff from the Greenville detention pond basin carried 24-27% of the total particulate loads and 23-37% of the total dissolved pollutant loads, thus, not exhibiting a first flush runoff pattern.

Settling column tests were done and the results included in the appendix. Particulate pollutant removals were higher in the settling column than in the pond. Strict comparisons cannot be made.

Eight storms were monitored during the study. All the storms displayed a variety of characteristics and antecedent conditions. The first 20% of the total storm runoff for the pond carried 24-27% of the total particulate pollutant loads and 23-37% of the total dissolved pollutant loads. It does not exhibit first flush runoff patterns. Measured efficiencies for other dry detention ponds vary widely, but overall it appears the Greenville Pond is typical.

Calculations show that total nutrient loading to the Tar River cannot be significantly reduced by urban runoff detention treatment. Urban runoff contributes a minor part (1-4%) of the total nitrogen and phosphorus loading to the system. Detention causes no significant removal of dissolved inorganic nutrient fractions and only partial removal of the particulate forms.

The author published two papers (1.3.1.075 and 1.3.1.073) on this dry detention pond study, with 1.3.1.075 containing the complete data sets. 1.3.1.073 contains a summary of event mean concentrations and rainfall data. Since there are no changes on the studied BMPs, the information from the two papers are summarized in one set of data in the database. The study provides comparisons between 6 other dry detention pond systems, with respect to watershed acres, imperviousness, drain time, number of storms monitored, and removal efficiencies. In paper 1.3.1.075; 15-minute precipitation data was provided for storm events in 1992. Graphs of inflow, outflow, and storage of runoff for 8 storms were provided. Both concentration and event mean concentration and treatment efficiency summary tables are included in the appendices.

Average Pollutant Removal Efficiencies *See notes at end of report.

PHOSPHORUS, TOTAL (MG/L AS P)	27 %
ZINC, TOTAL (UG/L AS ZN)	35 %
NICKEL, TOTAL (UG/L AS NI)	53 %
LEAD, TOTAL (UG/L AS PB)	49 %
COPPER, TOTAL (UG/L AS CU)	35 %
CADMIUM, TOTAL (UG/L AS CD)	40 %
CARBON, TOTAL ORGANIC (MG/L AS C)	14 %
PHOSPHORUS, SUSPENDED (MG/L AS P)	42 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	6 %

NITROGEN, ORGANIC, TOTAL (MG/L AS N)	56 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	75 %
PHOSPHORUS, DISSOLVED ORGANIC (MG/L AS P)	4 %
NITROGEN, TOTAL (MG/L AS N)	35 %

Test Site Name	Hank Aaron Stadium - NW Detention Basin

BMP Name	NW - Detention Basin	**Watershed Name**	Dog River Watershed - NW Deten
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	10.80 ac
State/Country	AL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	9	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	23		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools). This site was originally desinged as an extended dry pond facility.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Hank Aaron Stadium - SW Detention Basin

BMP Name	SW - Detention Basin	**Watershed Name**	Dog River Watershed - SW Deten
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	17.90 ac
State/Country	AL / US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	3	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	12		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools).

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Hillsdale Drive Detention Basin

BMP Name	Hillsdale Detention Basin	**Watershed Name**	Albemarle County
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	73.80 ac
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	14	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	185		
Minimum Flow Volume	1,382.82		
Maximum Flow Volume	22,412.20		

Comments

This database entry describes a pre-retrofit dry detention basin that was designed purely for flood control and demonstrates little to no water quality benefit. Retrofit plans for this basin include a reduced outlet orifice, wetland benches, an enhanced sediment forebay, and an outlet pool. Runoff enters the Hillsdale Drive dry detention basin through a 60-inch diameter concrete pipe and flow through a tree-lined channel to a 27-inch diameter outlet pipe. Automatic samplers at the inlet and outlet were programmed to run for three hours. First flush samples were collected four minutes apart, and later samples were collected at 30-minute intervals. Wet weather sample analyses included analyses of five discrete first-flush samples and of one flow weighted composite at each sampling location. Each composite was created from 10 samples collected over a three-hour period. For the 7/24/00 storm, rainfall continued after sampling was completed, however, the precipitation and total flow data given in this database entry reflect only the precipitation and runoff contributing to the sampled portion of the hydrograph--i.e. later peaks in the 7/24 hydrograph and the rainfall corresponding to these later runoff volumes were not included in the given totals or attached raw data.

TSS concentrations at this site were low, however, disturbing the pipe or channel bottom even slightly caused the water to become murky. Furthermore, storms at this site frequently cause changes to the streambed and shifting sandbars. This suggests that much of the solids transport at this location may be in the form of bedloads, which are not reflected in automatic samples. The negative removal efficiency of TSS (and poor removal of associated contaminants) reflects the high-energy, turbulent inflows during storm events and the subsequent channel erosion and scouring of the streambed.

There are large differences between measured flow volumes at the inlet and outlet of the basin. The high water levels in the inlet pipe are partly due to damming of the flow. One large storm during the summer carried large rocks downstream raising a natural rock dam just downstream of the inlet. This increased the baseflow in the pipe from approximately 13 in to almost 30 in. Therefore, the rocks were removed and the baseflow level dropped to 8 in. These changes explain why the inlet and outlet flows were much closer in magnitude for the 11/14 storm (after the baseflow adjustment) than for the July storm. However, there is still a large difference in flow, suggesting water is still backing up in to the inlet pipe. Due to the uncertainties associated with flow magnitude, removal efficiencies were calculated using a concentration-based rather than mass- or load-based method.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-15/SR-78 EDB

BMP Name	15/78	**Watershed Name**	15/78 edb
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Escondido	**Total Watershed Area**	13.40 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	38	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	570		
Minimum Flow Volume	8.58 ac ft		
Maximum Flow Volume	767.04 ac ft		

Comments

Information for the following required Detention Basin design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Half Brim Volume Empting time", "bottom stage volume, if any", "Bottom Surface Area, if any", "Forebay Volume", "Forebay surface area" and "Depth to water table".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-5 / SR-56

BMP Name	5/56	**Watershed Name**	56/5
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	San Diego	**Total Watershed Area**	5.30 ac
State/Country	CA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	35	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	492		
Minimum Flow Volume	8.38 ac ft		
Maximum Flow Volume	578.26 ac ft		

Comments

Information for the following required Detention Basin design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Half Brim Volume Empting time", "bottom stage volume, if any", "Bottom Surface Area, if any", "Forebay Volume", "Forebay surface area" and "Depth to water table".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-5/Manchester (east)

BMP Name	Manchester	**Watershed Name**	Manchester
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Encinitas	**Total Watershed Area**	4.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	28	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	516		
Minimum Flow Volume	22.10 ac ft		
Maximum Flow Volume	482.14 ac ft		

Comments

Information for the following required Detention Basin design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Half Brim Volume Empting time", "bottom stage volume, if any", "Bottom Surface Area, if any", "Forebay Volume", "Forebay surface area" and "Depth to water table".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-605 / SR-91 EDB

BMP Name	605/91 edb	**Watershed Name**	605/91edb
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Cerritos	**Total Watershed Area**	0.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	26	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	318		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	1,218.80 ac ft		

Comments

Information for the following required Detention Basin design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Half Brim Volume Empting time", "bottom stage volume, if any", "Bottom Surface Area, if any", "Forebay Volume", "Forebay surface area" and "Depth to water table".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Massie Road Detention Pond A

BMP Name Massie Detention Pond A

BMP Type Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm

City Charlottesville

State/Country VA /US

BMP Installation Date

Number of Flow Records 14

Number of Water Quality Records 96

Minimum Flow Volume 1.37

Maximum Flow Volume 16.74

Watershed Name Massie Rd. Parking Lot

Watershed Type Test

Total Watershed Area 7.88 ac

Watershed Area Disturbed

Avg Annual Rainfall 38.26 Inches

Avg Annual Storm Duration 10.90 Hour(s)

Comments

The pond receives runoff from a riprap-lined channel that receives runoff from two sources: a 61-cm concrete storm sewer draining 1.7 ha and a concrete trapezoidal ditch draining 0.6 ha. The two inflows converge in the riprap ditch and proceed into the pond area. The balance of the drainage area is 0.9 ha, which is the drainage area immediately surrounding the detention pond.
The pond was not designed or constructed with any specific objective for water quality improvements. The pond was designed only to attenuate the postdevelopment peak runoff flow rate to the predevelopment flow rate for 2- and 10-yr storms. In order for the pond to serve a water quality function, a modification was made to the outfall pipe to reduce the orifice diameter. Sampling results for the post-retrofit condition are entered under the BMP Test Site Name "Massie Road Detention Pond B." The results presented here are for the two pre-retrofit storms.Total flow volumes for the Massie Pond A study were only provided for the period for which samples were taken and not for the entire event.
DETENTION POND STAGE VS. STORAGE
Elevation (m), Surface Area (m^2), Total Storage (m^3)
144.47,0.0,0.0
145.08,408.9,124.6
145.69,614.1,565.7
146.3,832.0,877.7

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Massie Road Detention Pond B

BMP Name	Massie Detention Pond B	**Watershed Name**	Massie Rd. Parking Lot
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	7.88 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	92		
Minimum Flow Volume	58.52 ac ft		
Maximum Flow Volume	571.66 ac ft		

Comments

The pond receives runoff from a riprap-lined channel that receives runoff from two sources: a 24-in concrete storm sewer draining 4.2 ac and a concrete trapezoidal ditch draining 1.5 ac. The two inflows converge in the riprap ditch and proceed into the pond area. The balance of the drainage area is 2.2 ac, which is the drainage area immediately surrounding the detention pond.
The pond was not designed or constructed with any specific objective for water quality improvements. The pond was designed only to attenuate the postdevelopment peak runoff flow rate to the predevelopment flow rate for 2- and 10-yr storms. In order for the pond to serve a water quality function, a modification was made to the outfall pipe to reduce the orifice diameter. Sampling results for the pre-retrofit condition are entered under the BMP Test Site Name "Massie Road Detention Pond A." The results presented here are for the two post-retrofit storms.
The flow-metering strategy was altered in the second year of study at this site. Site set-up and results from this second year (1993) are entered under the BMP Test Site Name "Massie Road Detention Pond C."
DETENTION POND STAGE VS. STORAGE
Elevation (m), Surface Area (m^2), Total Storage (m^3)
144.47,0.0,0.0
145.08,408.9,124.6
145.69,614.1,565.7
146.3,832.0,877.7

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Massie Road Detention Pond C

BMP Name	Massie Detention Pond C	**Watershed Name**	Massie Rd. Parking Lot
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	7.88 ac
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	8	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	192		
Minimum Flow Volume	66.95 ac ft		
Maximum Flow Volume	902.61 ac ft		

Comments

The pond receives runoff from a riprap-lined channel that receives runoff from two sources: a 24-in concrete storm sewer draining 4.2 ac and a concrete trapezoidal ditch draining 1.5 ac. The two inflows converge in the riprap ditch and proceed into the pond area. The balance of the drainage area is 2.2 ac, which is the drainage area immediately surrounding the detention pond. The original flow-metering strategy monitored each of the two inlets separately, but this approach was altered in the second year of the study. A single inflow point was monitored downstream of the confluence of the trapezoidal channel and the concrete pipes. The outflow measurement was adjusted as well. Backwater conditions in the discharge pipe were suspected of affecting the depth-discharge relationship and the v-notch weir equation would not apply directly. Submerged weir conditions needed to be considered and equipment was unavailable for handling this condition. Therefore, the depth in the pond as well as inflow was measured at discrete time intervals. The outflow was computed by using a depth versus storage relationship. The curve was developed for the pond using as-built survey information conducted during this study. The modification to flow-measuring strategy more accurately characterized the flows into and out of the pond. The inflow is more characteristic of the actual condition because a larger percentage of the pond drainage area is measured before entering the pond. The surrounding drainage area not directly accounted for in the flow measurement was reduced from 2.2 acres to approximately 1.0 acres. Also, changes in pollutant characterization or transport that may or may not be significant were reduced by sampling the pollutants before they entered the pond thereby giving a more accurate description of the changes that resulted from the detention pond only and not the channel/pond system.
In order for the pond to serve a water quality function, in the first year of the study, a modification was made to the outfall pipe to reduce the orifice diameter. Sampling results for the pre-retrofit condition are entered under the BMP Test Site Name "Massie Road Detention Pond A." Sampling results for two post-retrofit storms (but before adjustments to the flow-metering strategy) are presented under the Test Site Name "Massie Road Detention Pond B."
Results from the second year (1993) of the study are presented here.

Misc. Info.
DETENTION POND STAGE VS. STORAGE
Elevation (m), Surface Area (m^2), Total Storage (m^3)
144.47,0.0,0.0
145.08,408.9,124.6
145.69,614.1,565.7
146.3,832.0,877.7

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Michie Dr Detention Basin

BMP Name	Michie Detention Basin	**Watershed Name**	City of Charlottesville
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	79.80 ac
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	212		
Minimum Flow Volume	15.45 ac ft		
Maximum Flow Volume	611.97 ac ft		

Comments

This database entry describes a pre-retrofit dry detention basin that was designed purely for flood control and demonstrates little to no water quality benefit. Retrofit plans for this basin include a reduced outlet orifice, enhanced sediment forebay, lengthened flow path, and bank stabilization. The primary inlet is a 60-inch diameter concrete pipe that empties into a small pool. Water leaving the pool flows through a tree-lined channel to a concrete outlet structure with a 45-in orifice. A second inlet discharges into a side channel that joins the main channel approximately one-third of the way between the pool and the outlet. There is no baseflow in the side channel. This secondary inlet is a 22-inch diameter concrete pipe. Automatic samplers at each inlet and the outlet were programmed to run for three hours. First flush samples were collected four minutes apart, and later samples were collected at 30-minute intervals. Wet weather sample analyses included analyses of five discrete first-flush samples and of one flow weighted composite at each sampling location. Each composite was created from 8-10 samples collected over a two to three-hour period. For the 9/19/00 storm, rainfall continued after sampling was completed, however, the precipitation and total flow data given in this database entry reflect only the precipitation and runoff contributing to the sampled portion of the hydrograph--i.e. later peaks in the 9/19 hydrograph and the rainfall corresponding to these later runoff volumes were not included in the given totals or attached raw data. At this basin, the measured outflow is considerably greater than the sum of the inflows. The primary factor creating this difference is a recently discovered spring that contributes groundwater to the basin during both baseflow and storm runoff conditions.

TSS results from this study reflect all suspended solids that could be collected with the automatic samplers; larger particles were not excluded. The very high concentrations are primarily due to large sand particles suspended in the stormflow rather than an extremely high number of sediments. The negative removal efficiency of TSS (and poor removal of associated contaminants) reflects the high-energy, turbulent inflows during storm events and the subsequent channel erosion and scouring of the streambed.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Mountain Park

BMP Name	Mountain Park Detention Basin	**Watershed Name**	Mountain Park
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Lilburn	**Total Watershed Area**	26.40 ac
State/Country	GA /US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	46.87 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	9.30 Hour(s)
Number of Water Quality Records	278		
Minimum Flow Volume	1.39 ac ft		
Maximum Flow Volume	406.92 ac ft		

Comments

Structural BMP, 26.4 ac. Drainage area, 100% Single Family Residential.50.77 inches/year annual rainfall. 2 inches/year average snowfall. 0% disturbed. 23% impervious. 3% slope

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Nurp, Lansing MI, Dryer Det Basin

BMP Name	Dryer Detention Basin	**Watershed Name**	Dryer Detention Basin
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Lansing	**Total Watershed Area**	112.70 ac
State/Country	MI/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	26.72 Inches
Number of Flow Records	2	**Avg Annual Storm Duration**	10.20 Hour(s)
Number of Water Quality Records	688		
Minimum Flow Volume	1,062.03 ac ft		
Maximum Flow Volume	1,689.51 ac ft		

Comments

The major objective of the Lansing Michigan NURP study was to evaluate the effectiveness of three BMP's; an in-line retention basin, an off-line retention basin, and two up-sized pipe sections. Other objectives included relating land use to pollutant loads and assessing the impact of the BMP's on the receiving waters. The Bogus Swamp Drainage District study area covered 450 acres. A total of ten sites were monitored for flow, water quality parameters and sediment pollutant concentrations.

Station 4 is located just upstream of the diversion to the off-line detention basin. The drainage area monitored by station 4 encompasses the areas of both stations 5 and 6 plus an additional 45.7 acres. The major difference in land use was the additional 23 acres of low density residential area. Also included were 12.5 acres of parkland, 8.4 acres of strip mall, and 1.8 acres of institutional land use.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Oakhampton Basin

BMP Name	Oakhampton Dry Basin	**Watershed Name**	Oakhampton Dry Basin
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Hampton	**Total Watershed Area**	16.80 ac
State/Country	MD/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	39.41 Inches
Number of Flow Records		**Avg Annual Storm Duration**	10.60 Hour(s)

Number of Water Quality Records 118

Minimum Flow Volume

Maximum Flow Volume

Comments

This paper describes a large project initiated in 1984 to retrofit several flood control basins to function as water quality detention basins. Of the 24 basins targeted for retrofit, only 5 were completed because of perceived liability and maintenance issues on the part of private landowners on whose property the basins were located. Retrofit included extending the detention time of the basins for smaller flows while maintaining their flood control ability for larger flows. This was accomplished by the installation of a low flow restricting orifice at the outflow that would detain 1 yr. (or 50% of 1 yr.) storm volume for 6 to 24 hours. Larger flows bypassed the orifice. Sufficient data was collected to calculate removal efficiencies for: Suspended Solids (TSS), Dissolved Phosphorus (DP), Total Phosphorus (T-P), Nitrite+Nitrate Nitrogen (NO3+NO2-N), and Ammonia Nitrogen (NH3-N) for 2 of the 5 basins. Also discussed in detail is the rationale used to select detention time for the basins.

The total drainage area for the Oak Hampton basin is 16.8 acres of high density residential (town homes) area. The basin retrofit was designed so the pond would provide 29 hours of detention for a 1 year storm event. There were single inlet and outlet structures, inlet flows were measured with a Palmer Bowlus flume and outlet flows were measured with 1.5 ft. H-flume installed at the end of the outlet pipe.

The Oak Hampton dry pond showed high to moderate storm removals (median values) for suspended solids (87%), ammonia (54%), and total phosphorus (26%). Small outfluxes were measured for dissolved phosphorus (-12%) and nitrate-nitrite nitrogen (-10%).

Appendix F in the document provided the raw data used to calculate the mean pollutant concentrations. However, due to the manner in which the data was presented, individual storm events (listed by date in the raw data) could not be linked to the storm event EMC's (listed by storm number) that were given. No precipitation data could be found in the document.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Twin Towers

BMP Name	Twin Towers Dry Pond	**Watershed Name**	Twin Towers Site
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Tallahassee	**Total Watershed Area**	26.20 ac
State/Country	FL / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	62.95 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	7.10 Hour(s)
Number of Water Quality Records	352		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	1,046.79 ac ft		

Comments

This project monitored five storm events for a dry detention basin in Tallahassee Florida. The dry detention basin consists of three inflows and 1 outflow. Inflow at two locations was estimated using the SCS Runoff Equation. Two Inflow samples were mixed and analyzed as time weighted composites and one inflow and one outflow was estimated using flow weighted composites. Several Detention Basin design parameters are missing from the following dataset;however, this information should be updated sometime in the near future.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Whispering Heights Residential Site

BMP Name	Whispering Heights Residential Pond	**Watershed Name**	Whispering Heights Res. Pond
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	76.01 ac
State/Country	WA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	481	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	469		
Minimum Flow Volume	0.50 ac ft		
Maximum Flow Volume	20,584.44 ac ft		

Comments

The efficiencies of two existing urban stormwater detention facilities in reducing pollutant loadings to receiving waters were investigated in this paper. The paper contained two field sites in King County, Washington: a 76 acre residential subdivision in the Vasa Creek/Lake Sammamish drainage basin (metro site), and a transit operating base in the Kelsey Creek/Lake Washington drainage basin (whispering heights residential site). Inflow and outflow hydrographs were estimated for several storm events, along with pollutant concentrations ranging from 3.75 minutes to 1 hour. This study investigates a detention pond at the whispering heights residential site (WH residential site). The metro site is also contained in the BMP database.

The whispering heights residential site serves approximately 76 acres of a single family residential area south of Bellevue, Washington. The retention pond provides approximately 15,000 cubic feet of stormwater storage capacity and discharges to Vasa Creek. A small creek runs directly through this detention pond, which is designated as a dry pond except when the creek flow exceeds 0.5 cfs. Precipitation, flow and time-discrete water quality samples were measured/taken at inflow and outflow points of the pond. Storm events were monitored from October 1981 through February 1982. The majority of the WH residential site samples were analyzed for TSS only since the principal water quality concern at the residential site was solids transport.

Resuspension of sediment in this pond was a major problem, and resulted in negative pollutant removal efficiencies for most storms. Multiple inflow concentration peaks during lengthy winter storms appeared to be related to sediment generation from residential construction activity. The first flush effect was not generally exhibited at this residential site.
Preliminary analysis of stormwater for heavy metals, grease and oil, total phosphorus and COD indicated that they were either present in very low concentrations or in concentrations below detection.

Although a tipping bucket rain gage was installed at the site, the continuos rainfall records were not provided in the report. The flow rate and pollutant concentration end times entered into the database were relative times from the start of each sampling event rather than the real times.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Control N on SH 45

BMP Name Control N on SH 45 Gravel Filter

BMP Type Filter - Other Media

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 18

Number of Water Quality Records 322

Minimum Flow Volume 83.34 ac ft

Maximum Flow Volume 655.31 ac ft

Watershed Name Control N on SH 45 Watershed

Watershed Type Test

Total Watershed Area 5.21 ac

Watershed Area Disturbed 0.00 ac

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The highway pollutant (solids, organic carbon, metals, oil and grease, and nitrate) removal efficiency of a liquid materials trap and a vertical gravel filter (preceded by a sedimentation basin) in series are evaluated in this report. The test site is located on State Highway 45 in Austin, TX. The treatment system was evaluated for 9 storm events. The report also summarized the following investigations, which were not included in the database:
1. Evaluation of hydraulic performance of sand and gravel filters at six test sites along highways in Austin.
2. Bench-scale studies to evaluate the removal efficiency of various types of filters and/or adsorption media (including sands and gravels, compost and zeolites) for treating highway runoff.

The liquid materials trap and gravel filter had good removal of solids (60%), poor (sometimes resulting in an increase of the constituent in the effluent) to good (63%) removal of metals, fair removal of oil and grease (18%), no removal of nitrate, total carbon and dissolved carbon (i.e., effluent concentrations were higher than influent concentrations).

Good data report. Extensive modeling of flow parameters where the parameters could not be measured in the field. However, some essential data (specific information pertaining to the BMPs) were not included in the report.
Original flow and precipitation files were corrupted, so it was not possible to provide or retrieve this information for this report.
Additional information on the site layout is available from the project report available at : http://www.crwr.utexas.edu/online.html See online report 95-8. A schematic of the BMP layout is provided in Figure 3.10. Photographs are provided in Figures 3.1 and 3.2. The specifications for the BMP are provided on page 23.

Average Pollutant Removal Efficiencies *See notes at end of report.

PHOSPHORUS, TOTAL (MG/L AS P)		48 %
ZINC, TOTAL (UG/L AS ZN)		85 %
NICKEL, TOTAL (UG/L AS NI)		50 %
LEAD, TOTAL (UG/L AS PB)		49 %
IRON, TOTAL (UG/L AS FE)		62 %
COPPER, TOTAL (UG/L AS CU)		64 %
CHROMIUM, TOTAL (UG/L AS CR)		42 %
CARBON, TOTAL ORGANIC (MG/L AS C)		29 %
NITRATE NITROGEN, TOTAL (MG/L AS N)		36 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)		75 %
RESIDUE, TOTAL VOLATILE (MG/L)		65 %
COD, .025N K2CR2O7	MG/L	49 %
CADMIUM, TOTAL (UG/L AS CD)		50 %
		%

Test Site Name I-5 / I-605 EDB

BMP Name	5/605 EDB	**Watershed Name**	5/605 edb
BMP Type	Detention Basin (Dry) - Concrete or Lined Tank/Basin With Open Surface	**Watershed Type**	Test
City	Downey	**Total Watershed Area**	2.75 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	26	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	166		
Minimum Flow Volume	25.66 ac ft		
Maximum Flow Volume	1,361.19 ac ft		

Comments

Information for the following required Detention Basin design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Half Brim Volume Empting time", "bottom stage volume, if any", "Bottom Surface Area, if any", "Forebay Volume", "Forebay surface area" and "Depth to water table".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Seton Pond Facility

BMP Name Seton Pond Filtration Facility (2)

BMP Type Filter - Combination of Media or Layered Media

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 20

Number of Water Quality Records 1817

Minimum Flow Volume 223.46 ac ft

Maximum Flow Volume 6,180.32 ac ft

Watershed Name Seton Pond Facility

Watershed Type Test

Total Watershed Area 83.03 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The performance of sedimentation/filtration systems which are the most common control for treating highway runoff are evaluated in this study. The study includes: 1) monitoring and evaluating the Seton Pond sedimentation/filtration facility in Austin, TX and 2) evaluating the factors that effect sedimentation in a prototype detention basin.The Seton Pond facility is an off-line facility that incorporates a dry extended detention basin and a horizontal bed (vertical flow) sand filter. Automatic samplers and flow meters were installed at three locations in the facility: the influent channel to the sedimentation basin, the sedimentation basin effluent and the filter effluent. The constituents analyzed in the study included TSS, turbidity, COD, TOC, nitrate, TKN, phosphorus and metals.

Removal efficiencies were calculated for each constituent analyzed and for the sedimentation alone and for a combination of sedimentation and filtration. Untreated runoff that bypassed the system was not included in the loading of a constituent and percent removal calculations. Due to the extensive construction activities in the contributing watershed, the sand filter was not put in use during the first six storm events of the monitoring period. These first six storm were treated by and analyzed for only sedimentation.

Since the filter exceeded the design drainage time of 24 hours, runoff from separate rainfall events mixed in the filter and it became impossible to distinguish between runoff generated from different events. Therefore, flow measurement data for separate rainfall events were discarded and a method was developed for determining the average constituent concentration in the effluent from the sand filter and applying the concentration to the total volume of runoff passing through the filter.

Results from the Seton Pond facility show that sedimentation/filtration is an excellent form of treatment for runoff captured in the system (removal percentage for TSS was 89%, turbidity 52%, COD 66%, TOC 62%, nitrate 3%, TKN 26%, phosphorus 51%, zinc 81% and iron 75%); however, the poor hydraulic performance of the sand filter reduces the facility's capture capacity and increases the quantity of untreated runoff that bypasses the system. Results from the prototype experiments show that detention time is more important than outlet design for achieving satisfactory removal of constituents in runoff. Treatment by sedimentation alone is comparable to sedimentation/filtration when adequate and consistent detention times are achieved.

The information on the experiments conducted to study the effectiveness of sedimentation as a method of treating highway runoff in the prototype-scale sedimentation basin were not included in the database as synthetic highway runoff were used in these experiments.
Additional information on the site layout is available from the project report available at : http://www.crwr.utexas.edu/online.html See online report 97-4. Plan view on page 12; Photos of the site on pages 13,14,15,16 and 17.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name MCTT, Pilot Scale UAB, Birmingham, AL

BMP Name MCTT Catchbasin

BMP Type Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)

City Birmingham

State/Country AL /US

BMP Installation Date

Number of Flow Records 52

Number of Water Quality Records 2650

Minimum Flow Volume

Maximum Flow Volume

Watershed Name UAB

Watershed Type Test

Total Watershed Area 8.01 ac

Watershed Area Disturbed

Avg Annual Rainfall 50.71 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

This monitoring activity was funded by the EPA's Wet Weather Flow Research Program, Edison, NJ, under the direction of Richard Field. The field monitoring was performed by Robert Pitt, Department of Civil and Environmental Engineering at the University of Alabama at Birmingham. The estimated total monitoring effort was about $150,000 (including MCTT development costs and bench-scale tests). The facility was installed in 1997 and 13 events were monitored over a 6 month period.

The annual rainfall in Birmingham is about 55 inches per year, and measurable snowfall is rare (every several years). Summers are characterized by hot and humid conditions, while winters are more mild and drier. Fall is the driest season.

The multi-chambered treatment tank (MCTT) is a combination device having numerous unit processes, including: an initial inlet grit chamber, a main sedimentation (augmented with lamella plates) chamber, with sorbent pillows and aeration, and a final filter/sorption chamber. Each unit is specifically designed for a certain capacity and specific function and is intended for stormwater treatment at critical source areas, especially for high removal levels of heavy metal and organic toxicants. It was developed after extensive field and laboratory treatability tests. The EPA research report (referenced at end of comments) has much information that should be helpful to others wishing to develop other devices that may be used at critical source areas. The MCTT is most suitable for use at relatively small and isolated paved critical source areas, from about 0.1 to 1 ha (0.25 to 2.5 acre) in area. These areas would include vehicle service facilities (gas stations, car washes, oil change stores, etc.), convenience store parking areas and areas used for equipment storage, along with salvage yards. The MCTT is an underground device.

The following figure shows a general cross-sectional view of a MCTT. It includes a special catchbasin followed by a two chambered tank that is intended to reduce a broad range of toxicants (volatile, particulate, and dissolved). The runoff enters the catchbasin chamber by passing over a flash aerator (small column packing balls with counter-current air flow) to remove highly volatile components. This catchbasin also serves as a grit chamber to remove the largest (fastest settling) particles. The second chamber serves as an enhanced settling chamber to remove smaller particles and has inclined tube or plate settlers to enhance sedimentation. This chamber also contains fine bubble diffusers and sorbent pads to further enhance the removal of floatable hydrocarbons and additional volatile compounds. The water is then pumped to the final chamber at a slow rate to maximize pollutant reductions. The final chamber contains a mixed media (sand and peat) slow filter/ion exchange device, with a filter fabric top layer. The MCTT is typically sized to totally contain all of the runoff from a 6 to 20 mm (0.25 to 0.8 in) rain, depending on interevent time, typical rain size, and rain intensity.

These pilot-scale tests were conducted at a remote parting lot on the campus of the University of Alabama at Birmingham. Vehicle maintenance and a fuel pumping facility are also located at this parking area. The parking lot is about 8 acres, and is totally paved. This large-scale pilot-scale test was a pumped operation, where a portion of the runoff from the parking lot was directed to the treatment unit. A float-switch operated pump was installed in a sump at the drainage inlet and automatically pumped runoff to the MCTT during rains, through a grit chamber and then into the main settling chamber. When the main settling chamber was full, another float switch turned the pump off. An aerator was also automatically started at the beginning of the pumping cycle. After 72 hours (time based on laboratory tests and dependent on geometry of the device), the water was then pumped into the filter/sorbent chamber, where it flowed by gravity and was then discharged. During these tests, flow-weighted composite samples were obtained at the inlet, between the grit chamber and main settling chamber, between the main settling chamber and the filter/sorbent chamber, and at the outlet. These samples were analyzed for a wide range of conventional pollutants and toxicants.

The catchbasin/grit chamber for the pilot-scale device was a 25-cm vertical PVC pipe containing about 6 L of 3-cm diameter packing column spheres. The main settling chamber was about 1.3 m2 in area and 1 m deep which with a 72-hour settling time was expected to result in a median toxicity reduction of about 90%. The filter chamber was about 1.5 m2 in area and contained 0.5 m of sand and peat directly on 0.15 m of sand over a fine plastic screen and coarse gravel that covers the underdrain. A Gunderboom(filter fabric covered the top of the filter media to distribute the water over the filter surface by reducing the water infiltration rate through the filter and to provide additional pollutant capture.

During monitoring of the 13 storms at the parking facility, the pilot-scale MCTT was found to have the following overall median reduction rates: 96% for total toxicity, 98% for filtered toxicity, 83% for SS, 60% for COD, 40% for turbidity, 100% for lead, 91% for zinc, 100% for n-Nitro-di-n-proplamine, 100% for pyrene, and 99% for bis (2-ethyl hexyl) phthalate. The color was increased by about 50% due to staining from the peat and the pH decreased by about one-half pH unit, also from the peat media. Ammonia nitrogen was increased by several times, and nitrate nitrogen had low reductions (about 14%). The MCTT therefore operated as intended: it had very effective reduction rates for both filtered and particulate stormwater toxicants and SS. Increased filterable toxicant reductions were obtained in the peat/sand mixed media sorption-ion exchange chamber, at the expense of increased color, lowered pH, and depressed COD and nitrate reduction rates.

The following tables summarize some of the significant percentage changes in concentrations of the constituents as they passed through each chamber (settling chamber, filter, and overall) of the pilot-scale MCTT. No data is shown for the catchbasin/grit chamber because of the lack of significant concentration changes observed:

Median Observed Percentage Changes in Constituent Concentrations

	Main Settling Chamber	Sand/Peat Chamber	Overall Device
Common Constituents			
Total solids	31%	2.6%	32%
Suspended solids	91	-44	83
Turbidity	50	-150	40
PH	-0.3	6.7	7.9
COD	56	-24	60
Nutrients			
Nitrate	27	-5	14
Ammonia	-155	-7	-400
Toxicants			
Microtox((unfiltered)	18	70	96
Microtox((filtered)	64	43	98
Lead	89	38	100
Zinc	39	62	91
n-Nitro-di-n-propylamine	82	100	100
Hexachlorobutadiene	72	83	34
Pyrene	100	n/a	100
Bis(2-ethylhexyl)phthalate	99	-190	99

Birmingham Pilot-Scale MCTT Results (median reductions and median effluent quality)

	Birmingham MCTT(13 events)
suspended solids	83 (5.5 mg/L)
volatile suspended solids	66 (6 mg/L)
COD	60 (17 mg/L)
turbidity	40 (4.4 NTU)
pH	8 (6.4 pH)
ammonia	-210 (0.31 mg/L)
nitrates	24 (1.5 mg/L)
Phosphorus (total)	ndb
Phosphorus (filtered)	nd
Microtox(toxicity (total)	100 (0%)
Microtox(toxicity (filtered)	87 (3%)
Cadmium (total)	18 (0.6 ug/L)
Cadmium (filtered)	16 (0.5 ug/L)
Copper (total)	15 (15 ug/L)
Copper (filtered)	17 (21 ug/L)
Lead (total)	93 (<2 ug/L)
Lead (filtered)	42 (<2 ug/L)
Zinc (total)	91 (18 ug/L)
Zinc (filtered)	54 (6 ug/L)
benzo(a)anthracene	nd
benzo(b)fluoranthene	nd

dibenzo(a,h)anthracene	nd
fluoranthene	100 (<0.6 ug/L)
indeno(1,2,3-cd)pyrene	nd
phenanthrene	nd
pentachlorophenol	100 (<1 ug/L)
phenol	99 (<0.4 ug/L)
pyrene	100 (<0.5 ug/L)

na : not analyzed
ndb: not detected in most of the samples

See the following report or the conference proceeding for a more complete description of this research project:

Pitt, R., B. Robertson, P. Barron, A. Ayyoubi, and S. Clark. Stormwater Treatment at Critical Areas: The Multi-Chambered Treatment Train (MCTT). U.S. Environmental Protection Agency, Wet Weather Flow Management Program, National Risk Management Research Laboratory. EPA/600/R-99/017. Cincinnati, Ohio. 505 pgs. March 1999.

Pitt, R. and B. Robertson. "Treatment of Stormwater from Critical Source Areas Using a Multi-Chambered Treatment Train (MCTT)." 67th Annual Water Environment Federation Conference. Chicago, IL. October 1994.

In addition, see the other MCTT monitoring entries included in this database: a full-sized facility at a municipal/state park parking lot in Minocqua, WI, and another full-sized unit at a public works garage in Milwaukee, WI. Three others are being monitored in Los Angeles County by Caltrans, and they also eventually be described in the database.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Barton Creek Square Shopping Center

BMP Name Barton Creek Square Shopping Center Pond

BMP Type Filter - Combination of Media or Layered Media

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 45

Number of Water Quality Records 445

Minimum Flow Volume 194.70 ac ft

Maximum Flow Volume 7,774.26 ac ft

Watershed Name Barton Creek Square Det. Pond

Watershed Type Test

Total Watershed Area 79.49 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

This report summarizes the precipitation, streamflow, and water quality data collected from September 1982 to September 1984 upstream and downstream from a detention and filtering pond near Barton Creek Square Shopping Center, a large shopping center southwest of downtown Austin. The report also analyzes and presents the effects of this runoff control on streamflow and the quality of runoff water.

The detention and filtering pond has a storage capacity of approximately 3.5 acre-ft and is about 270-ft wide, 320-ft long and a 14-ft max. depth. The bed of the pond consists of three layers of material (fine sand, coarse sand and gravel) that are used to filter water in the pond. For small and moderate-sized storms, the runoff is contained in the detention pond and passes through a filter system; runoff from large storms overflows into the drop outlet.

Rain gage and streamflow and water quality stations were established and operated at the principle points of inflow and outflow from the pond. Rainfall and streamflow data were analyzed to show the relation between rainfall and runoff, the change in peak flow between the inflow and outflow, and the water budget. Water quality data were analyzed by comparing the discharge-weighted and peak concentrations and loads of selected constituents computed at the inflow station with values computed at outflow stations.

Discharge-weighted densities of fecal-coliform and fecal-streptococci bacteria and discharge-weighted concentrations of BOD, COD, TOC, TSS, NH_3+organic N, and total phosphorus generally were larger in the inflow than in the outflow. However, discharge-weighted concentrations of total nitrite plus nitrate nitrogen and dissolved solids generally were much smaller in the inflow than in the outflow.
Measured peak concentrations or densities of most constituents in the inflow were significantly larger than those in the outflow. Loads of most constituents and total numbers of bacteria were significantly larger in the inflow than in the outflow.

This pond is served as a detention as well as filtering pond, since the bed of pond consists of layers that used to filter water in the pond.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Seton Pond Facility

BMP Name	Seton Pond Filtration Facility (2)	**Watershed Name**	Seton Pond Facility
BMP Type	Filter - Combination of Media or Layered Media	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	83.03 ac
State/Country	TX /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	1817		
Minimum Flow Volume	223.46 ac ft		
Maximum Flow Volume	6,180.32 ac ft		

Comments

The performance of sedimentation/filtration systems which are the most common control for treating highway runoff are evaluated in this study. The study includes: 1) monitoring and evaluating the Seton Pond sedimentation/filtration facility in Austin, TX and 2) evaluating the factors that effect sedimentation in a prototype detention basin.The Seton Pond facility is an off-line facility that incorporates a dry extended detention basin and a horizontal bed (vertical flow) sand filter. Automatic samplers and flow meters were installed at three locations in the facility: the influent channel to the sedimentation basin, the sedimentation basin effluent and the filter effluent. The constituents analyzed in the study included TSS, turbidity, COD, TOC, nitrate, TKN, phosphorus and metals.

Removal efficiencies were calculated for each constituent analyzed and for the sedimentation alone and for a combination of sedimentation and filtration. Untreated runoff that bypassed the system was not included in the loading of a constituent and percent removal calculations. Due to the extensive construction activities in the contributing watershed, the sand filter was not put in use during the first six storm events of the monitoring period. These first six storm were treated by and analyzed for only sedimentation.

Since the filter exceeded the design drainage time of 24 hours, runoff from separate rainfall events mixed in the filter and it became impossible to distinguish between runoff generated from different events. Therefore, flow measurement data for separate rainfall events were discarded and a method was developed for determining the average constituent concentration in the effluent from the sand filter and applying the concentration to the total volume of runoff passing through the filter.

Results from the Seton Pond facility show that sedimentation/filtration is an excellent form of treatment for runoff captured in the system (removal percentage for TSS was 89%, turbidity 52%, COD 66%, TOC 62%, nitrate 3%, TKN 26%, phosphorus 51%, zinc 81% and iron 75%); however, the poor hydraulic performance of the sand filter reduces the facility's capture capacity and increases the quantity of untreated runoff that bypasses the system. Results from the prototype experiments show that detention time is more important than outlet design for achieving satisfactory removal of constituents in runoff. Treatment by sedimentation alone is comparable to sedimentation/filtration when adequate and consistent detention times are achieved.

The information on the experiments conducted to study the effectiveness of sedimentation as a method of treating highway runoff in the prototype-scale sedimentation basin were not included in the database as synthetic highway runoff were used in these experiments.
Additional information on the site layout is available from the project report available at : http://www.crwr.utexas.edu/online.html
See online report 97-4. Plan view on page 12; Photos of the site on pages 13,14,15,16 and 17.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name	Stafford NJ Sub. Colony Lakes Soil Save		
BMP Name	Stafford Township NJ inlet Colony Lakes Soil Save	**Watershed Name**	Stafford Township NJ Inlets Co
BMP Type	Filter - Combination of Media or Layered Media	**Watershed Type**	Test
City	Manahawkin	**Total Watershed Area**	5.99 ac
State/Country	NJ /US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	38.80 Inches
Number of Flow Records	14	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	718		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

Located on Jennings Road

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Stafford NJ Subdiv. Colony Lakes EMCON

BMP Name Emcon Unit

Watershed Name Stafford Township NJ Inlets Co

BMP Type Filter - Combination of Media or Layered Media

Watershed Type Test

City Manahawkin

Total Watershed Area 5.19 ac

State/Country NJ /US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 38.80 Inches

Number of Flow Records 12

Avg Annual Storm Duration 10.00 Hour(s)

Number of Water Quality Records 719

Minimum Flow Volume

Maximum Flow Volume

Comments

Located on Jennings Road

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Stafford NJ Subdivision Colony Lakes OCB		
BMP Name	Stafford Township NJ Inlet Colony Lakes	**Watershed Name**	Stafford Township NJ Inlets Co
BMP Type	Filter - Combination of Media or Layered Media	**Watershed Type**	Test
City	Manahawkin	**Total Watershed Area**	10.50 ac
State/Country	NJ /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.80 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	717		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

Located in Jennings Road

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Barton Spgs. Street Inlet Filter Traps

BMP Name Barton Spgs. SIFT

BMP Type Filter - Other Media

City Austin

State/Country TX / US

BMP Installation Date

Number of Flow Records 7

Number of Water Quality Records 310

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Barton Springs Road Watershed

Watershed Type Test

Total Watershed Area 13.36 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

No flow measurements were taken at this site. Only a single grab sample was taken at the filter trap location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Control N on SH 45

BMP Name	Control N on SH 45 Gravel Filter	**Watershed Name**	Control N on SH 45 Watershed
BMP Type	Filter - Other Media	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	5.21 ac
State/Country	TX / US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	18	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	322		
Minimum Flow Volume	83.34 ac ft		
Maximum Flow Volume	655.31 ac ft		

Comments

The highway pollutant (solids, organic carbon, metals, oil and grease, and nitrate) removal efficiency of a liquid materials trap and a vertical gravel filter (preceded by a sedimentation basin) in series are evaluated in this report. The test site is located on State Highway 45 in Austin, TX. The treatment system was evaluated for 9 storm events. The report also summarized the following investigations, which were not included in the database:
1. Evaluation of hydraulic performance of sand and gravel filters at six test sites along highways in Austin.
2. Bench-scale studies to evaluate the removal efficiency of various types of filters and/or adsorption media (including sands and gravels, compost and zeolites) for treating highway runoff.

The liquid materials trap and gravel filter had good removal of solids (60%), poor (sometimes resulting in an increase of the constituent in the effluent) to good (63%) removal of metals, fair removal of oil and grease (18%), no removal of nitrate, total carbon and dissolved carbon (i.e., effluent concentrations were higher than influent concentrations).

Good data report. Extensive modeling of flow parameters where the parameters could not be measured in the field. However, some essential data (specific information pertaining to the BMPs) were not included in the report.
Original flow and precipitation files were corrupted, so it was not possible to provide or retrieve this information for this report.
Additional information on the site layout is available from the project report available at : http://www.crwr.utexas.edu/online.html See online report 95-8. A schematic of the BMP layout is provided in Figure 3.10. Photographs are provided in Figures 3.1 and 3.2. The specifications for the BMP are provided on page 23.

Average Pollutant Removal Efficiencies *See notes at end of report.

NITRATE NITROGEN, TOTAL (MG/L AS N)	36 %
ZINC, TOTAL (UG/L AS ZN)	85 %
NICKEL, TOTAL (UG/L AS NI)	50 %
LEAD, TOTAL (UG/L AS PB)	49 %
IRON, TOTAL (UG/L AS FE)	62 %
COPPER, TOTAL (UG/L AS CU)	64 %
CHROMIUM, TOTAL (UG/L AS CR)	42 %
CADMIUM, TOTAL (UG/L AS CD)	50 %
PHOSPHORUS, TOTAL (MG/L AS P)	48 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	75 %
RESIDUE, TOTAL VOLATILE (MG/L)	65 %
COD, .025N K2CR2O7 MG/L	49 %
CARBON, TOTAL ORGANIC (MG/L AS C)	29 %
	%

Test Site Name Downtown Street Inlet Filter Traps

BMP Name	Downtown SIFT	**Watershed Name**	Downtown Street Inlet Filter T
BMP Type	Filter - Other Media	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	12.28 ac
State/Country	TX / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	7	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	308		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

Also known as 5th Street Inlet Filter Traps. No flow measurements were taken at this site. Only a single grab sample was taken at the filter trap location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Gillis Park Street Inlet Filter Traps

BMP Name	Gillis Park SIFT	**Watershed Name**	Gillis Park Watershed
BMP Type	Filter - Other Media	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	21.11 ac
State/Country	TX /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	7	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	631		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

No flow measurements were taken at this site. Only a single grab sample was taken at the filter trap location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Kearny Mesa MS

BMP Name	Kearny Mesa	**Watershed Name**	Kearny Mesa
BMP Type	Filter - Other Media	**Watershed Type**	Test
City	San Diego	**Total Watershed Area**	1.50 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	36	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	696		
Minimum Flow Volume	8.56 ac ft		
Maximum Flow Volume	654.94 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Lake Stevens compost filter

BMP Name	compost 1	**Watershed Name**	Lake Stevens
BMP Type	Filter - Other Media	**Watershed Type**	Test
City	Lake Stevens	**Total Watershed Area**	0.23 ac
State/Country	WA/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	92		

Minimum Flow Volume 0.28 ac ft

Maximum Flow Volume 7.97 ac ft

Comments

Precipitation values were measured off-site at a location approximately 2 miles from the compost filter sampling location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Zilker Park Street Inlet Filter Traps

BMP Name Zilker Park SIFT

BMP Type Filter - Other Media

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 6

Number of Water Quality Records 545

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Zilker Park Watershed

Watershed Type Test

Total Watershed Area 110.25 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

No flow measurements were taken at this site. Only a single grab sample was taken at the filter trap location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Lakewood P&R

BMP Name Lakewood

BMP Type Filter - Peat Mixed With Sand

City Downey

State/Country CA /US

BMP Installation Date

Number of Flow Records 20

Number of Water Quality Records 424

Minimum Flow Volume 20.20 ac ft

Maximum Flow Volume 169.16 ac ft

Watershed Name Lakewood

Watershed Type Test

Total Watershed Area 1.90 ac

Watershed Area Disturbed

Avg Annual Rainfall 11.65 Inches

Avg Annual Storm Duration 11.70 Hour(s)

Comments

The following required design information is not relevant to this device including “Permanent Pool Length”, “Surcharge Detention Volume”, “Surcharge Detention Volume Surface Area”, “Surcharge Detention Volume Length”, “Surcharge Detention Volume Depth”, “Surcharge Detention Volume Drain time” and “Angle of sloping or vertical filter media”. Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	MCTT, Pilot Scale UAB, Birmingham, AL		
BMP Name	MCTT Catchbasin	**Watershed Name**	UAB
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Birmingham	**Total Watershed Area**	8.01 ac
State/Country	AL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	50.71 Inches
Number of Flow Records	52	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	2650		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

This monitoring activity was funded by the EPA's Wet Weather Flow Research Program, Edison, NJ, under the direction of Richard Field. The field monitoring was performed by Robert Pitt, Department of Civil and Environmental Engineering at the University of Alabama at Birmingham. The estimated total monitoring effort was about $150,000 (including MCTT development costs and bench-scale tests). The facility was installed in 1997 and 13 events were monitored over a 6 month period.

The annual rainfall in Birmingham is about 55 inches per year, and measurable snowfall is rare (every several years). Summers are characterized by hot and humid conditions, while winters are more mild and drier. Fall is the driest season.

The multi-chambered treatment tank (MCTT) is a combination device having numerous unit processes, including: an initial inlet grit chamber, a main sedimentation (augmented with lamella plates) chamber, with sorbent pillows and aeration, and a final filter/sorption chamber. Each unit is specifically designed for a certain capacity and specific function and is intended for stormwater treatment at critical source areas, especially for high removal levels of heavy metal and organic toxicants. It was developed after extensive field and laboratory treatability tests. The EPA research report (referenced at end of comments) has much information that should be helpful to others wishing to develop other devices that may be used at critical source areas. The MCTT is most suitable for use at relatively small and isolated paved critical source areas, from about 0.1 to 1 ha (0.25 to 2.5 acre) in area. These areas would include vehicle service facilities (gas stations, car washes, oil change stores, etc.), convenience store parking areas and areas used for equipment storage, along with salvage yards. The MCTT is an underground device.

The following figure shows a general cross-sectional view of a MCTT. It includes a special catchbasin followed by a two chambered tank that is intended to reduce a broad range of toxicants (volatile, particulate, and dissolved). The runoff enters the catchbasin chamber by passing over a flash aerator (small column packing balls with counter-current air flow) to remove highly volatile components. This catchbasin also serves as a grit chamber to remove the largest (fastest settling) particles. The second chamber serves as an enhanced settling chamber to remove smaller particles and has inclined tube or plate settlers to enhance sedimentation. This chamber also contains fine bubble diffusers and sorbent pads to further enhance the removal of floatable hydrocarbons and additional volatile compounds. The water is then pumped to the final chamber at a slow rate to maximize pollutant reductions. The final chamber contains a mixed media (sand and peat) slow filter/ion exchange device, with a filter fabric top layer. The MCTT is typically sized to totally contain all of the runoff from a 6 to 20 mm (0.25 to 0.8 in) rain, depending on interevent time, typical rain size, and rain intensity.

These pilot-scale tests were conducted at a remote parting lot on the campus of the University of Alabama at Birmingham. Vehicle maintenance and a fuel pumping facility are also located at this parking area. The parking lot is about 8 acres, and is totally paved. This large-scale pilot-scale test was a pumped operation, where a portion of the runoff from the parking lot was directed to the treatment unit. A float-switch operated pump was installed in a sump at the drainage inlet and automatically pumped runoff to the MCTT during rains, through a grit chamber and then into the main settling chamber. When the main settling chamber was full, another float switch turned the pump off. An aerator was also automatically started at the beginning of the pumping cycle. After 72 hours (time based on laboratory tests and dependent on geometry of the device), the water was then pumped into the filter/sorbent chamber, where it flowed by gravity and was then discharged. During these tests, flow-weighted composite samples were obtained at the inlet, between the grit chamber and main settling chamber, between the main settling chamber and the filter/sorbent chamber, and at the outlet. These samples were analyzed for a wide range of conventional pollutants and toxicants.

The catchbasin/grit chamber for the pilot-scale device was a 25-cm vertical PVC pipe containing about 6 L of 3-cm diameter packing column spheres. The main settling chamber was about 1.3 m2 in area and 1 m deep which with a 72-hour settling time was expected to result in a median toxicity reduction of about 90%. The filter chamber was about 1.5 m2 in area and contained 0.5 m of sand and peat directly on 0.15 m of sand over a fine plastic screen and coarse gravel that covers the underdrain. A Gunderboom(filter fabric covered the top of the filter media to distribute the water over the filter surface by reducing the water infiltration rate through the filter and to provide additional pollutant capture.

During monitoring of the 13 storms at the parking facility, the pilot-scale MCTT was found to have the following overall median reduction rates: 96% for total toxicity, 98% for filtered toxicity, 83% for SS, 60% for COD, 40% for turbidity, 100% for lead, 91% for zinc, 100% for n-Nitro-di-n-proplamine, 100% for pyrene, and 99% for bis (2-ethyl hexyl) phthalate. The color was increased by about 50% due to staining from the peat and the pH decreased by about one-half pH unit, also from the peat media. Ammonia nitrogen was increased by several times, and nitrate nitrogen had low reductions (about 14%). The MCTT therefore operated as intended: it had very effective reduction rates for both filtered and particulate stormwater toxicants and SS. Increased filterable toxicant reductions were obtained in the peat/sand mixed media sorption-ion exchange chamber, at the expense of increased color, lowered pH, and depressed COD and nitrate reduction rates.

The following tables summarize some of the significant percentage changes in concentrations of the constituents as they passed through each chamber (settling chamber, filter, and overall) of the pilot-scale MCTT. No data is shown for the catchbasin/grit chamber because of the lack of significant concentration changes observed:

Median Observed Percentage Changes in Constituent Concentrations

	Main Settling Chamber	Sand/Peat Chamber	Overall Device
Common Constituents			
Total solids	31%	2.6%	32%
Suspended solids	91	-44	83
Turbidity	50	-150	40
PH	-0.3	6.7	7.9
COD	56	-24	60
Nutrients			
Nitrate	27	-5	14
Ammonia	-155	-7	-400
Toxicants			
Microtox((unfiltered)	18	70	96
Microtox((filtered)	64	43	98
Lead	89	38	100
Zinc	39	62	91
n-Nitro-di-n-propylamine	82	100	100
Hexachlorobutadiene	72	83	34
Pyrene	100	n/a	100
Bis(2-ethylhexyl)phthalate	99	-190	99

Birmingham Pilot-Scale MCTT Results (median reductions and median effluent quality)

	Birmingham MCTT(13 events)
suspended solids	83 (5.5 mg/L)
volatile suspended solids	66 (6 mg/L)
COD	60 (17 mg/L)
turbidity	40 (4.4 NTU)
pH	8 (6.4 pH)
ammonia	-210 (0.31 mg/L)
nitrates	24 (1.5 mg/L)
Phosphorus (total)	ndb
Phosphorus (filtered)	nd
Microtox(toxicity (total)	100 (0%)
Microtox(toxicity (filtered)	87 (3%)
Cadmium (total)	18 (0.6 ug/L)
Cadmium (filtered)	16 (0.5 ug/L)
Copper (total)	15 (15 ug/L)
Copper (filtered)	17 (21 ug/L)
Lead (total)	93 (<2 ug/L)
Lead (filtered)	42 (<2 ug/L)
Zinc (total)	91 (18 ug/L)
Zinc (filtered)	54 (6 ug/L)
benzo(a)anthracene	nd
benzo(b)fluoranthene	nd
dibenzo(a,h)anthracene	nd
fluoranthene	100 (<0.6 ug/L)
indeno(1,2,3-cd)pyrene	nd
phenanthrene	nd
pentachlorophenol	100 (<1 ug/L)

phenol	99 (<0.4 ug/L)
pyrene	100 (<0.5 ug/L)

na : not analyzed
ndb: not detected in most of the samples

See the following report or the conference proceeding for a more complete description of this research project:

Pitt, R., B. Robertson, P. Barron, A. Ayyoubi, and S. Clark. Stormwater Treatment at Critical Areas: The Multi-Chambered Treatment Train (MCTT). U.S. Environmental Protection Agency, Wet Weather Flow Management Program, National Risk Management Research Laboratory. EPA/600/R-99/017. Cincinnati, Ohio. 505 pgs. March 1999.

Pitt, R. and B. Robertson. "Treatment of Stormwater from Critical Source Areas Using a Multi-Chambered Treatment Train (MCTT)." 67th Annual Water Environment Federation Conference. Chicago, IL. October 1994.

In addition, see the other MCTT monitoring entries included in this database: a full-sized facility at a municipal/state park parking lot in Minocqua, WI, and another full-sized unit at a public works garage in Milwaukee, WI. Three others are being monitored in Los Angeles County by Caltrans, and they also eventually be described in the database.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

Test Site Name Via Verde P&R

BMP Name	Via Verde	**Watershed Name**	Via Verde
BMP Type	Filter - Peat Mixed With Sand	**Watershed Type**	Test
City	San Dimas	**Total Watershed Area**	1.10 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Numher of Flow Records	16	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	322		
Minimum Flow Volume	10.18 ac ft		
Maximum Flow Volume	114.21 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes:** **Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Airpark

BMP Name	Airpark Sand Filter	**Watershed Name**	Airpark Sand Filter Watershed
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Alexandria	**Total Watershed Area**	0.70 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	560		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

Two Delaware Sand Filters were constructed in the Parking lot near National Airport in Alexandria, Virginia, to treat the runoff from the parking lot and meet the pollutant removal requirements of the Virginia Chesapeake Bay Preservation Act and the Stormwater Management Act. The objective of this study was to determine the removal efficiency of one of the sand filter BMPs (the south filter) for 15 constituents, including solids, nutrients, heavy metals BOD and TPH. The BMP influent and effluent was monitored for 20 storms events, and the performance was compared to other operating intermittent sand filters.

Several anomalies in the filters were discovered at the outset of the project: slow drainage (perforated underdrains were installed in the south filter), the outflow drain in the south filter was above the invert of the filter box (this created an environment subject to become anaerobic in the bottom of the filter), and the pipe discharging in the monitoring manhole was too steep for accurate flow measurement (the project team then decided to use calculated flow instead of measured). To further study the anaerobic environment and its effect in the efficiency of removal of pollutants, the research team changed the initial objective of studying both filters to investigating only the south filter. This investigation lead to the development of a compound filter system to enhance nutrient removal.

This study also includes sampling of the filter sand (both new and used), the direct rainfall, and the water in the permanent pool.

The input concentration study showed that the nutrient pollutant concentrations were higher than predicted by the National Urban Runoff Program (NURP). The authors identified the atmospheric deposition as the source of the excess nutrients pollutants.

The anaerobic conditions were found to have an impact in the nutrient pollutant removal efficiency. When in an aerobic state, the south filter had a high total phosphorus (TP) removal (>70%). Anaerobic conditions reduced the TP removal to 60%. The removal efficiency also increased with higher input concentrations. The total nitrogen (TN) removal efficiency was also very high (32-52%) as compared to what had been found in other similar filter studies. The research team concluded that the anaerobic activity was the reason for the high removal rates.

Removal efficiencies for BOD5 were found to be higher than in other existing filters. Removal efficiencies for total suspended solids and zinc increased with input concentrations, and were found to be in the same range as other existing intermittent sand filters.

The study includes an extensive investigation of the input and output concentrations for a variety of constituents. It also includes a detailed comparison of the results with similar operating intermittent sand filters. However, there is limited storm data and important information (I.e., permanent pool water analyses) was omitted. The anomalies encountered in the outset of the project have also affected the final outcome of the investigation. Calculated flows had to be used instead of measured flows due to poor design of the filter discharge pipe.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Birmingham, AL, Wet Pond

BMP Name	SE Landfill Pond	**Watershed Name**	S. Eastern Landfill Pond and F
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Birmingham	**Total Watershed Area**	102.05 ac
State/Country	AL / US	**Watershed Area Disturbed**	63.26 ac
BMP Installation Date		**Avg Annual Rainfall**	50.71 Inches
Number of Flow Records	24	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	85		
Minimum Flow Volume	241.86 ac ft		
Maximum Flow Volume	2,417.80 ac ft		

Comments

A combination wet detention pond/sand filter had been installed at the City of Birmingham's Southeast landfill (Alabama) in the 1980s in order to meet the local NPDES requirements for runoff from the disturbed landfill area (50 NTU). Robert Creel, a University of Alabama at Birmingham graduate student in the Department of Civil Engineering, monitored and evaluated this system as part of his MSCE research during 1990 and 1991.

The total drainage area to the pond was 41.3 ha, including 20.3 ha of bare disturbed soil (the active landfill site), 4 ha of paved highways, and 13.3 ha of mature hardwood forests. The pond included a small isolated pre-settling pond (0.1 ha) at the upper end of the main pond (about 1 ha), and the polishing sand filter (140 m2). Therefore, about 60% of the drainage area was disturbed and the resulting suspended solids and turbidity levels of the drainage water were very high, especially considering that the soil was clayey.

Six storms were monitored between Nov 28, 1990 and January 10, 1991, having the following rain depths: 25, 16, 9, 20, 11, and 13 mm. Almost all of the monitored particles were in the range of 15 to 45 mm. Numerous turbidity measurements were made throughout the monitored events at the four sampling locations. The turbidity of water leaving the small pond was very similar to the sheetflow water entering the small pond (several hundred to several thousand NTU), while the turbidity of the water leaving the large pond was greatly reduced (to between 20 and 50 NTU), which was further reduced by the sand filter (to about 1 to 10 NTU), to levels below the required effluent limit of 50 NTU.

The pond was relatively large for the drainage area size. The landfill was operating under a restrictive NPDES permit and the pond and filter were therefore designed and constructed larger than thought necessary in order to better meet this discharge limit. Since the sand filter clogged quickly and required manual cleaning, it was only used when necessary to ensure the effluent turbidity was less than the discharge limit. Since the pond was over-sized for the site conditions, it was predicted (and shown to have) almost complete removal of the suspended solids.

For detailed project information, see the following report:

Robert Creel. Evaluating Detention Pond Performance with Computer Modeling Verification, MSCE Thesis. Dept. of Civil and Environmental Engineering, University of Alabama at Birmingham, AL. 1994, 137 pgs.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Eastern Regional MS

BMP Name	Eastern SF	**Watershed Name**	Eastern
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Whittier	**Total Watershed Area**	1.50 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	22	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	603		
Minimum Flow Volume	27.40 ac ft		
Maximum Flow Volume	249.12 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Escondido MS

BMP Name	Escondido	**Watershed Name**	Escondido
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Escondido	**Total Watershed Area**	0.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	36	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	695		
Minimum Flow Volume	4.72 ac ft		
Maximum Flow Volume	163.07 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Foothill MS (Sand Filter)

BMP Name	Foothill SF	**Watershed Name**	Foothill (sand)
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Monrovia	**Total Watershed Area**	1.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	26	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	166		
Minimum Flow Volume	12.91 ac ft		
Maximum Flow Volume	844.34 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-5/SR-78 P&R

BMP Name	5/78	**Watershed Name**	5/78 SF
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Vista	**Total Watershed Area**	0.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	36	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	540		
Minimum Flow Volume	5.83 ac ft		
Maximum Flow Volume	115.25 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name La Costa P&R

BMP Name	La Costa PR	**Watershed Name**	La Costa PR
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Carlsbad	**Total Watershed Area**	2.80 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	36	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	648		
Minimum Flow Volume	3.89 ac ft		
Maximum Flow Volume	288.18 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Megginnis Creek

BMP Name Megginis Ck. Marsh

BMP Type Wetland - Channel With Wetland Bottom

City Tallahassee

State/Country FL /US

BMP Installation Date

Number of Flow Records 37

Number of Water Quality Records 2798

Minimum Flow Volume 67.42 ac ft

Maximum Flow Volume 1,097,396.07 ac ft

Watershed Name Megginnis Ck. Marsh/Snd Filter

Watershed Type Test

Total Watershed Area 2,730.50 ac

Watershed Area Disturbed

Avg Annual Rainfall 62.95 Inches

Avg Annual Storm Duration 7.10 Hour(s)

Comments

The report investigated the efficiency of a sand filter and an artificial marsh in removing solids and nutrients from runoff originating from a highly commercialized area in Tallahassee. The BMPs are located on Megginnis Arm Creek which flows into Lake Jackson. The BMPs were monitored for 11 storm events from 1983-1987.

Additional information/studies that were included in the report, but not entered into the database are as follows:
1. Kinetics of nutrient uptake by the marsh
2. Effect of the treatment system on long-term chlorophyll concentrations in Megginnis Arm Creek and Lake Jackson
3. Effects of bypass on the quality of the effluent from the treatment system
4. Effect of different filter fabric materials (fabric between sand and limestone) on particle removal

The sand filter removed more than 90% solids. Filter removal efficiency reduced over time due to plugging. The effluent from the filter showed an increase in calcium, magnesium and nitrate. Nitrifying bacteria in the impoundment basin oxidized ammonia to nitrate which in turn produced nitric acid and dissolved the calcium and magnesium in the limestone filter underdrain. The artificial marsh removed an average of 60-65% of dissolved nutrients.

The data report is comprehensive. Most essential database field information is included, but some important information such as the BMP catchment area and a description of how the flow data were collected is missing. Most of the studies in the report were not included in the database. Very good QA/QC protocol.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name	Termination P&R		
BMP Name	Termination	**Watershed Name**	Termination
BMP Type	Filter - Sand	**Watershed Type**	Test
City	Norwalk	**Total Watershed Area**	2.80 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	18	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	370		
Minimum Flow Volume	14.37 ac ft		
Maximum Flow Volume	633.09 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

***Notes:** Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.*

BMP Test Site Summary Information

Test Site Name Foothill MS (FossilFilter)

BMP Name Foothill FF

BMP Type Filter - Geotextile Fabric Membrane (Vertical)

City Monrovia

State/Country CA /US

BMP Installation Date

Number of Flow Records 11

Number of Water Quality Records 78

Minimum Flow Volume 8.12 ac ft

Maximum Flow Volume 285.43 ac ft

Watershed Name Foothil FF

Watershed Type Test

Total Watershed Area 1.60 ac

Watershed Area Disturbed

Avg Annual Rainfall 11.65 Inches

Avg Annual Storm Duration 11.70 Hour(s)

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Foothill MS (StreamGuard)

BMP Name	Foothill SG	**Watershed Name**	Foothill SG
BMP Type	Filter - Geotextile Fabric Membrane (Vertical)	**Watershed Type**	Test
City	Monrovia	**Total Watershed Area**	0.20 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	11	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	165		
Minimum Flow Volume	6.06 ac ft		
Maximum Flow Volume	244.06 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Las Flores MS (FossilFilter)

BMP Name Las Flores FF

Watershed Name Las Flores FF

BMP Type Filter - Geotextile Fabric Membrane (Vertical)

Watershed Type Test

City Malibu

Total Watershed Area 0.80 ac

State/Country CA /US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 11.65 Inches

Number of Flow Records 10

Avg Annual Storm Duration 11.70 Hour(s)

Number of Water Quality Records 65

Minimum Flow Volume 11.85 ac ft

Maximum Flow Volume 190.24 ac ft

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Las Flores MS (StreamGuard)

BMP Name Las Flores SG

Watershed Name Las Flores SG

BMP Type Filter - Geotextile Fabric Membrane (Vertical)

Watershed Type Test

City Malibu

Total Watershed Area 0.20 ac

State/Country CA /US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 11.65 Inches

Number of Flow Records 9

Avg Annual Storm Duration 11.70 Hour(s)

Number of Water Quality Records 52

Minimum Flow Volume 1.09 ac ft

Maximum Flow Volume 21.59 ac ft

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Rosemead MS (FossilFilter)		
BMP Name	Rosemead FF	**Watershed Name**	Rosemead FF
BMP Type	Filter - Geotextile Fabric Membrane (Vertical)	**Watershed Type**	Test
City	Rosemead	**Total Watershed Area**	0.20 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	10	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	65		
Minimum Flow Volume	1.83 ac ft		
Maximum Flow Volume	91.95 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Rosemead MS (StreamGuard)

BMP Name	Rosemead SG	**Watershed Name**	Rosemead SG
BMP Type	Filter - Geotextile Fabric Membrane (Vertical)	**Watershed Type**	Test
City	Rosemead	**Total Watershed Area**	1.20 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	10	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	65		
Minimum Flow Volume	15.06 ac ft		
Maximum Flow Volume	310.97 ac ft		

Comments

The following required design information is not relevant to this device including "Permanent Pool Volume", "Permanent Pool Surface Area", "Permanent Pool Length", "Surcharge Detention Volume", "Surcharge Detention Volume Surface Area", "Surcharge Detention Volume Length", "Surcharge Detention Volume Depth", "Surcharge Detention Volume Drain time", "Media Surface Area" and "Angle of sloping or vertical filter media". Therefore, these values were not provided for this study. No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name	Addison-Wesley Publishers Interceptor		
BMP Name	Addison-Wesley Incterceptor	**Watershed Name**	Addison-Wesley Interceptor
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Menlo Park	**Total Watershed Area**	4.60 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	17.06 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	13.30 Hour(s)
Number of Water Quality Records	179		
Minimum Flow Volume	178.62 ac ft		
Maximum Flow Volume	486.12 ac ft		

Comments

The study was designed to evaluate the effectiveness of the Jensen Precast High Velocity Stormwater Interceptor as a Best Management Practice (BMP) to treat stormwater runoff from parking lots. The goals of the study are as follows:
-- Estimate the efficiency at which the Jensen Stormwater Interceptor removes pollutant loads from stormwater runoff.
-- During the entire study period, estimate the runoff treated by the interceptor compared with the volume of runoff that bypasses the system.
-- Characterize the quantity and quality of sediments accumulated in the interceptor relative to the volume of stormwater passing through the interceptor and cumulative rainfall.

A Jensen Model JPHV-5000 was installed to treat runoff for a parking lot at Addison-Wesley Publishers. This model was designed to handle flows up to 1000 gpm with a detention time of at least five minutes.

The study was designed to continuously monitor flows through the interceptor, flows by-passing the interceptor, and rainfall for an entire wet weather season. Automated samples of influent and effluent waters were analyzed for total and dissolved trace metals (cadmium, copper, lead, and zinc), total organic carbon (TOC), total suspended solids (TSS), particle size distribution (PSD), five-day biochemical oxygen demand, pH, and total hardness.

Oil and grease removal was evaluated by collecting grab samples during the first two events.

Trapped sediments in the interceptor were quantified and sampled three times (after the first two monitored events, in mid-season, and after the final event of the season). Sediment samples were analyzed for total trace metals (cadmium, copper, lead, and zinc), TOC, total petroleum hydrocarbons (TPH), PSD, percent solids, and polynuclear aromatic hydrocarbons (PAHs).

The total runoff during the study equaled 75 percent of the rainfall volume, and approximately 82 percent of this runoff passed through the interceptor.

The study results led to the following conclusions: (1) The Jensen interceptor effectively removed total copper, total lead, and suspended solids throughout the study period. (2) Removal efficiencies of cadmium, copper, lead, and, to a lesser degree, zinc from stormwater were strongly influenced by both the total concentration of each metal and the degree to which each metal was associated with the particulate fraction. (3) Trace metal concentrations were typically highest during earlier monitored storm events and declined to lower, more consistent levels later in the rainy season. (4) Trace metals in stormwater runoff were most strongly associated with the particulate fraction during the early rainy season. (5) Sediments trapped by the interceptor were predominantly coarse materials, consisting of 72 to 87 percent sand with a median phi size of 3.12 to 3.18. (6) Removal of particulates and associated pollutants was most effective during storm events monitored during the early rainy season when influent concentrations were the highest.

This is a relevant study on the pollutant removal efficiency of a stormwater interceptor device. A possible limitation is that monitoring was done over only one rainy season (a 95-day period).

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Austin Rec Center OSTC		
BMP Name	ARC Oil Seperator	**Watershed Name**	Austin Rec Center Watershed
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	89.99 ac
State/Country	TX /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	28	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	1048		
Minimum Flow Volume	38.08 ac ft		
Maximum Flow Volume	2,515.03 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Charlottesville Stormceptor

BMP Name	Stormceptor STC 3600	**Watershed Name**	UVA Scott Stadium Parking Lot
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	2.50 ac
State/Country	VA / US	**Watershed Area Disturbed**	1.88 ac
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	79		
Minimum Flow Volume	0.14 ac ft		
Maximum Flow Volume	28.58 ac ft		

Comments

The Stormceptor unit is a STC 3600 pre-cast concrete model with a fiberglass disk insert. This unit has a total holding capacity of 3750 gal, a maximum sediment storage capacity of 345 cubic feet, and a maximum oil storage capacity of 880 gal. The maximum flowrate for this unit without bypass is 1.058 cfs. Configuration of the effluent pipe is at 100 degrees with the influent pipe; not the typical 180 degrees, which is the preferred configuration recommended by the manufacturer. The Stormceptor is a vault/reservoir oil and grit separator that operates on a one inch head differential between the influent and effluent pipes. The unit operates under two conditions: normal flow and high flow conditions. During normal flow, the u-shaped weir at the inlet creates a swirl affect and inflow is discharged into the treatment chamber where it eventually reaches the outlet riser pipe. When the inflow rate exceeds the maximum treatable design flowrate, the system undergoes bypass and minimal to no treatment is provided under this condition. Oil, grease, and flotables are trapped under the fiberglass insert while sediment settles to the bottom of the unit.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-210 / Filmore Street

BMP Name	Filmore	**Watershed Name**	Filmore
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Lake View Terrace	**Total Watershed Area**	2.50 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	14	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	210		
Minimum Flow Volume	66.73 ac ft		
Maximum Flow Volume	265.50 ac ft		

Comments

The following required Hydrodynamic Device design fields were not relevant to this device including "WQ Surcharge Detention volume", "Brim full emptying time" "1/2 Brim full emptying time" and "Forebay Volume".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-210 / Orcas Ave

BMP Name	Orcas	**Watershed Name**	Orcas
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Lake View Terrace	**Total Watershed Area**	1.10 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	11.65 Inches
Number of Flow Records	8	**Avg Annual Storm Duration**	11.70 Hour(s)
Number of Water Quality Records	120		
Minimum Flow Volume	22.93 ac ft		
Maximum Flow Volume	116.50 ac ft		

Comments

The following required Hydrodynamic Device design fields were not relevant to this device including "WQ Surcharge Detention volume", "Brim full emptying time" "1/2 Brim full emptying time" and "Forebay Volume".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Indian River Lagoon CDS Unit

BMP Name CDS Unit

BMP Type Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)

City Williams Point

State/Country FL /US

BMP Installation Date

Number of Flow Records 8

Number of Water Quality Records 48

Minimum Flow Volume 5.51 ac ft

Maximum Flow Volume 329.76 ac ft

Watershed Name Indian River

Watershed Type Test

Total Watershed Area 61.45 ac

Watershed Area Disturbed

Avg Annual Rainfall 55.17 Inches

Avg Annual Storm Duration 6.00 Hour(s)

Comments

This device is a CDS unit installed along a ditch at the north end of Brentwood Drive near the Indian River. A total of 5 complete storm events were monitored at this site; however, only data from 4 events were entered into the database because of flow measurements problems on 7/7/98. Inflow and outflow were assumed to be equal through the device for all storm events. Inflow was measured with a bubble guage and a 90-degree v-notch weir. After 1/1/99 the unit was modified by removing a flow limiting plate at the outflow pipe orifice. The flow limiting plate was the suspected culprit of the inaccurate flow measurements recorded for the event not included in the database. After 1/1/99 flow was measured only at the outflow using a doppler area-velocity flow meter.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Jensen Precast (Sacramento)

BMP Name	Sacramento Stormvault	**Watershed Name**	Paratransit site
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Sacramento	**Total Watershed Area**	2.00 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	16.72 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	13.70 Hour(s)
Number of Water Quality Records	180		
Minimum Flow Volume	11.18 ac ft		
Maximum Flow Volume	183.85 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Jensen Precast (UVA) - Phase I

BMP Name	UVA Stormvault Phase I	**Watershed Name**	Albemarle Co Office Building P
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	0.28 ac
State/Country	VA/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	14	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	26		
Minimum Flow Volume	4.30 ac ft		
Maximum Flow Volume	57.64 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Jensen Precast (UVA) - Phase II

BMP Name	UVA Stormvault Phase II	**Watershed Name**	Albemarle Co Office Building P
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	0.28 ac
State/Country	VA/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	30	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	114		
Minimum Flow Volume	2.15 ac ft		
Maximum Flow Volume	50.13 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Madison, WI, Stormceptor

BMP Name	Urban Storm Treatment Unit in Madison, Wisconsin	**Watershed Name**	Maintenance Yard Station no. 0
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Madison	**Total Watershed Area**	4.30 ac
State/Country	WI/US	**Watershed Area Disturbed**	4.30 ac
BMP Installation Date		**Avg Annual Rainfall**	29.41 Inches
Number of Flow Records	90	**Avg Annual Storm Duration**	9.50 Hour(s)
Number of Water Quality Records	1311		
Minimum Flow Volume	2.22 ac ft		
Maximum Flow Volume	481.24 ac ft		

Comments

The USGS and the WI DNR cooperated in monitoring a large hydrodynamic stormwater treatment device (a Stormceptor) at a 4.3 acre public works yard in Madison, WI. The average annual precipitation in Madison is about 35 inches, and the average annual snowfall is about 25 inches. There were some sand and debris piles at the public works yard, and the site was about 90% impervious.

The unit was retrofitted into an existing 24" RCP in 1996, and was 10 ft. in diameter and 12 ft. in depth. Flow measurements were made and water samples were collected at the inlet to, outlet from, and bypass around the treatment chamber of the device. The estimated cost for monitoring the treatment unit was about $40,000. About 90 percent of the runoff water from the drainage area was treated by the unit. The remaining 10 percent bypassed the treatment chamber when the flow rate reached approximately 500 gallons per minute.

Forty-five flow-weighted composite influent and effluent samples were collected and analyzed for a broad list of constituents (including conventional pollutants, toxicants, particle size and sediment characteristics). In addition, the accumulated sediment was also measured and compared to the sampled loads.

According to the USGS, the suspended solids removal efficiency of the treatment chamber was about 25 percent, and the efficiency of the unit as a whole was 21 percent. A 24 percent difference between the estimated amount (405 kilograms) and the actual amount (536 kilograms) of retained material in the treatment chamber was attributed to bedload material that the automatic samplers could not effectively collect. Therefore, about 8 percent of the total mass in the untreated runoff water was estimated as the unsampled bedload. If the unsampled bedload material was accounted for, the treatment chamber efficiency would increase to about 33 percent.

About 19 percent of the total phosphorus was removed from the water that passed through the treatment chamber and 17 percent was removed by the unit as a whole. Total polycyclic aromatic hydrocarbon (PAH) loads were reduced about 39 percent by the treatment chamber and 34 percent by the unit as a whole; these were some of the most effectively removed constituents. Total metals were reduced about 20 to 30 percent by both the treatment chamber and the unit as a whole. In general, dissolved constituents were unaffected by the unit.

The Stormceptor was cleaned at the end of the monitoring period. Cleaning of the sump and removal of accumulated floating oil is generally needed every year or so. The material retained in the treatment chamber had high concentrations of lead and PAH and may be subject to special disposal restrictions based on those concentrations and the presence of benzo(a)anthracene.

Complete project information is available from the USGS report: Waschbusch, R.J. Evaluation of the Effectiveness of an Urban Stormwater Treatment Unit in Madison, Wisconsin, 1996-97. US Geological Survey Water Resources Investigations Report 99-4195. Middleton, WI. 1999.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name MCTT, Pilot Scale UAB, Birmingham, AL

BMP Name MCTT Catchbasin

BMP Type Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)

City Birmingham

State/Country AL/US

BMP Installation Date

Number of Flow Records 52

Number of Water Quality Records 2650

Minimum Flow Volume

Maximum Flow Volume

Watershed Name UAB

Watershed Type Test

Total Watershed Area 8.01 ac

Watershed Area Disturbed

Avg Annual Rainfall 50.71 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

This monitoring activity was funded by the EPA's Wet Weather Flow Research Program, Edison, NJ, under the direction of Richard Field. The field monitoring was performed by Robert Pitt, Department of Civil and Environmental Engineering at the University of Alabama at Birmingham. The estimated total monitoring effort was about $150,000 (including MCTT development costs and bench-scale tests). The facility was installed in 1997 and 13 events were monitored over a 6 month period.

The annual rainfall in Birmingham is about 55 inches per year, and measurable snowfall is rare (every several years). Summers are characterized by hot and humid conditions, while winters are more mild and drier. Fall is the driest season.

The multi-chambered treatment tank (MCTT) is a combination device having numerous unit processes, including: an initial inlet grit chamber, a main sedimentation (augmented with lamella plates) chamber, with sorbent pillows and aeration, and a final filter/sorption chamber. Each unit is specifically designed for a certain capacity and specific function and is intended for stormwater treatment at critical source areas, especially for high removal levels of heavy metal and organic toxicants. It was developed after extensive field and laboratory treatability tests. The EPA research report (referenced at end of comments) has much information that should be helpful to others wishing to develop other devices that may be used at critical source areas. The MCTT is most suitable for use at relatively small and isolated paved critical source areas, from about 0.1 to 1 ha (0.25 to 2.5 acre) in area. These areas would include vehicle service facilities (gas stations, car washes, oil change stores, etc.), convenience store parking areas and areas used for equipment storage, along with salvage yards. The MCTT is an underground device.

The following figure shows a general cross-sectional view of a MCTT. It includes a special catchbasin followed by a two chambered tank that is intended to reduce a broad range of toxicants (volatile, particulate, and dissolved). The runoff enters the catchbasin chamber by passing over a flash aerator (small column packing balls with counter-current air flow) to remove highly volatile components. This catchbasin also serves as a grit chamber to remove the largest (fastest settling) particles. The second chamber serves as an enhanced settling chamber to remove smaller particles and has inclined tube or plate settlers to enhance sedimentation. This chamber also contains fine bubble diffusers and sorbent pads to further enhance the removal of floatable hydrocarbons and additional volatile compounds. The water is then pumped to the final chamber at a slow rate to maximize pollutant reductions. The final chamber contains a mixed media (sand and peat) slow filter/ion exchange device, with a filter fabric top layer. The MCTT is typically sized to totally contain all of the runoff from a 6 to 20 mm (0.25 to 0.8 in) rain, depending on interevent time, typical rain size, and rain intensity.

These pilot-scale tests were conducted at a remote parting lot on the campus of the University of Alabama at Birmingham. Vehicle maintenance and a fuel pumping facility are also located at this parking area. The parking lot is about 8 acres, and is totally paved. This large-scale pilot-scale test was a pumped operation, where a portion of the runoff from the parking lot was directed to the treatment unit. A float-switch operated pump was installed in a sump at the drainage inlet and automatically pumped runoff to the MCTT during rains, through a grit chamber and then into the main settling chamber. When the main settling chamber was full, another float switch turned the pump off. An aerator was also automatically started at the beginning of the pumping cycle. After 72 hours (time based on laboratory tests and dependent on geometry of the device), the water was then pumped into the filter/sorbent chamber, where it flowed by gravity and was then discharged. During these tests, flow-weighted composite samples were obtained at the inlet, between the grit chamber and main settling chamber, between the main settling chamber and the filter/sorbent chamber, and at the outlet. These samples were analyzed for a wide range of conventional pollutants and toxicants.

The catchbasin/grit chamber for the pilot-scale device was a 25-cm vertical PVC pipe containing about 6 L of 3-cm diameter packing column spheres. The main settling chamber was about 1.3 m2 in area and 1 m deep which with a 72-hour settling time was expected to result in a median toxicity reduction of about 90%. The filter chamber was about 1.5 m2 in area and contained 0.5 m of sand and peat directly on 0.15 m of sand over a fine plastic screen and coarse gravel that covers the underdrain. A Gunderboom(filter fabric covered the top of the filter media to distribute the water over the filter surface by reducing the water infiltration rate through the filter and to provide additional pollutant capture.

During monitoring of the 13 storms at the parking facility, the pilot-scale MCTT was found to have the following overall median reduction rates: 96% for total toxicity, 98% for filtered toxicity, 83% for SS, 60% for COD, 40% for turbidity, 100% for lead, 91% for zinc, 100% for n-Nitro-di-n-proplamine, 100% for pyrene, and 99% for bis (2-ethyl hexyl) phthalate. The color was increased by about 50% due to staining from the peat and the pH decreased by about one-half pH unit, also from the peat media. Ammonia nitrogen was increased by several times, and nitrate nitrogen had low reductions (about 14%). The MCTT therefore operated as intended: it had very effective reduction rates for both filtered and particulate stormwater toxicants and SS. Increased filterable toxicant reductions were obtained in the peat/sand mixed media sorption-ion exchange chamber, at the expense of increased color, lowered pH, and depressed COD and nitrate reduction rates.

The following tables summarize some of the significant percentage changes in concentrations of the constituents as they passed through each chamber (settling chamber, filter, and overall) of the pilot-scale MCTT. No data is shown for the catchbasin/grit chamber because of the lack of significant concentration changes observed:

Median Observed Percentage Changes in Constituent Concentrations

	Main Settling Chamber	Sand/Peat Chamber	Overall Device
Common Constituents			
Total solids	31%	2.6%	32%
Suspended solids	91	-44	83
Turbidity	50	-150	40
PH	-0.3	6.7	7.9
COD	56	-24	60
Nutrients			
Nitrate	27	-5	14
Ammonia	-155	-7	-400
Toxicants			
Microtox((unfiltered)	18	70	96
Microtox((filtered)	64	43	98
Lead	89	38	100
Zinc	39	62	91
n-Nitro-di-n-propylamine	82	100	100
Hexachlorobutadiene	72	83	34
Pyrene	100	n/a	100
Bis(2-ethylhexyl)phthalate	99	-190	99

Birmingham Pilot-Scale MCTT Results (median reductions and median effluent quality)

	Birmingham MCTT(13 events)
suspended solids	83 (5.5 mg/L)
volatile suspended solids	66 (6 mg/L)
COD	60 (17 mg/L)
turbidity	40 (4.4 NTU)
pH	8 (6.4 pH)
ammonia	-210 (0.31 mg/L)
nitrates	24 (1.5 mg/L)
Phosphorus (total)	ndb
Phosphorus (filtered)	nd
Microtox(toxicity (total)	100 (0%)
Microtox(toxicity (filtered)	87 (3%)
Cadmium (total)	18 (0.6 ug/L)
Cadmium (filtered)	16 (0.5 ug/L)
Copper (total)	15 (15 ug/L)
Copper (filtered)	17 (21 ug/L)
Lead (total)	93 (<2 ug/L)
Lead (filtered)	42 (<2 ug/L)
Zinc (total)	91 (18 ug/L)
Zinc (filtered)	54 (6 ug/L)
benzo(a)anthracene	nd
benzo(b)fluoranthene	nd
dibenzo(a,h)anthracene	nd
fluoranthene	100 (<0.6 ug/L)
indeno(1,2,3-cd)pyrene	nd
phenanthrene	nd
pentachlorophenol	100 (<1 ug/L)

phenol	99 (<0.4 ug/L)
pyrene	100 (<0.5 ug/L)

na : not analyzed
ndb: not detected in most of the samples

See the following report or the conference proceeding for a more complete description of this research project:

Pitt, R., B. Robertson, P. Barron, A. Ayyoubi, and S. Clark. Stormwater Treatment at Critical Areas: The Multi-Chambered Treatment Train (MCTT). U.S. Environmental Protection Agency, Wet Weather Flow Management Program, National Risk Management Research Laboratory. EPA/600/R-99/017. Cincinnati, Ohio. 505 pgs. March 1999.

Pitt, R. and B. Robertson. "Treatment of Stormwater from Critical Source Areas Using a Multi-Chambered Treatment Train (MCTT)." 67th Annual Water Environment Federation Conference. Chicago, IL. October 1994.

In addition, see the other MCTT monitoring entries included in this database: a full-sized facility at a municipal/state park parking lot in Minocqua, WI, and another full-sized unit at a public works garage in Milwaukee, WI. Three others are being monitored in Los Angeles County by Caltrans, and they also eventually be described in the database.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

Test Site Name Sunset Park Baffle Box

BMP Name	Sunset Park Baffle Box #2	**Watershed Name**	Indialantic Watershed Basin H
BMP Type	Hydrodynamic Devices (e.g. Swirl Concentrator, Separation Systems, etc..)	**Watershed Type**	Test
City	Indialantic	**Total Watershed Area**	24.50 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	55.17 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	6.00 Hour(s)
Number of Water Quality Records	24		
Minimum Flow Volume	0.64 ac ft		
Maximum Flow Volume	2.55 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Austin Gravel Trench Lot

BMP Name Austin Gravel Trench

BMP Type Infiltration (Percolation) Trench

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 3

Number of Water Quality Records 21

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Austin Grvl Trnch Lot Watershe

Watershed Type Test

Total Watershed Area 1.36 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The study addresses the following objectives: To determine the stormwater hydrologic and water quality characteristics of nonporous pavements; to determine the relative capability of porous and nonporous pavements to assimilate or reduce typical pollutants in urban runoff through storage and percolation; to evaluate the performance of porous pavement systems with physical characteristics under a range of storm conditions; and to develop a design methodology for porous pavements which can be used by engineers, planners, and building plan reviewers to estimate facility performance at proposed development sites.

This paper studies a Gravel Trench parking lot during 3 simulated storm events. Observations during the storm events indicated the small diameter surface gravel causing a small amount of surface runoff to flow across the top of the trench. A first-flush effect was observed during the event for TSS, COD, Pb, TN and Zn. The observed high suspended solids concentration were possibly attributable to scouring of backfill material which supports an asphalt ramp constructed across the gravel trench. Although there is some information on water quality for this BMP, the primary function of the gravel trench study was to compare to a porous asphalt pavement BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Alameda MS

BMP Name Alameda

BMP Type Oil & Water Separator

City Los Angeles

State/Country CA /US

BMP Installation Date

Number of Flow Records 10

Number of Water Quality Records 36

Minimum Flow Volume 4.19 ac ft

Maximum Flow Volume 97.25 ac ft

Watershed Name Alameda

Watershed Type Test

Total Watershed Area 0.80 ac

Watershed Area Disturbed

Avg Annual Rainfall 11.65 Inches

Avg Annual Storm Duration 11.70 Hour(s)

Comments

The following required Hydrodynamic Device design fields were not relevant to this device including "WQ Surcharge Detention volume", "Brim full emptying time" "1/2 Brim full emptying time" and "Forebay Volume". No influent flow or water quality data was monitored at this site, however, this study can be used to compare effluent water quality between BMPs of a similar nature.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Boeing Computer Services

BMP Name	Boeing Detention Pond	**Watershed Name**	Boeing Watershed
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Seattle	**Total Watershed Area**	18.00 ac
State/Country	WA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	7	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	745		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

This study was primarily concerned with the treatability of urban stormwater for oil and grease using a detention basin/coalescing plate oil separator treatment system. The project site was an 18 acre controlled and mostly impervious area (parking lot) which drained into a small pond (approximately 165,000 ft^3 in total volume). Data was collected during 3 natural storms and 4 synthetic storms. The synthetic storms were generated using the domestic water supply and irrigation sprinklers attached to fire hydrants on-site. The drainage area for the synthetic storms was approximately 1.0 acre. All samples were grab samples and the parameters analyzed were: Total Suspended Solids (TSS), Total Phosphorous (TP), Nitrate (NO3), Nitrate-nitrogen (NO3-N), Oil and Grease (O/G), Arsenic (AS), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb), and Zinc (Zn).

The detention pond at the Boeing site removed between -122 and 99% of the TSS, with removal efficiency being highest when influent concentrations were the highest. By eliminating the cases where influent TSS was < 7 mg/l, the removal efficiency for TSS increased to 77- 90%. Most of the lead, 25-33% of the total phosphorous and variable proportions of other metals were removed by the system. The oil and grease concentrations in the runoff were very low, and the capacity of the coalescing plate was not utilized. Materials in the separator added substantial quantities of Zinc to the runoff.

The major factor limiting the usefulness of this study is that its purpose was to evaluate the effectiveness of coalescing plate oil/water separator and the runoff from the site contained very low concentrations of oil and grease. There is a lot of water quality information provided in the study but it may be difficult to use. Samples were taken after the storm event for the 2 of the 3 natural events. For the other natural event, there was precipitation for four hours preceding the event and for 2 hours into the sampling period. For the synthetic events, sampling was done at the influent to the pond during the storm events and at the effluent and oil/water separator 4 to 24 hrs after the event. Composite samples were taken at all three sampling stations for the first 4 storms and only at station 1(the influent to the pond) for the other 3 storms.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Charlottesville Isoilater O&G Separator

BMP Name Char Oil & Grit Separator

BMP Type Oil & Water Separator

City Charlottesville

State/Country VA/US

BMP Installation Date

Number of Flow Records 75

Number of Water Quality Records 194

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Bus Maintenance/Parking Lot

Watershed Type Test

Total Watershed Area 0.20 ac

Watershed Area Disturbed

Avg Annual Rainfall 38.26 Inches

Avg Annual Storm Duration 10.90 Hour(s)

Comments

The Isoilater is a vault/reservoir structure with a storage capacity of 1000 gallons and a maximum treatable flowrate of 0.64 cfs This Isoilater is designed to treat the first flush flows of rainfall events and bypass higher flows by a hydraulic jump using a v-notch overflow plate. The unit consists of a fiberglass separator device that is housed in a conventional diameter manhole. Beneath the separator device is the treatment tank, which consists of a manhole segment of the diameter and height needed to provide for the storage capacity of the unit. The unit operates under two conditions: full treatment (flowrate less than the maximum treatable flowrate) and no treatment or partial treatment (flowrate at or near maximum bypass flowrate). The unit is designed to operate on a head differential across the device and the riser pipe. Treatable flow falls into the treatment chamber by means of a specially designed overflow plate placed over the opening of a down pipe.

In addition to runoff from storm events, approximately 1 to 2 times per month, the Charlottesville Isoilater receives "runoff" from the city bus maintenance/parking lot during washing of the city bus engines and the garage floor. A compound called Rockfort IS-1000 is used to wash the buses. It consists of sodium metasilicate, ethylene glycol monobutyl ether, and sodium dodecylbenezene sufonate. The concrete garage floor is washed with sodium meatsilicate. Inflow pollutant concentrations during the engine and garage floor washings were high compared to samples during rainfall events and to samples collected immediately prior to washing events. In most cases, no significant outflow was observed during maintenance events, therefore most pollutants were retained by the Isoilater. This was most likely due to the low volume of "runoff" (approximately 20-30 gal) which was less than 5% of Isoilater storage volume. On 8/28/97, some of the accumulated material was siphoned out of the unit, resulting in a decrease in level of approximately 16 in, which was most likely the reason for no flow out of the system during the garage floor washing. The high concentration of pollutants entering the unit during the washing events results in a significant mass load to the unit, even though the volume is low. Since there is no outflow, pollutants are concentrated in the vault. During subsequent storms, outflow concentrations of several pollutants were higher than for the inflow due to wash-out of accumulated matter. "Runoff" from bus engine and garage floor washing is theoretically similar to an accidental oil spill, which is normally associated with pollution of high concentration and small volume. Since most of the volume was retained within the unit, the engine and garage floor washing serve as a good example of the potential benefit of the vault in preventing contamination of a receiving water body from an accidental spill. However, pollution may be released during subsequent low-flow events; therefore units should be cleaned out as soon as possible after spills.

In addition to storm events, samples were periodically collected from the standing water in the vault to help characterize accumulated waste. Dry weather grab samplers were collected from three strata in the vault: the top 'oil and grease' layer (V1), a middle 'outflow' layer (V2), and a bottom 'sediment' layer (V3), using a "Kemmerer," or depth-sampler. Based on the total depth of the vault, the "top" sample was taken at approximately 0.5 ft below the water level; the "middle" sample was taken at half of the total depth, and the "bottom" sample was taken when the Kemmerer touched the bottom platform.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Warrenton Isoilater Oil/Grit Separator		
BMP Name	Warr Oil and Grit Separator	**Watershed Name**	Route 17 Bypass
BMP Type	Oil & Water Separator	**Watershed Type**	Test
City	Warrenton	**Total Watershed Area**	0.20 ac
State/Country	VA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	29	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	107		
Minimum Flow Volume	2.03 ac ft		
Maximum Flow Volume	68.48 ac ft		

Comments

The Isoilater is a vault/reservoir structure with a storage capacity of 2000 gallons, a maximum treatable flowrate of 0.64 cfs, a residence time of approximately 7 minutes, and an inlet pipe diameter of 18 inches. This particular model has an oil holding capacity of 300 gal, a sediment holding capacity of 201 cubic feet, a maximum treatable acreage of 1.41 acres and a maximum bypass flowrate of 16 cfs. The Isoilater unit was installed with both the influent and effluent pipes in a straight line configuration. This Isoilater is designed to treat the first flush flows of rainfall events and bypass higher flows by a hydraulic jump using a v-notch overflow plate. The unit consists of a fiberglass separator device that is housed in a conventional diameter manhole. Beneath the separator device is the treatment tank, which consists of a manhole segment of the diameter and height needed to provide for the storage capacity of the unit. The unit operates under two conditions: full treatment (flowrate less than the maximum treatable flowrate) and no treatment or partial treatment (flowrate at or near maximum bypass flowrate). The unit is designed to operate on a head differential across the device and the riser pipe. Treatable flow falls into the treatment chamber by means of a specially designed overflow plate placed over the opening of a down pipe.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Austin Asphalt Lot

BMP Name Austin Asphalt Lot

BMP Type Porous Pavement - Asphalt

City Austin

State/Country TX / US

BMP Installation Date

Number of Flow Records 2

Number of Water Quality Records 19

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Austin Asphalt Lot Watershed

Watershed Type Test

Total Watershed Area 0.26 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The study addresses the following objectives: To determine the stormwater hydrologic and water quality characteristics of nonporous pavements; to determine the relative capability of porous and nonporous pavements to assimilate or reduce typical pollutants in urban runoff through storage and percolation; to evaluate the performance of porous pavement systems with physical characteristics under a range of storm conditions; and to develop a design methodology for porous pavements which can be used by engineers, planners, and building plan reviewers to estimate facility performance at proposed development sites.

This paper studies an Asphalt parking lot during one simulated and one natural storm event. Lack of depression storage on the lot, the small surface area, and a relatively smooth surface contributed to low detention times indicating a rapid catchment response. A first-flush effect was observed for TSS and COD levels during the two events. Relatively high COD levels recorded at this lot may be due to perennial litterfall. Organic debris accumulates on the pavement surface from deciduous trees overhanging the lot. Although there is some information on water quality for this BMP, the primary function of the conventional concrete parking lot study was to compare to a porous asphalt pavement BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Austin Porous Asphalt Lot

BMP Name	Austin Porous Asphalt Lot	**Watershed Name**	Austin Porous Pvment Watershed
BMP Type	Porous Pavement - Asphalt	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	0.35 ac
State/Country	TX / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	3	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	21		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

The study addresses the following objectives: To determine the stormwater hydrologic and water quality characteristics of nonporous pavements; to determine the relative capability of porous and nonporous pavements to assimilate or reduce typical pollutants in urban runoff through storage and percolation; to evaluate the performance of porous pavement systems with physical characteristics under a range of storm conditions; and to develop a design methodology for porous pavements which can be used by engineers, planners, and building plan reviewers to estimate facility performance at proposed development sites.

This paper studies a porous asphalt parking lot during 3 simulated storm events. Based on the Austin experience, porous asphalt construction costs are comparable to costs for conventional asphalt construction. In compaction of the porous asphalt pavement, the type of compaction is less important than compacting the surface at a temperature near 180 degrees Fahrenheit. The computer simulation program PORPAV can be used to estimate the stormwater hydraulic response of both porous and nonporous pavement facilities. The design methodology developed during this study is an effective tool for preliminary design of a porous asphalt facility. Although this study is not strictly focused on water quality, there is a wealth of detailed information regarding the construction of porous asphalt pavement and the use of the PORPAV computer model as an analytical tool.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Austin Concrete Lot

BMP Name Austin Concrete Lot

BMP Type Porous Pavement - Poured Concrete

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records 3

Number of Water Quality Records 36

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Austin Concrete Lot Watershed

Watershed Type Test

Total Watershed Area 0.37 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The study addresses the following objectives: To determine the stormwater hydrologic and water quality characteristics of nonporous pavements; to determine the relative capability of porous and nonporous pavements to assimilate or reduce typical pollutants in urban runoff through storage and percolation; to evaluate the performance of porous pavement systems with physical characteristics under a range of storm conditions; and to develop a design methodology for porous pavements which can be used by engineers, planners, and building plan reviewers to estimate facility performance at proposed development sites.

This paper studies a concrete parking lot during 3 natural storm events. The water quality of the surface runoff leaving the concrete lot was better than was expected. The conventional concrete detention times were relatively long compared to the other impervious lots, reflecting the storage of rainfall in surface abstractions prior to runoff commencement. First-flush effects were observed for TSS, TN, and Pb during two of the storm events. Although there is some information on water quality for this BMP, the primary function of the conventional asphalt parking lot study was to compare to a porous asphalt pavement BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Austin Lattice Block Lot

BMP Name Austin Lattice Block Lot

BMP Type Porous Pavement - Modular Concrete Block

City Austin

State/Country TX /US

BMP Installation Date

Number of Flow Records

Number of Water Quality Records 21

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Austin Lattice Block Watershed

Watershed Type Test

Total Watershed Area 0.14 ac

Watershed Area Disturbed

Avg Annual Rainfall 31.46 Inches

Avg Annual Storm Duration 8.40 Hour(s)

Comments

The study addresses the following objectives: To determine the stormwater hydrologic and water quality characteristics of nonporous pavements; to determine the relative capability of porous and nonporous pavements to assimilate or reduce typical pollutants in urban runoff through storage and percolation; to evaluate the performance of porous pavement systems with physical characteristics under a range of storm conditions; and to develop a design methodology for porous pavements which can be used by engineers, planners, and building plan reviewers to estimate facility performance at proposed development sites.

This paper studies a lattice block parking lot during 3 simulated storm events. Short detention times at the lattice block lot reflected non-uniform permeabilities of the surface layer resulting in more surface runoff than expected. Water quality samples reflected overland runoff response. TSS and COD consistently displayed a first flush effect and zinc displayed a first flush event during the second simulated storm event. There is not a lot of information to support the benefits of the BMP based on water quality. However, there is good information on construction costs and maintenance costs for a lattice block parking lot. This BMP was studied to compare to the porous asphalt pavement BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Dayton Grass Pavement Parking Lot

BMP Name Dayton Grass Pavement Parking Lot

BMP Type Porous Pavement - Modular Concrete Block

City Dayton

State/Country OH /US

BMP Installation Date

Number of Flow Records 5

Number of Water Quality Records 97

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 14.99 ac ft

Watershed Name Dayton Grass Pvmnt Watershed

Watershed Type Test

Total Watershed Area 0.78 ac

Watershed Area Disturbed

Avg Annual Rainfall 34.93 Inches

Avg Annual Storm Duration 10.00 Hour(s)

Comments

This paper includes several studies that present and evaluate the design, specifications, water runoff, maintenance, and water quality of a grass pavement (lattice block) parking lot. This study includes eleven storm events; however, water quality data is recorded for only five of the storm events. Water quality data was collected for nine parameters using lysimeters at two locations in the grass pavement (lattice block) area and one location in the grass adjacent to the lot. The lawned parking appeared to be functioning adequately as a filter for pollutants. The high cation exchange capacity of the soil in the lot along with its alkaline pH, presents a soil environment that minimizes the mobility of metals and the pollution hazards associated with them. Also, the nitrogen and phosphorous compounds and the metals do not present pollution hazards at their concentrations. The filtering effect will probably be even more effective because, in this study, the groundwater table depth was below the depth at which the samples were collected (one foot below ground surface).

There is not a lot of information to support the benefits of the BMP based on water quality. However, there is good information on construction costs and maintenance costs for a porous parking lot.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Birmingham, AL, Wet Pond

BMP Name SE Landfill Pond

Watershed Name S. Eastern Landfill Pond and F

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

Watershed Type Test

City Birmingham

Total Watershed Area 102.05 ac

State/Country AL /US

Watershed Area Disturbed 63.26 ac

BMP Installation Date

Avg Annual Rainfall 50.71 Inches

Number of Flow Records 24

Avg Annual Storm Duration 8.40 Hour(s)

Number of Water Quality Records 85

Minimum Flow Volume 241.86 ac ft

Maximum Flow Volume 2,417.80 ac ft

Comments

A combination wet detention pond/sand filter had been installed at the City of Birmingham's Southeast landfill (Alabama) in the 1980s in order to meet the local NPDES requirements for runoff from the disturbed landfill area (50 NTU). Robert Creel, a University of Alabama at Birmingham graduate student in the Department of Civil Engineering, monitored and evaluated this system as part of his MSCE research during 1990 and 1991.

The total drainage area to the pond was 41.3 ha, including 20.3 ha of bare disturbed soil (the active landfill site), 4 ha of paved highways, and 13.3 ha of mature hardwood forests. The pond included a small isolated pre-settling pond (0.1 ha) at the upper end of the main pond (about 1 ha), and the polishing sand filter (140 m2). Therefore, about 60% of the drainage area was disturbed and the resulting suspended solids and turbidity levels of the drainage water were very high, especially considering that the soil was clayey.

Six storms were monitored between Nov 28, 1990 and January 10, 1991, having the following rain depths: 25, 16, 9, 20, 11, and 13 mm. Almost all of the monitored particles were in the range of 15 to 45 mm. Numerous turbidity measurements were made throughout the monitored events at the four sampling locations. The turbidity of water leaving the small pond was very similar to the sheetflow water entering the small pond (several hundred to several thousand NTU), while the turbidity of the water leaving the large pond was greatly reduced (to between 20 and 50 NTU), which was further reduced by the sand filter (to about 1 to 10 NTU), to levels below the required effluent limit of 50 NTU.

The pond was relatively large for the drainage area size. The landfill was operating under a restrictive NPDES permit and the pond and filter were therefore designed and constructed larger than thought necessary in order to better meet this discharge limit. Since the sand filter clogged quickly and required manual cleaning, it was only used when necessary to ensure the effluent turbidity was less than the discharge limit. Since the pond was over-sized for the site conditions, it was predicted (and shown to have) almost complete removal of the suspended solids.

For detailed project information, see the following report:

Robert Creel. Evaluating Detention Pond Performance with Computer Modeling Verification. MSCE Thesis. Dept. of Civil and Environmental Engineering, University of Alabama at Birmingham, AL. 1994, 137 pgs.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Carver Ravine Wetland/Detention Facility

BMP Name Carver Ravine Detention Pond

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

City Woodbury

State/Country MN /US

BMP Installation Date

Number of Flow Records

Number of Water Quality Records 410

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Carver Ravine wet/de Watershed

Watershed Type Test

Total Watershed Area 431.94 ac

Watershed Area Disturbed 28.81 ac

Avg Annual Rainfall 25.52 Inches

Avg Annual Storm Duration 9.80 Hour(s)

Comments

The facility consists of a small wetland and detention pond, in-line. The entire area of the combined wetland/detention facility is 4.3 acres. Evaluation of this facility is complicated by the fact that there is a pumped discharge into the study watershed when a hordering closed-end detention facility reaches a prescribed elevation. Contributions from the pumped storage appeared to occur quite unpredictably, apparently a function of total rain (usually any amount over 0.33") and pervious period without pumping. The routine weekly pump testing contributed a volume of water enough to often qualify as an event.

The period of data collection for the study was very hot and dry. A drought condition existed for most of the sampling period, limiting available rainfall events that could be sampled. It is suspected that the drought resulted in more highly concentrated runoff moving into facilities that contained reduced permanent pools. Precipitation during the period of study was well below normal. The prolonged lack of rain lowered the groundwater table, dried up baseflow, and decreased the volume of the permanent pool. With little or no runoff coming from pervious surfaces all runoff was essentially from impervious surfaces only. The Carver Ravine site was not included in the initial site selection but was added in April 1988. As a result, there were fewer data collected at the site than others.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Central Park Wet Pond

BMP Name	Central Park Wet pond	**Watershed Name**	Central Park Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Austin	**Total Watershed Area**	1,639.63 ac
State/Country	TX /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	31.46 Inches
Number of Flow Records	30	**Avg Annual Storm Duration**	8.40 Hour(s)
Number of Water Quality Records	4252		
Minimum Flow Volume	819.60 ac ft		
Maximum Flow Volume	365,316.20 ac ft		

Comments

Need EPA reach code.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name COCKROACH BAY AGRICULTURAL SITE

BMP Name Wet Pond

Watershed Name COCKROACH BAY AGRICULTURAL SIT

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

Watershed Type Test

City RUSKIN

Total Watershed Area 210.01 ac

State/Country FL/US

Watershed Area Disturbed 189.01 ac

BMP Installation Date

Avg Annual Rainfall 46.86 Inches

Number of Flow Records 152

Avg Annual Storm Duration 5.50 Hour(s)

Number of Water Quality Records 2871

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 25,446.13 ac ft

Comments

The drainage basin consists entirely of active and fallow row crop agricultural fields. The fields are irrigated using ground water and the crops are winter vegtables. Runoff from the basin flows into a grass-lined ditch before entering the pond through a submerged culvert. The control elevation is 2.5 NGVD. The pond does not discharge until well into the rainy season, which accounts for much more inflow than outflow samples. Rainfall directly on the pond accounts for 26 percent of storm input to the pond and the exact amount in cubic feet for each storm is listed in the comment section for the inflow. Much more background data is available but it is not related to a storm event and is not included with this data. A more complete report is available. The principal meridian is in the UTM Zone 17.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Commonwealth S Central Stormwater Facil.

BMP Name South Central Stormwater Facility

Watershed Name South Central Basin Watershed

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

Watershed Type Test

City Tallahassee

Total Watershed Area

State/Country FL/US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 62.95 Inches

Number of Flow Records 12

Avg Annual Storm Duration 7.10 Hour(s)

Number of Water Quality Records 195

Minimum Flow Volume 154.84 ac ft

Maximum Flow Volume 1,724.08 ac ft

Comments

Much of the watershed characteristic and design information is missing from this study. This information will be amended in the near future.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	DeBary Detention with Filtration Pond		
BMP Name	DeBary Detention with Filtration Pond	**Watershed Name**	DeBary Detention Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	DeBary	**Total Watershed Area**	50.71 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	47.15 Inches
Number of Flow Records	80	**Avg Annual Storm Duration**	5.90 Hour(s)
Number of Water Quality Records	3373		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	5,417.69 ac ft		

Comments

Field work was conducted from June 1992 through November of 1992 to evaluate the hydraulic and water quality characteristics of a detention pond with filtration system. A hydrologic budget was determined for the system. Samples were collected on a flow weighted basis during the study period. Sediment core samples were collected in the ponds, control and filter areas. Pilot scale experiments were conducted to evaluate the effects of filter media, configurations, and sod cover on hydraulic performance of the system.

In general, mass retention for all nitrogen species was relatively poor, with no net removal observed for total nitrogen within the detention pond. Consistent removals were observed for all measured species of phosphorous, with an overall removal of 61% for total P during the 6-month study period. Mass retention for TSS and BOD within the pond was excellent, with an average retention of 98% for TSS and 99% for BOD. Consistent mass removals were also observed for each of the measured heavy metals, with removal of approximately 40% for Cu, 50% for total cadmium and total chromium, 70% for total Pb and Fe, and 90% for total Zn. Water column processes were responsible for primary removal of orthophosphates, total phosphorous, turbidity, and heavy metals within the system. The filter media exhibited virtually no affinity for retaining heavy metals or nutrients within the media. Media filter type did not significantly alter removal efficiency. A small amount of removal was provided in a bench scale model using sod cover on the filter media.

Article appears to be a comprehensive analysis of the design and performance of the detention pond system with a short monitoring period (6-months). Over 48,000 separate field and laboratory measurements were generated during the course of the project. The appendixes are included in the document on a floppy disk.

Average Pollutant Removal Efficiencies *See notes at end of report.

PHOSPHORUS, DISSOLVED ORGANIC (MG/L AS P)	39 %
CHLORIDE,TOTAL IN WATER MG/L	-60 %
BOD, 5 DAY, 20 DEG C MG/L	66 %
CHROMIUM, DISSOLVED (UG/L AS CR)	39 %
ZINC, TOTAL (UG/L AS ZN)	93 %
ZINC, DISSOLVED (UG/L AS ZN)	87 %
CADMIUM, DISSOLVED (UG/L AS CD)	57 %
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	43 %
CHROMIUM, TOTAL (UG/L AS CR)	61 %
NITROGEN, ORGANIC, DISSOLVED (MG/L AS N)	-22 %
CADMIUM, TOTAL (UG/L AS CD)	63 %
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	62 %
NITROGEN, TOTAL (MG/L AS N)	11 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	99 %
ALKALINITY,FIXED ENDPOINT TITRATION, USGS LAB MG/L	-16 %
PHOSPHORUS, SUSPENDED (MG/L AS P)	88 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	22 %
LEAD, TOTAL (UG/L AS PB)	82 %

NITROGEN, AMMONIA, TOTAL (MG/L AS N)	-123 %
IRON, DISSOLVED (UG/L AS FE)	-273 %
COPPER, DISSOLVED (UG/L AS CU)	27 %
PHOSPHORUS, TOTAL (MG/L AS P)	71 %
LEAD, DISSOLVED (UG/L AS PB)	29 %
IRON, TOTAL (UG/L AS FE)	73 %
COPPER, TOTAL (UG/L AS CU)	27 %

Test Site Name Dem. Urban SW Treatment (DUST) Marsh

BMP Name	DUST Marsh Debris Basin	**Watershed Name**	DUST Marsh Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Fremont	**Total Watershed Area**	1,198.04 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	17.06 Inches
Number of Flow Records	131	**Avg Annual Storm Duration**	13.30 Hour(s)
Number of Water Quality Records	3506		
Minimum Flow Volume	67.10 ac ft		
Maximum Flow Volume	29,047.04 ac ft		

Comments

The Demonstration Urban Stormwater Treatment (DUST) Marsh at Coyote Hills Regional Park in Fremont (Alameda County), California was designed as a prototype system and research facility to study wetland creation for stormwater treatment in the San Francisco Bay Area. The design of the marsh was intended to test various system configurations for water treatment effectiveness, to maintain and enhance other uses of the area such as flood control and wildlife habitat, and to demonstrate the practicality of constructing a treatment wetland.

The project site is approximately 55 acres and it receives urban runoff from a 4.6 sq. mi area within the city of Fremont, California. Runoff water enters the initial Debris Basin and is divided among two parallel flow systems (a lagoon and a pond system) that may be operated independently. The two systems discharge into a common third system (a marsh system).

The treatment performance of the DUST Marsh over 7 monitored storms during Winter 1985-1986 and on a seasonal mass loading basis showed the following removal rates: TSS -64%; oil and grease -11%; Nitrate-nitrogen -15%; Ortho-phosphates -56%; chromium -68%; copper -31%; lead -88%; and zinc -33%. No detectable concentrations of selenium were found in the selection of water samples. Overall, the third system which supported a well developed marsh system with mature vegetation provided the best treatment of metals, suspended solids, and oil and grease. The first system, a lagoon, provided good treatment of suspended solids, ortho-phosphate, and chromium. The second system, an overland flow/pond system, provided the best treatment of copper and Nitrate-nitrogen.

Overall, the DUST Marsh was effective in the reduction of suspended solids, inorganic nitrogen, phosphorous, cadmium, and lead regardless of the system. As the marsh becomes more established, the differences in treatment levels in the three systems that are due to design variations will become more apparent.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

%

Test Site Name Duval County Pond 1

BMP Name	Duvall County Pond 1	**Watershed Name**	Duval County Pond 1
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Jacksonville	**Total Watershed Area**	7.00 ac
State/Country	FL /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	50.02 Inches
Number of Flow Records	8	**Avg Annual Storm Duration**	7.40 Hour(s)
Number of Water Quality Records	1473		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

Water and sediment samples were analyzed for major chemical constituents, nutrients, and heavy metals following 10 storm events at 2 stormwater detention ponds that receive highway surface runoff. The purpose of the sampling program was to detect changes in constituent concentration with time of detention within the pond system. Pond 1 is in the infield of the intersection of two major highways, U.S. Highway 1 and Interstate 95. Inflow is routed to the pond by three drainage culverts (55%) and by overland flow (45%). Constituent behavior could be grouped into five relatively independent processes for Pond 1: (1) interaction with shallow groundwater system, (2) solubilization of bottom materials, (3) nutrient uptake, (4) seasonal changes in precipitation, and (5) sedimentation. Most of the observed water-quality changes in the ponds were virtually complete within 3 days following the storm event. This study was hampered by problems with one of its ponds (Pond 2), as well drought conditions during the study period, which limited the number of storms suitable for sampling. The study report provides some useful data, but lacks suitable QA/QC discussion, and does not provide flow measurements.

There was going to be a second detention pond in the study (Pond 2), which drains a 6 acre shopping center parking lot. However, the pumping system at the site malfunctioned early in the study, and was not promptly repaired. As a result, only limited data was collected, and no conclusions could be made.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name I-5 / La Costa (east)

BMP Name	La Costa WB	**Watershed Name**	La Costa WB
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Encinitas	**Total Watershed Area**	4.20 ac
State/Country	CA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	8.97 Inches
Number of Flow Records	28	**Avg Annual Storm Duration**	11.80 Hour(s)
Number of Water Quality Records	425		
Minimum Flow Volume	15.62 ac ft		
Maximum Flow Volume	255.90 ac ft		

Comments

Information for the following required Retention Pond design parameters were not provided because they were not relevant to or calculated for the design of this BMP. These fields include "Littoral Zone Surface Area", " Littoral Zone Plant Species" and "1/2 Brim-full emptying time".

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Lake Ellyn

BMP Name	Lake Ellyn	**Watershed Name**	Lake Ellyn Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Glen Ellyn	**Total Watershed Area**	533.99 ac
State/Country	IL / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	33.38 Inches
Number of Flow Records	54	**Avg Annual Storm Duration**	9.20 Hour(s)
Number of Water Quality Records	1011		
Minimum Flow Volume	1,203.16 ac ft		
Maximum Flow Volume	22,420.41 ac ft		

Comments

Glen Ellen Lake is a 10.2 acre impoundment on the Du Page River near Chicago, Illinois. The lake receives runoff from a predominantly residential urban watershed, approximately 534 acres in total area. Lake Ellyn has a volume of 45 acre feet which affords the watershed sufficient storage capacity for 1 inch of rainfall. Seventy-three percent of the runoff enters the lake through the main channel inlet, a 4.0 X 4.5 ft rectangular concrete storm drain. There are six smaller inlets through which most of the remaining runoff enters the lake with a smaller fraction being introduced as overland flow. There are two outlet structures, one on the surface and one submerged. The surface outlet is a 5.25 ft fixed concrete weir draining to a 2.0 ft diameter concrete pipe. The submerged outlet is a 2.5 ft concrete pipe attached to a stilling well that contains a 6.0 ft adjustable metal weir.

The trap efficiency of the Lake was measured for several stormwater related pollutants during 18 storm events over a period of 1 year (April 1980 to June 1981). The parameters monitored were: Suspended Solids (TSS), Suspended Sediment (SS), Total Copper (T-Cu), Dissolved Copper (Dis-Cu), Total Iron (T-Fe), Dissolved Iron (Dis-Fe), Total Lead(T-Pb), Dissolved Lead (Dis-Pb), Total Zinc (T-Zn), Dissolved Zinc (Dis-Zn), Dissolved Solids (TDS), Calcium (Ca), Chloride (Cl), Magnesium (Mg), Potassium (K), Sodium (Na), Sulfate (SO4), Total Nitrogen (T-N), Dissolved Nitrogen (Dis-N), Total Phosphorus (T-P), and Dissolved Phosphorus (Dis-P). Flow and precipitation were also monitored for the 18 storm events studied. In addition to the water quality parameters studied, sediments were sampled, and the relative abundance and diversity of benthic organisms and ichthyofauna were investigated.

Overall trap efficiencies ranged from (87.9 to 93.7%) for TSS, (90.6 to 95.0%) for SS, (77.1 to 87.9%) for T-Cu, (12.6 to 53.8%) for Dis-Cu, (87.5 to 93.4%) for T-Fe, (17.2 to 55.7%) for Dis-Fe, (83.9 to 91.5%) for T-Pb, (-651 to -300%) for Dis-Pb, (76.4 to 87.7%) for T-Zn, (62.0 to 79.8%) for Dis-Z, (-307 to -111%) for TDS, (-216 to -63.0%) for T-Ca, (-414 to -174%) for Cl, (-334 to -137%) for Mg, (-73.4 to 5.4%) for K, (-200 to -59.6%) for Na, (-142 to - 30.8%) for SO4, (20.0 to 57.8%) for T-N, (9.6 to 53.6%) for Dis-N, (31.6 to 64.2%) for T-P, (12.6 to 54.5%) for Dis-P. These results indicate that the lake is effective for removal of those pollutants which associate themselves with sediments. High concentrations of these types of pollutants in the sediments tended to confirm this. Some dissolved pollutant concentrations (TDS and the major ions) actually showed negative removals by the Lake. The author attributes these negative values to insufficient sampling in the winter months when most of these pollutants are introduced as road deicing runoff, and suggests that steady-state removals are approximately 0%.

As the project was part of the NURP study QA/QC was assumed to have been in accordance with NURP/EPA protocol. The document was thorough and well reported except for the design specifications for the reservoir.

Average Pollutant Removal Efficiencies *See notes at end of report.

SULFATE, TOTAL (MG/L AS SO4)	-31 %
CHLORIDE,TOTAL IN WATER MG/L	-140 %
COPPER, DISSOLVED (UG/L AS CU)	57 %
IRON, DISSOLVED (UG/L AS FE)	57 %
SODIUM, TOTAL (MG/L AS NA)	-33 %
COPPER, TOTAL (UG/L AS CU)	89 %
ZINC, TOTAL (UG/L AS ZN)	90 %
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	-98 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	94 %
POTASSIUM, TOTAL MG/L AS K)	-160 %
LEAD, DISSOLVED (UG/L AS PB)	-275 %
LEAD, TOTAL (UG/L AS PB)	93 %

ZINC, DISSOLVED (UG/L AS ZN)	81 %
MAGNESIUM, TOTAL (MG/L AS MG)	-140 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	57 %
PHOSPHORUS, TOTAL (MG/L AS P)	66 %
CALCIUM (MG/L AS CACO3)	-72 %
NITROGEN, TOTAL (MG/L AS N)	62 %
IRON, TOTAL (UG/L AS FE)	95 %

Test Site Name Lake McCarrons Wetland Treatment System

BMP Name Lake McCarrons Sedimentation Basin

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

City Roseville

State/Country MN/US

BMP Installation Date

Number of Flow Records 144

Number of Water Quality Records 1449

Minimum Flow Volume 40.32 ac ft

Maximum Flow Volume 17,486.67 ac ft

Watershed Name Lake McCarrons Wetland Ouflow

Watershed Type Test

Total Watershed Area 636.05 ac

Watershed Area Disturbed

Avg Annual Rainfall 25.52 Inches

Avg Annual Storm Duration 9.80 Hour(s)

Comments

The McCarrons Wetland Treatment System (MWTS) is a surface water management facility consisting of a detention pond followed by six "chambered" wetlands and discharging to the northwest end of Lake McCarrons.

Water quality monitoring of the MWTS has shown the system to be very effective in the removal of solids-associated pollutants and moderately effective in removing soluble nutrients. Most of the reduction in pollutants occurs in the detention pond because of the highly concentrated manner in which runoff enters.

Performance conclusions are based on results from 21 monitored events of the 57 rainfall events and four periods of snowmelt. Climatic conditions and the precipitation during the 21 months of study were not "normal", but rather reflective of a mild, dry period within which a major event and two very wet months occurred.

The detention pond is performing at the best level that can be expected. The pond has lost 18% of its permanent pool volume (5% of crest volume) in 21 months of operation. Attributes that are thought to contribute positively to treatment levels in the pond include diffuse inflow from three separate tributaries, a low total dissolved-to-total phosphorous ratio (TDP:TP) in entering runoff water, and newly exposed peat soils with a high affinity for attracting TP. The pond did not respond well to snowmelt loading during the melt of 1988 because of an ice layer that forced flow either under the ice in a turbulent manner or over the ice where settling depth was insufficient and turbulence was high. Changes in the design of the outlet structure could improve the effectiveness of the detention pond in treating snowmelt.

Hydrologic variables that appear to be important to the performance of the detention pond include rainfall intensity, hydraulic detention time, total amount of precipitation in the event, and time since last rainfall over 0.1 inch. These variables seem to be related to the transport of solids-related pollutants to the pond and the amount of time that quiescent settling occurs between events.

The post-detention wetland system was intended to "polish" outflows form the detention pond before the water discharges to the lake. The wetlands continues the good job of solids settling begun in the pond, but is somewhat less effective for soluble nutrients. Even though nutrient removal in the wetland
is not high, there is a net reduction, so the wetland is performing in the manner intended.

Average Pollutant Removal Efficiencies *See notes at end of report.

LEAD, TOTAL (UG/L AS PB)	70 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	30 %
RESIDUE, TOTAL VOLATILE (MG/L)	84 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	84 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	16 %
PHOSPHORUS, TOTAL (MG/L AS P)	55 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	14 %
COD, .025N K2CR2O7 MG/L	64 %
NITROGEN, TOTAL (MG/L AS N)	27 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	46 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	83 %
RESIDUE, TOTAL VOLATILE (MG/L)	78 %

NITROGEN, TOTAL (MG/L AS N)		56 %
NITRATE NITROGEN, TOTAL (MG/L AS N)		54 %
PHOSPHORUS, TOTAL (MG/L AS P)		56 %
LEAD, TOTAL (UG/L AS PB)		80 %
COD, .025N K2CR2O7	MG/L	62 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)		56 %

Test Site Name Lake Munson System

BMP Name	Lake Munson	**Watershed Name**	Lake Munson System Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Tallahassee	**Total Watershed Area**	29,405.42 ac
State/Country	FL /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	62.95 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	7.10 Hour(s)
Number of Water Quality Records	119		
Minimum Flow Volume	26,909.49 ac ft		
Maximum Flow Volume	986,062.82 ac ft		

Comments

The study examines the long term performance of a wetland/lake system for stormwater discharge and wastewater effluent discharge. This paper studies a 255-acre wetland/lake system which has received wastewater effluent and stormwater discharges for over 30 years. Six storms were sampled upstream and three storms downstream of the lake. The study documents the constituent removal efficiency for 25 parameters.

Lake Munson displays removal rates that would be commonly expected from relatively new wet detention ponds having similar dimensions and stormwater loading rates. The lake system was effective at retaining particulate material from incoming stormwaters (turbidity 87% removal, suspended solids 95% removal, total P 64% removal, total N 31% removal, BOD 20% removal, TOC 24% removal, total Cr 78% removal, total Cu 72% removal, total Pb 91% removal). Dissolved organic nitrogen and orthophosphate had negative removal rates of -15% and -50%, respectively.

The following general conclusions were also made. The author suggests a design criteria to provide twice the volume of the average storm event in order to reduce the impact of any one storm on pond water quality. The Lake Munson performance was surprising because the system has received heavy nutrient loads from wastewater and stormwater discharges for over 30 years and has never been maintained. Removal efficiencies increased rapidly with increasing pond surface area up to a point of diminishing returns beyond which efficiencies improved little with increasing pond area. Removal of suspended material was insensitive to pond depths. Phosphorous removal rates were sensitive to increasing pond depths versus pond area, particularly for pond areas larger than 1.5 to 2.0 percent of the watershed.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Lake Ridge Detention Pond

BMP Name	Lake Ridge Detention Pond	**Watershed Name**	Lake Ridge Det. Pond Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Woodbury	**Total Watershed Area**	335.07 ac
State/Country	MN /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	25.52 Inches
Number of Flow Records	39	**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	527		
Minimum Flow Volume	241.89 ac ft		
Maximum Flow Volume	25,327.96 ac ft		

Comments

The Metropolitan Council has been studying the occurrence and control of non-point source pollution since 1976. It became apparent that little data existed to evaluate the effectiveness of BMP's, and, as a result, the council began a program to document such practices. In the area the two most common techniques for runoff control are wetlands and detention ponds. The council decided to study four management facilities, all located within the Ramsey, Washington Metro Watershed District. The facility researched within this site was the Lake Ridge Detention Pond.

The Lake Ridge detention pond was installed in 1981 by the city of Woodbury in conjunction with the construction of the Lake Ridge condominiums. Lake Ridge was on the original site selection list, and was the first facility equipped in the fall of 1987. Data collection began with a rainfall event in October 1987 and ended with an early April 1989 rainfall event. Data collection was not without complication. Because of the extremely dry year (1988) the upper 216 acres of the watershed often did not discharge enough to flow out of a mid-watershed wetland. Contributing watershed area has been adjusted for the events where it was reduced.

Nutrient reduction effectiveness depends upon the particular nutrient and the amount of storage available. A permanent storage pool over four feet in maximum depth and with a permanent pool volume to average storm volume ratio over 1.0 detains runoff for an adequate period of time and improves pollutant removal. The facilities should be designed for frequently occurring events, rather than for large volume, low frequency events. Problems associated with ice and frozen conditions can be minimized by deepening water levels under ice, dewatering facilities, passing baseflow through quickly, routing water around frozen ponds and wetlands until they thaw, and building a variable discharge outlet structure. The pond should be deepened to six feet. As a safety measure, a three foot wide vegetative strip should be around the edge of the pool. This pond needs to be cleaned out and maintained. An installation of a forebay may reduce bedload.

Average Pollutant Removal Efficiencies *See notes at end of report.

LEAD, TOTAL (UG/L AS PB)	78 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	63 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	44 %
LEAD, DISSOLVED (UG/L AS PB)	54 %
NITROGEN, TOTAL (MG/L AS N)	37 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	48 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	36 %
RESIDUE, TOTAL VOLATILE (MG/L)	77 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	93 %
PHOSPHORUS, TOTAL (MG/L AS P)	58 %

Test Site Name Lakeside (LS) Pond

BMP Name	Lakeside (LS) Pond	**Watershed Name**	Lakeside Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Charlotte	**Total Watershed Area**	65.01 ac
State/Country	NC /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.79 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	9.50 Hour(s)
Number of Water Quality Records	84		
Minimum Flow Volume	316.52 ac ft		
Maximum Flow Volume	27,837.41 ac ft		

Comments

The results of a monitoring program conducted on three urban wet detention ponds within the Piedmont region of North Carolina were summarized in two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074). Data collected from 11 storm events over a sampling period of 13 months were employed to study the relationship between detention pond performance and pond surface/watershed area ratios (SAR). Water quality parameters examined included TSS, total and dissolved metals of lead, zinc, copper and iron, TKN and total phosphorus. In addition, runoff samples were collected from several storms and during the various stages of a storm event to analyze particle size distribution.

Three urban detention ponds, Lakeside (LS), Waterford (WF), and Runaway Bay (RB) ponds were included in this study. The RB pond is located downstream of LS and WF ponds and receives the combined outflows from both ponds. The SAR ratios based on pond surface and local drainage acreage were 7.5%, 0.6%, and 4.6% for LS, WF, and RB ponds, respectively.

A total of five stream gauging stations were installed at major inflows and outflows of each pond. A rain gauge was installed near the downstream portion of the watershed. Stormwater samples were collected from outflows of each detention pond using ISCO automatic samplers; runoff samples were manually collected from the inflow of the LS pond and the two storm pipes draining into the RB pond.
Nonstorm samples were collected once every two or three weeks at pond outlets to establish a background water quality conditions.

Water quality parameters examined included TSS, TKN, NH3-N, Total phosphorus, ortho-phosphorus, and total and dissolved lead, zinc, copper, and iron. Particle size distribution were analyzed for the runoff samples from several storms.

The study demonstrates that surface to area ratio can be a useful predictor of wet pond performance. Within the range of 1-2% SARs, the removal efficiencies estimated for iron, zinc, TKN and TP would be 60,40, 30 and 45%, respectively. The SAR ratios required to achieve 70% or better TSS removal would be 1% or better.

In comparison to data from the NURP study, runoff quality of the study area is generally better and runoff sediment can be characterized by a finer particle size distribution. The attenuation of peak discharge appears to be unsatisfactory due to short circuiting of local drainage entering the detention ponds from surrounding areas. Even though the detention ponds were not built for water quality control, the observed improvement in water quality justifies the use of wet ponds for urban runoff pollution abatement.

The authors published two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074) on this wet detention pond monitoring study, with 1.3.1.072 and 1.3.1.074 containing longer monitoring records. Since there are no changes on the studied BMPs, the information from these three documents are summarized in one set of data in the database. Water quality data in the papers were presented based on averaged concentrations for all storms, rather than on individual storm events in the two papers. However, event mean concentrations were included in the report for each storm event.

Paper 1.3.1.065 presents water quality data collected from 5 storm events during January to June 1987. Paper 1.3.1.072 and report 1.3.1.074 contain monitoring data collected from 11 storm events, including the 5 ones in 1.3.1.065.

Average Pollutant Removal Efficiencies *See notes at end of report.

RESIDUE, TOTAL NONFILTRABLE (MG/L)	93 %
PHOSPHORUS, TOTAL (MG/L AS P)	44 %
IRON, TOTAL (UG/L AS FE)	87 %
ZINC, TOTAL (UG/L AS ZN)	81 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	31 %

Test Site Name Madison, WI, Wet Pond Monroe St.

BMP Name	Wet detention pond, Monroe St.	**Watershed Name**	Westmorland
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Madison	**Total Watershed Area**	237.22 ac
State/Country	WI/US	**Watershed Area Disturbed**	237.22 ac
BMP Installation Date		**Avg Annual Rainfall**	29.41 Inches
Number of Flow Records	237	**Avg Annual Storm Duration**	9.50 Hour(s)
Number of Water Quality Records	2279		
Minimum Flow Volume	39.75		
Maximum Flow Volume	10,597.78		

Comments

The US Geological Survey (USGS), in cooperation with the Wisconsin Department of Natural Resources (WDNR) investigated the Monroe St. wet detention pond located in Madison, WI. The University of Wisconsin Arboretum originally constructed the pond to protect the water quality and ecology of Lake Wingra and surrounding wetlands from stormwater. The pond is located on the downstream side of Monroe street at the outlet of a storm sewer that drains a 0.96 square km (237 acre) urbanized area. Land use in the watershed area consists mostly of single family residences and commercial strip development, with some institutional uses (schools and churches). The average basin slope is 2.2 percent.

The Monroe Street pond has a surface area of 5,670 m2 (1.42 Acre), a maximum depth of 2.3 m (7.5 ft) and an average depth of 1.1 m (3.6 ft) at normal pool elevation. The shape of the pond is basically round to oval with a small island. The inlet side is nearest to Monroe Street and the two outlets are on the far side away from Monroe Street. The pond has a surcharge storage volume above the normal pool elevation that is capable of holding the 10 year, 24 hour storm runoff volume without overtopping the containment berm around the pond. The pond has two outlets, each controlled by 90 degree V notch weirs that drain to channels leading to Lake Wingra. The weirs are located in 8 ft. diameter concrete vaults, with 30 in. concrete pipes leading to the pond. The outlets in the pond are therefore submerged. The bottom of the pond consists of a clay layer that inhibits infiltration of water from or into the pond.

The initial primary outlet configuration consisted of two 8 ft. long rectangular weirs located in the vaults, made with concrete block walls. The original flow capacity of these two weirs was enormous, being about 50 cfs at 1 ft. head and 250 cfs at 3 ft. head. The discharges from the pond were little attenuated from the inflow velocities and severe channel erosion was occurring in the wetlands, negating the sediment trapping benefits of the pond. There was also no evidence that the emergency spillway was ever used since construction, even with several massive storms. In fact, the pond elevation barely fluctuated. The outlets were therefore modified by the WDNR to reduce the downstream erosion problems by removing several courses of concrete blocks and installing 90-degree V-notch weirs made of plate steel in each vault. The pond normal water level was dropped about 6 inches with a lowered invert. The new primary outlets have total flow capacities of about 5 cfs at 1 ft. head and 80 cfs at 3 ft. head. The pond surface fluctuates more now, and the emergency spillway has been active every few years. Most significantly, the downstream channels are now stable.

The USGS and the Wisconsin Department of Natural Resources have been monitoring the Monroe St. wet detention pond in Madison for a number of years. Performance data have been collected for about 50 storms. The pond was re-designed for an expected 90% event mean concentration (EMC) removal for suspended solids (particulate residue). Actual long-term monitored SS removals were about 87%. The ratio of pond to drainage area is 0.6 percent. This pond area to land area ratio is close to the value (0.4% to 0.8%) required for 5 mm control for the land uses in the watershed, which generally corresponds to a 90 percent reduction of suspended solids.

A total of 64 events were extensively monitored between February 1987 and April 1988. The monitored rains varied from 2 to more than 82 mm during this period. Periodic water quality and flow monitoring has also continued at this pond since 1988.

Complete project information is contained in the following USGS report:

House, L. B., Waschbusch, R. J. and Hughes, P. E. Water quality of an urban wet detention pond in Madison, Wisconsin,1987-88. U.S. Geological Survey, Open-File Report 93-172. 1993.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name McKnight Basin Detention Pond

BMP Name	McKnight Basin Detention Pond	**Watershed Name**	McKnight Basin Det. Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Maplewood	**Total Watershed Area**	725.00 ac
State/Country	MN /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	25.52 Inches
Number of Flow Records	40	**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	561		
Minimum Flow Volume	1,300.16 ac ft		
Maximum Flow Volume	81,980.75 ac ft		

Comments

This report presents the finding of a Metropolitan Council study of the water quality effectiveness of five urban runoff treatment facilities. The site and facility studied in this review were the McKnight Basin detention ponds in Maplewood. The largest facility studied was the three-pond McKnight Basin system. The period of data collection for the study was very hot and dry. A drought condition existed for most of the sampling period, limiting available rainfall events that could be sampled. It is suspected that the drought resulted in more highly concentrated runoff moving into facilities that contained reduced permanent pools.

The McKnight Basin system was one of the originally selected sites. Data collection began with baseflow sampling in early October 1987, followed by the October 15-16, 1987 rainfall event and continued throughout the large snowmelt of 1989.The facility reduced the inflow of pollutants to some degree. The McKnight Basin ponds are well designed although they do not treat the soluble nutrients that well, possibly because of vegetative "polishing" provided by other systems.

Specific recommendations for the McKnight Basin ponds primarily address maintenance. The upper part of Pond #1 contains a large amount of sediment that should be removed. The outflow structure of the system continually clogs with debris, resulting in an increase in pond depth and a net loss in available storage volume. This loss was not critical in any events monitored but could be for larger events in the future. It is suggested that a well maintained floatables skimmer just upgradient from the outflow gate be installed. Capturing sediment by some sort of sump or forebay would be beneficial.
The idea of biomanipulation should be considered to control algae in the ponds.

This report documents a thorough study of a 3 pond detention system. There is substantial data from the study of storm events between October of 1987 and April of 1989.

Average Pollutant Removal Efficiencies *See notes at end of report.

NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	38 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	57 %
LEAD, DISSOLVED (UG/L AS PB)	0 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	17 %
PHOSPHORUS, TOTAL (MG/L AS P)	54 %
NITROGEN, TOTAL (MG/L AS N)	41 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	87 %
RESIDUE, TOTAL VOLATILE (MG/L)	69 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	51 %
LEAD, TOTAL (UG/L AS PB)	78 %

Test Site Name	Nurp, Lansing MI, Waverly Ret Basin		
BMP Name	Waverly Retention Basin	**Watershed Name**	Waverly Retention Basin
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Lansing	**Total Watershed Area**	30.30 ac
State/Country	MI/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	26.72 Inches
Number of Flow Records	6	**Avg Annual Storm Duration**	10.20 Hour(s)
Number of Water Quality Records	1651		
Minimum Flow Volume	2.48 ac ft		
Maximum Flow Volume	831.83 ac ft		

Comments

The major objective of the Lansing Michigan NURP study was to evaluate the effectiveness of three BMP's; an in-line retention basin, an off-line retention basin, and two up-sized pipe sections. Other objectives included relating land use to pollutant loads and assessing the impact of the BMP's on the receiving waters. The Bogus Swamp Drainage District study area covered 450 acres. A total of ten sites were monitored for flow, water quality parameters and sediment pollutant concentrations.

Station 4 is located just upstream of the diversion to the off-line detention basin. The drainage area monitored by station 4 encompasses the areas of both stations 5 and 6 plus an additional 45.7 acres. The major difference in land use was the additional 23 acres of low density residential area. Also included were 12.5 acres of parkland, 8.4 acres of strip mall, and 1.8 acres of institutional land use.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Phantom Lake Pond C

BMP Name	Pond C	**Watershed Name**	Phantom Creek Watershed Pond C
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	12.36 ac
State/Country	WA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	34	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	89		
Minimum Flow Volume	92.33 ac ft		
Maximum Flow Volume	1,088.38 ac ft		

Comments

Impervious areas were not provided for this study, however, the majority of the 5 ha waterhsed is parking lot. Therefore, this watershed is assumed to be highly impervious though no percent imperviousness is provided in the data set. Inflow and outlfow measurements were taken at the sight, however, only outflow measurements are provided in this data set because of the inability to accurately measure the flow at the inflow of the facility. Inflow measurements provided in this data set are not actual inflow measurements, but are assumed to be equal to the outlfow measurents taken at the site.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Phanton Lake Pond A

BMP Name	Pond A	**Watershed Name**	Phantom Lake Watershed Pond A
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	98.84 ac
State/Country	WA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	34	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	318		
Minimum Flow Volume	463.30 ac ft		
Maximum Flow Volume	3,820.76 ac ft		

Comments

Please note that flow records are total flows which include both stormwater runoff and baseflow. Inflow was assumed to eqaul outflow due to measurement errors at the outflow location.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Pinellas Detention Pond

BMP Name	Pinellas Park Detention Pond	**Watershed Name**	Pinellas Detention Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Pinellas Park	**Total Watershed Area**	1,632.12 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	46.86 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	5.50 Hour(s)
Number of Water Quality Records	168		
Minimum Flow Volume	24,525.94 ac ft		
Maximum Flow Volume	163,120.65 ac ft		

Comments

A multipurpose wet stormwater-detention pond was studied to determine its effectiveness in reducing the load of selected water-quality constituents commonly found in urban streamflow. This paper studies the loading of 19 chemical and physical constituents during six storm events.

Because all stormwater entering the detention pond was not measured at the inflow site, computed stormwater inflow loads were adjusted to account for loads from the unmonitored areas. Stormwater loads of the major ions (chloride, calcium and bicarbonate) and dissolved solids at the outflow site exceeded loads at the inflow site, partly as a result of mixing with base flow stored within the pond. However, the detention pond was effective in reducing the stormwater load of metals (25% to >60%), nutrients (2% to 52%), suspended solids (7% to 11%), and biochemical and chemical oxygen demand (16% to 49%). The author attributes the reductions in base-flow loads to adsorption, chemical precipitation, biologic uptake, and settling within the detention pond. These processes were more effective in reducing base-flow loads after the establishment of aquatic vegetation in the pond.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Pittsfield Retention Basin

BMP Name Pittsfield Retention Pond

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

City Ann Arbor

State/Country MI/US

BMP Installation Date

Number of Flow Records 14

Number of Water Quality Records 70

Minimum Flow Volume 12,262.97 ac ft

Maximum Flow Volume 624,717.42 ac ft

Watershed Name Pittsfield Retention Basin

Watershed Type Test

Total Watershed Area 4,872.90 ac

Watershed Area Disturbed

Avg Annual Rainfall 30.05 Inches

Avg Annual Storm Duration 9.80 Hour(s)

Comments

Conducted in the Huron River Basin, the objectives of this project were to evaluate the effectiveness of BMP's in reducing pollutant loads present in urban stormwater runoff. Two documents, (1.3.0.028) and (1.3.0.029), cover the same project which was part of the larger NURP program.

Pollutant loads and removals were evaluated for 3 separate BMP's, including; 1) a retention basin, 2) a surface detention basin, and 3) a natural wetland. Parameters evaluated were: Suspended Solids (TSS), Total Phosphorus (T-P), Total Kjeldahl Nitrogen (TKN), Total Iron (T-Fe), and Total Lead (T-Pb).The Pittsfield retention basin was originally designed to provide flood relief to the downstream channel, however, it was assumed that some water quality benefits were also being achieved by the basin.

Pollutant removal efficiencies were evaluated "as is" for 5 storms and 1 snowmelt event between June 1979 and October 1980. The retention basin had permanent storage capacity of 914,760 ft^3 and collected runoff from a total drainage of 6,363 acres. Land use in the watershed is 47% residential, 14% commercial, 8% industrial, 11 % agricultural with the remaining area being mostly rural and parkland.

The author presented adjusted removal efficiencies for the retention basin. These adjusted values were generated by subtracting the base flow loadings prior to calculating the removal efficiencies and are much higher than overall removal efficiencies. Adjusted removal efficiencies of 10-85% for TSS, 0-50% for TKN, 0-82% for T-P and 10-20% for BOD, 7-53% for T-Fe, and 43->90 % for T-Pb were reported.

The Pittsfield retention basin is an existing structure and not originally designed for stormwater treatment. Some of the design features (most notable the outlet weir) may actually increase TSS concentrations as a result of scouring during high flows.

Some valuable information may be gleaned from this study; however, the results obtained must be carefully considered because: 1) none of the BMP's evaluated were designed specifically for the use to which they were put, 2) design problems may have contributed to increased pollutant loads from the Pittsfield and Traver Creek retention basins, 3) the Traver Creek and the Swift Creek watersheds were rural rather than urban, and were dominated by agricultural land uses, not the primary focus of this study. The above mentioned factors may make it difficult to compare the results obtained in this study to those obtained from projects with similar BMP's.

Average Pollutant Removal Efficiencies *See notes at end of report.

IRON, TOTAL (UG/L AS FE)	25 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	42 %
PHOSPHORUS, TOTAL (MG/L AS P)	15 %
LEAD, TOTAL (UG/L AS PB)	45 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	15 %

Test Site Name Runaway Bay (RB) Pond

BMP Name	Runaway Bay (RB) Pond	**Watershed Name**	Runaway Bay Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Charlotte	**Total Watershed Area**	437.13 ac
State/Country	NC /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.79 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	9.50 Hour(s)
Number of Water Quality Records	83		
Minimum Flow Volume	1,874.15 ac ft		
Maximum Flow Volume	107,326.45 ac ft		

Comments

The results of a monitoring program conducted on three urban wet detention ponds within the Piedmont region of North Carolina were summarized in two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074). Data collected from 11 storm events over a sampling period of 13 months were employed to study the relationship between detention pond performance and pond surface/watershed area ratios (SAR). Water quality parameters examined included TSS, total and dissolved lead, zinc, copper and iron, TKN and total phosphorus. In addition, runoff samples were collected from several storms and during the various stages of a storm event for analyzing particle size distribution.

Three urban detention ponds, Lakeside (LS), Waterford (WF), and Runaway Bay (RB) ponds were included in this study. The RB pond is located downstream of LS and WF ponds and receives the combined outflows from both ponds. The SAR ratios based on pond surface and local drainage acreage were 7.5%, 0.6%, and 4.6% for LS, WF, and RB ponds, respectively.

A total of five stream gauging stations were installed at major inflows and outflows of each pond. A rain gauge was installed near the downstream portion of the watershed. Stormwater samples were collected from outflows of each detention pond using ISCO automatic samplers; runoff samples were manually collected from the inflow of the LS pond and the two storm pipes draining into the RB pond.
Nonstorm samples were collected once every two or three weeks at pond outlets to establish a background water quality conditions.

Water quality parameters examined included TSS, TKN, NH3-N, Total phosphorus, ortho-phosphorus, and total and dissolved lead, zinc, copper, and iron. Particle size distribution were analyzed for the runoff samples from several storms.

The study demonstrates that surface to area ratio can be a useful predictor of wet pond performance. Within the range of 1-2% SARs, the removal efficiencies estimated for iron, zinc, TKN and TP would be 60,40, 30 and 45%, respectively. The SAR ratios required to achieve 70% or better TSS removal would be 1% or better.

In comparison to data from the NURP study, runoff quality of the study area is generally better and runoff sediment can be characterized by a finer particle size distribution. The attenuation of peak discharge appears to be unsatisfactory due to short circuiting of local drainage entering the detention ponds from surrounding areas. Even though the detention ponds were not built for water quality control, the observed improvement in water quality justifies the use of wet ponds for urban runoff pollution abatement.

The authors published two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074) on this wet detention pond monitoring study, with 1.3.1.072 and 1.3.1.074 containing longer monitoring records. Since there are no changes on the studied BMPs, the information from these three documents are summarized in one set of data in the database. Water quality data in the papers were presented based on averaged concentrations for all storms, rather than on individual storm events in the two papers. However, event mean concentrations were included in the report for each storm event.

Paper 1.3.1.065 presents water quality data collected from 5 storm events during January to June 1987. Paper 1.3.1.072 and report 1.3.1.074 contain monitoring data collected from 11 storm events, including the 5 ones in 1.3.1.065.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Shawnee Ridge

BMP Name	Shawnee Ridge Retention Pond	**Watershed Name**	Shawnee Ridge Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Suwanee	**Total Watershed Area**	495.02 ac
State/Country	GA/US	**Watershed Area Disturbed**	50.90 ac
BMP Installation Date		**Avg Annual Rainfall**	46.87 Inches
Number of Flow Records	15	**Avg Annual Storm Duration**	9.30 Hour(s)
Number of Water Quality Records	199		
Minimum Flow Volume	27.77 ac ft		
Maximum Flow Volume	29,574.51 ac ft		

Comments

This facility is a wet pond consisting of 6 inflows and 1 outflow. Only one of the six inflows was monitored at this site. The majority of the basin flows into the pond by way of a stream, where the inflow monitoring takes place. The other five inflows consist of culverts draining smaller areas, roads, and parking lots, which were not monitored. However, they did influence the early stages of the outlet hydrograph. Precipitation data was only provided for some of the events.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Shop Creek Wetland-Pond (1990-94)

BMP Name	Shop Creek Pond (90-94)	**Watershed Name**	Shop Creek Watershed (90-94)
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Aurora	**Total Watershed Area**	550.02 ac
State/Country	CO /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	13.74 Inches
Number of Flow Records	114	**Avg Annual Storm Duration**	11.20 Hour(s)
Number of Water Quality Records	1876		
Minimum Flow Volume	338.27 ac ft		
Maximum Flow Volume	32,832.60 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name	Shop Creek Wetland-Pond (1995-97)		
BMP Name	Shop Creek Pond (95-97)	**Watershed Name**	Shop Creek Watershed (95-97)
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Aurora	**Total Watershed Area**	550.02 ac
State/Country	CO / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	13.74 Inches
Number of Flow Records	69	**Avg Annual Storm Duration**	11.20 Hour(s)
Number of Water Quality Records	2064		
Minimum Flow Volume	14.58 ac ft		
Maximum Flow Volume	24,842.93 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Silver Star Rd Det./Wtlnd System

BMP Name	Silver Star Rd Detention Pond	**Watershed Name**	Silver Star Rd Det. Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Orlando	**Total Watershed Area**	41.61 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	47.15 Inches
Number of Flow Records	37	**Avg Annual Storm Duration**	5.90 Hour(s)
Number of Water Quality Records	767		
Minimum Flow Volume	185.93 ac ft		
Maximum Flow Volume	2,664.97 ac ft		

Comments

The study examines the efficiency of a detention pond/wetland system for temporary storage of urban stormwater runoff from a Florida Department of Transportation roadway. The system is an online temporary storage pond-wetland system in series. The study documents the regression efficiency for 22 constituents. 13 storms were monitored.

The author concludes that the pond generally reduced suspended constituent loads (TSS, 65%, suspended Pb, 41%, suspended Zn, 37%, Suspended N, 17%, and suspended P, 21%). Additionally, the wetland was generally effective in reducing suspended constituent loads. (TSS, 66%, Pb 75%, Zn, 50%, N, 30%, P, 19%), and dissolved loads (TDS, 38%, Pb, 54%, Zn, 75%, N, 13%, P, 0%). The system was quite effective at reducing pollutant loads.

One of the most interesting aspects of the article is the use of an efficiency calculation method termed the "regression efficiency". This method is carried out by regressing loads-out as a function of loads-in with the intercept of the regression constrained to the origin. The regression efficiency is thus defined as unity minus the regression slope. The regression efficiency assumes that the efficiency is the same for all storms and that the storms monitored are representative of all storms for the BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name The Seattle METRO site

BMP Name	Seattle METRO Retention Pond	**Watershed Name**	Seattle METRO Detention Pond
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	15.00 ac
State/Country	WA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	323	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	1105		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	363.19 ac ft		

Comments

The efficiencies of two existing urban stormwater detention facilities in reducing pollutant loadings to receiving waters were investigated in this paper. The paper contained two field sites in King County, Washington: a 76 acre residential subdivision in the Vasa Creek/Lake Sammamish drainage basin (metro site), and a transit operating base in the Kelsey Creek/Lake Washington drainage basin (whispering heights residential site). Inflow and outflow hydrographs were estimated for several storm events, along with pollutant concentrations ranging from 3.75 minutes to 1 hour. This study investigates a detention pond at the metro site. The whispering heights residential site is also contained in the BMP database.

The metro retention pond provides 6800 cubic feet of temporary storage for runoff from 15 acres of land used for bus parking and maintenance sheds. The pond storage discharges directly into the West tributary of Kelsey Creek through both an outflow pipe (which has a large oil water separation tank in between) and an overflow outflow pipe. Precipitation, flow and time-discrete water quality samples were measured/taken at inflow and outflow points of the pond.

Storm events were monitored from August 1982 through February 1983. Runoff was sampled from artificial events (flooding from hydrants) as well as natural storms. Samples were analyzed for the following parameters: TSS, total and soluble metals (Zn, Pb, Cd, Cr, Ni, As, Cu), total phosphorus, orthophosphate, oil and grease and turbidity.

First flush effect was observed for TSS, oil and grease and lead at this site. First flush was not observed for total phosphorus, zinc and cadmium. Particulate pollutant removal efficiencies were greatest during storms which exhibited the most distinct first flush characteristics. The pond dynamics converted particulate or exchangeable forms of metals into more soluble forms.

Comparison of synthetic storm event runoff concentration and loadings with those of true storm events were performed to determine the relative contribution of pipe flushing to total stormwater runoff pollution. No direct relationships were found between average or maximum pollutant concentrations and traffic volume or antecedent conditions. High concentrations of oil and grease, total and soluble cadmium, lead and zinc, total phosphorus and TSS have been found in baseline (dry weather) discharge. High intensity precipitation can cause overflow of the oil/water separation system resulting in discharge of high concentrations of oil/grease which have been accumulated over past small storms.

Although a tipping bucket rain gage was installed at the site, the continuos rainfall records were not provided in the report. The flow rate and pollutant concentration end times entered into the database were relative times from the start of each sampling event rather than the real times.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name The Tampa Office Pond

BMP Name	Tampa Office Pond (1) 1990-91	**Watershed Name**	Tampa Office Pond
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Tampa	**Total Watershed Area**	6.50 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	46.86 Inches
Number of Flow Records	279	**Avg Annual Storm Duration**	5.50 Hour(s)
Number of Water Quality Records	4447		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	1,997.64 ac ft		

Comments

One stormwater wet detention pond at Tampa, Florida was altered to compare its efficiency for removing pollutants using three different designs. Each pond configuration was studied for an eight month period (June through January) which covered representative conditions for both wet and dry seasons. Hydrology and water quality were analyzed for each year separately and the averaged results compared to each other. Also investigated were some of the other processes taking place such as sedimentation, groundwater interactions, vegetation colonization and insect species diversity.

The major components of the wet detention pond consist of a permanent water pool, an overlying zone in which the stormwater fluctuating volume temporarily increases the depth and a shallow littoral zone to act as a biological filter. The main purpose of this research was to determine how much improvement in water quality can be expected by increasing residence time of the water in the permanent pool.

During the first year of study (1990), the pond was shallow and completely vegetated with a permanent pool less than one foot deep and an average wet season residence time of two days. In the second year (1993), the vegetated littoral zone covered 35% of the pond area and the volume of the permanent pool was increased to include a five day residence time by excavating the pond to a depth of five feet. For the final year (1994), the vegetated littoral zone was planted with desirable species, the depth of the pond was maintained at five feet and the area of the permanent pool was enlarged for a calculated wet season residence time of 14 days.

Flow rates were measured and flow weighted composite samples were collected for over 20 storm events occurring from June through January of each monitoring year at the inflow and outflow point of the pond. Field parameters and sediment samples were taken at representative points on the site. Discrete samples were collected for three storm events to represent the rising limb, the top, the falling limb and the tail of the hydrograph. Vegetation analysis and aquatic macroinvertebrate measurements were also performed.

The efficiency of pollutant removal in the pond was dramatically improved in 1994 when the residence time was increased to 14 days. The percent efficiency for pollutant load removal is at least 20 percent better when 1994 is compared to 1990 (first design). The specific removal rates from 1990 to 1994 are: TSS from 71% to 94%; Ammonia from 54% to 90%; Nitrate+Nitrite from 64% to 88%; Ortho-phosphate from 69% to 92%; Total phosphorus from 62% to 90%, Total zinc from 56% to 87%, Total iron from 40% to 94% and Total Cadmium from 55% to 87%.

The report provided very good and useful information on a wet detention pond. Discrete water quality sampling results and field measurements (except averaged values) were presented as graphs in the report.

Average Pollutant Removal Efficiencies *See notes at end of report.

ZINC, TOTAL (UG/L AS ZN)	67 %
CALCIUM (MG/L AS CACO3)	0 %
CADMIUM, TOTAL (UG/L AS CD)	5 %
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	55 %
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	70 %
PHOSPHORUS, TOTAL (MG/L AS P)	77 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	78 %
HARDNESS, TOTAL (MG/L AS CACO3)	2 %
MAGNESIUM, TOTAL (MG/L AS MG)	16 %
SODIUM, TOTAL (MG/L AS NA)	6 %

IRON, TOTAL (UG/L AS FE)	84 %
CHLORIDE,TOTAL IN WATER MG/L	4 %
CARBON, TOTAL ORGANIC (MG/L AS C)	37 %
LEAD, TOTAL (UG/L AS PB)	85 %
POTASSIUM, TOTAL MG/L AS K)	24 %
COPPER, TOTAL (UG/L AS CU)	31 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	88 %
SULFATE, TOTAL (MG/L AS SO4)	-18 %
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	28 %
MANGANESE, TOTAL (UG/L AS MN)	67 %
	%
	%

Test Site Name Traver Creek Detention Basin

BMP Name Traver Creek Retention Pond

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

City Ann Arbor

State/Country MI/US

BMP Installation Date

Number of Flow Records 10

Number of Water Quality Records 40

Minimum Flow Volume 12,494.35 ac ft

Maximum Flow Volume 76,354.35 ac ft

Watershed Name Traver Creek Detention Basin

Watershed Type Test

Total Watershed Area 2,303.26 ac

Watershed Area Disturbed

Avg Annual Rainfall 30.05 Inches

Avg Annual Storm Duration 9.80 Hour(s)

Comments

Conducted in the Huron River Basin, the objectives of this project were to evaluate the effectiveness of BMP's in reducing pollutant loads present in urban stormwater runoff. Two documents, (1.3.0.028) and (1.3.0.029), cover the same project which was part of the larger NURP program.

Pollutant loads and removals were evaluated for 3 separate BMP'S, including; 1) a retention basin, 2) a surface detention basin, and 3) a natural wetland. Parameters evaluated were: Suspended Solids (TSS), Total Phosphorus (T-P), Total Kjeldahl Nitrogen (TKN), Total Iron (T-Fe), and Total Lead (T-Pb). The dual purpose Traver Creek Detention Basin was designed as an off-line dry retention basin for both flood control and water quality improvement. Due to construction delays, the bypass for the structure had not been completed prior to the study and, as a result, the basin was studied as an on-line wet detention basin.

The storage volume of the basin varied depending on stage, from a low of 512,000 ft^3 at 0 ft and 0 cfs discharge to 344,000 ft^3 at 6 ft and 10.5 cfs discharge. The average detention times for the events studied ranged from 65 to 130 hours. The drainage area above the basin is 2300 acres of which about 80% is dedicated to agricultural uses with the remaining being mostly parkland and some residential use.

Five storms events were sampled between 4/11/81 and 6/13/81 for the parameters listed above. Event mean concentrations and basin pollutant removal efficiencies were calculated. Similar to the Pittsfield Basin and Swift Wetland, only adjusted removal efficiencies are reported.

The design of the Traver Creek basin provided good control of outlet flow and long detention times; however, removal efficiencies were not as high as should be expected for such a facility. Removal efficiencies obtained were; 0-34% for TSS, 25-62% for T-P, 0-59% for TKN, and 0-53% for T-Fe. Given that removal efficiencies for parameters other than suspended solids more accurately reflected design values, the author inferred that the high TSS loads were probably a result of soil erosion from the banks of the basin itself, and there was probably significant settling occurring within the basin.

Some valuable information may be gleaned from this study; however, the results obtained must be carefully considered because: 1) none of the BMP's evaluated were designed specifically for the use to which they were put, 2) design problems may have contributed to increased pollutant loads from the Pittsfield and Traver Creek retention basins, 3) the Traver Creek and the Swift Creek watersheds were rural rather than urban, and were dominated by agricultural land uses, not the primary focus of this study. The above mentioned factors may make it difficult to compare the results obtained in this study to those obtained from projects with similar BMP's.

Average Pollutant Removal Efficiencies *See notes at end of report.

RESIDUE, TOTAL NONFILTRABLE (MG/L)	0 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	21 %
PHOSPHORUS, TOTAL (MG/L AS P)	40 %
IRON, TOTAL (UG/L AS FE)	7 %

Test Site Name Waterford (WF) Pond

BMP Name	Waterford (WF) Pond	**Watershed Name**	Waterford Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Charlotte	**Total Watershed Area**	301.96 ac
State/Country	NC / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.79 Inches
Number of Flow Records	11	**Avg Annual Storm Duration**	9.50 Hour(s)
Number of Water Quality Records	50		
Minimum Flow Volume	1,191.13 ac ft		
Maximum Flow Volume	73,516.74 ac ft		

Comments

The results of a monitoring program conducted on three urban wet detention ponds within the Piedmont region of North Carolina were summarized in two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074). Data collected from 11 storm events over a sampling period of 13 months were employed to study the relationship between detention pond performance and pond surface/watershed area ratios (SAR). Water quality parameters examined included TSS, total and dissolved lead, zinc, copper and iron, TKN and total phosphorus. In addition, runoff samples were collected from several storms and during the various stages of a storm event for analyzing particle size distribution.

Three urban detention ponds, Lakeside (LS), Waterford (WF), and Runaway Bay (RB) ponds were included in this study. The RB pond is located downstream of LS and WF ponds and receives the combined outflows from both ponds. The SAR ratios based on pond surface and local drainage acreage were 7.5%, 0.6%, and 4.6% for LS, WF, and RB ponds, respectively.

A total of five stream gauging stations were installed at major inflows and outflows of each pond. A rain gauge was installed near the downstream portion of the watershed. Stormwater samples were collected from outflows of each detention pond using ISCO automatic samplers; runoff samples were manually collected from the inflow of the LS pond and the two storm pipes draining into the RB pond.
Nonstorm samples were collected once every two or three weeks at pond outlets to establish a background water quality conditions.

Water quality parameters examined included TSS, TKN, NH3-N, Total phosphorus, ortho-phosphorus, and total and dissolved lead, zinc, copper, and iron. Particle size distribution were analyzed for the runoff samples from several storms.

The study demonstrates that surface to area ratio can be a useful predictor of wet pond performance. Within the range of 1-2% SARs, the removal efficiencies estimated for iron, zinc, TKN and TP would be 60,40, 30 and 45%, respectively. The SAR ratios required to achieve 70% or better TSS removal would be 1% or better.

In comparison to data from the NURP study, runoff quality of the study area is generally better and runoff sediment can be characterized by a finer particle size distribution. The attenuation of peak discharge appears to be unsatisfactory due to short circuiting of local drainage entering the detention ponds from surrounding areas. Even though the detention ponds were not built for water quality control, the observed improvement in water quality justifies the use of wet ponds for urban runoff pollution abatement.

The authors published two papers (1.3.1.072 and 1.3.1.065) and one report (1.3.1.074) on this wet detention pond monitoring study, with 1.3.1.072 and 1.3.1.074 containing longer monitoring records. Since there are no changes on the studied BMPs, the information from these three documents are summarized in one set of data in the database. Water quality data in the papers were presented based on averaged concentrations for all storms, rather than on individual storm events in the two papers. However, event mean concentrations were included in the report for each storm event.

Paper 1.3.1.065 presents water quality data collected from 5 storm events during January to June 1987. Paper 1.3.1.072 and report 1.3.1.074 contain monitoring data collected from 11 storm events, including the 5 ones in 1.3.1.065.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

***Notes:** Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.*

BMP Test Site Summary Information

Test Site Name BES Water Garden

BMP Name Water Garden

BMP Type Wetland - Basin With Open Water Surfaces

City Portland

State/Country OR /US

BMP Installation Date

Number of Flow Records 14

Number of Water Quality Records 320

Minimum Flow Volume 59.14 ac ft

Maximum Flow Volume 1,305.31 ac ft

Watershed Name City of Portland BES Test Site

Watershed Type Test

Total Watershed Area 50.00 ac

Watershed Area Disturbed 0.00 ac

Avg Annual Rainfall 34.60 Inches

Avg Annual Storm Duration 15.90 Hour(s)

Comments

The water garden is a two-cell wet pond that was constructed in 1997. It was designed to treat stormwater runoff from a 50-acre catchment of mixed land use. The pond has a 100-foot long rock-filled concrete flume that conveys runoff entering the pond. The outlet structure is hidden in a circular rock wall. Side slopes range from 3:1 to 5:1 and maximum water depth is two feet during non-storm periods. The pond includes a 12-inch diameter inlet, a 30-inch diameter bypass pipe, and a 12-inch diameter outlet. Water quality samples are collected at the inlet and outlet and flow measurements are made at the inlet, outlet, and bypass. Four of the seven storm event water balances yielded a significant difference between inflow and outflow to the detention basin. Three events (05/98, 11/98, 01/99) indicated that substantially more water left the pond than entered. One event (05/99) indicated substantially less water left the pond than entered. Two of the events with excess outflows were relatively large storms (0.94 inches on 11/98 and 0.86 inches on 01/99), while the event with excess outflow was the smallest storm sampled at 0.21 inches of rain. The flow monitoring equipment was checked and appeared to be functioning properly. The excess outflows would indicate inflow from sources other than the inlet pipe. Groundwater flows are not known at this time and it is believed that there are no connections from the old sewer system that could bypass the flow meter. Overland flow into the detention pond has been observed and it is believed that this is the primary factor contributing to excess outflows. The event with excess inflow can be explained in part by the volume required to fill the pond to the point of discharge. Approximately 2000 cubic feet (of the 5800 cubic feet difference between inflow and outflow) pond remains unaccounted for and is very unlikely that infiltration could account for this volume of water. Monitoring results indicate that in general the Water Garden performs better in terms of pollutant removal during smaller storm events as opposed to the larger ones. The Water Garden appears to be particularly effective at removing bacteria and TSS, other parameters with greater than 70% removals include total oil and grease, total lead, and total zinc. The Water Garden is less effective at removing nutrients and dissolved metals. In general the pond appears to be more effective at removing particulate as opposed to dissolved parameters.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Brooke Detention Basin and Wetland

BMP Name	Brooke Detention Pond	**Watershed Name**	Brooke Commuter Rail Parking L
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Brooke	**Total Watershed Area**	12.01 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	23	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	74		
Minimum Flow Volume	8.78 ac ft		
Maximum Flow Volume	730.36 ac ft		

Comments

The Brooke site consists of a 0.08 ha emergent detention pond and a 2.83 ha mitigated wetland in series. The site receives stormwater runoff from a commuter parking lot, a grassed area, and a railway. Conditions range from permanently flooded regions where deep (up to 1 m) pools exist to intermittently flooded regions where surface water is present during storm events and near-saturated to saturated soil conditions prevail during dry weather. The site has approximately 0.4 ha (14 % of total area) of open water. The detention basin is intermittently flooded with water levels rising as high as 2 m during large storm events. Like the rest of the site, the basin's soil is usually at or near saturation during dry periods. Vegetation density is moderate to dense in all but the open water area. Wool Grass, Cattail, and Soft Rush are the dominant emergent species and Black Willow is dense along the main channel of the wetland. Primary species in the detention basin are Wool Grass, Cattail, Goldenrod, and Soft Rush.

Flow volumes could not be recovered for the 10/19/1996 storm event.
A study of the relative abundance of various plant species in the Brooke wetland was conducted. A composite of one-meter plots was used to determine the overall composition of the wetland. The figures do not include woody species or floating aquatic plants that can not be easily counted individually, such as Duckweed. The composite composition of vegetation at the Brooke wetland is as follows: Soft Rush (34.06%), Stinking Marsh-Fleabane (0.39%), Cattail (22.24%), Broom sedge (0.39%), Sphagnum (21.46%), Buttonbush (0.39%), St. John's Wort (8.86%), Lurid Sedge (1.18%), Goldenrod (10.04%), and Spotted Joe Pye Weed (0.98%).

While minimal or negative removals are indicated for the Brooke wetland for TSS, OP, COD, and Zn, these figures must be viewed within the context of the system as a whole. A comparison of the detention basin inflow and the relatively lower wetland inflow (detention outflow) concentrations for the Brooke wetland indicate that a significant portion of removal at this site occurs in the detention basin rather than in the wetland. While effluent from the Brooke wetland may contain higher pollutant concentrations for some parameters than the wetland inflow, the concentration is still far lower than that in the inflow to the system, resulting in overall pollutant reductions.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name	Carver Ravine Wetland/Detention Facility		
BMP Name	Carver Ravine Detention Pond	**Watershed Name**	Carver Ravine wet/de Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Woodbury	**Total Watershed Area**	431.94 ac
State/Country	MN / US	**Watershed Area Disturbed**	28.81 ac
BMP Installation Date		**Avg Annual Rainfall**	25.52 Inches
Number of Flow Records		**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	410		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

The facility consists of a small wetland and detention pond, in-line. The entire area of the combined wetland/detention facility is 4.3 acres. Evaluation of this facility is complicated by the fact that there is a pumped discharge into the study watershed when a bordering closed-end detention facility reaches a prescribed elevation. Contributions from the pumped storage appeared to occur quite unpredictably, apparently a function of total rain (usually any amount over 0.33") and pervious period without pumping. The routine weekly pump testing contributed a volume of water enough to often qualify as an event.

The period of data collection for the study was very hot and dry. A drought condition existed for most of the sampling period, limiting available rainfall events that could be sampled. It is suspected that the drought resulted in more highly concentrated runoff moving into facilities that contained reduced permanent pools. Precipitation during the period of study was well below normal. The prolonged lack of rain lowered the groundwater table, dried up baseflow, and decreased the volume of the permanent pool. With little or no runoff coming from pervious surfaces all runoff was essentially from impervious surfaces only. The Carver Ravine site was not included in the initial site selection but was added in April 1988. As a result, there were fewer data collected at the site than others.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Chesterfield Mitigated Wetland

BMP Name	Rt 288 Mitigated Wetland	**Watershed Name**	Rt 288
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Chesterfield	**Total Watershed Area**	
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	42.28 Inches
Number of Flow Records	33	**Avg Annual Storm Duration**	9.90 Hour(s)
Number of Water Quality Records	148		
Minimum Flow Volume	0.05 ac ft		
Maximum Flow Volume	1,980.05 ac ft		

Comments

This mitigation site is a 2.02 ha mitigated wetland located in the median of a four-lane highway with a 50,000 vehicle ADT in Chesterfield. The site is characterized by a combination of wet meadow, fresh marsh, and tree swamp area, with a large open water zone near the outlet (approximately 25 percent of the site). Although some dry areas exist, soil conditions are mainly saturated, evidenced by shallow standing water (2.5 - 10 cm) covering most of the site. The site provides a water retention area for stream overflow during wet weather.

The Chesterfiled wetland is fairly linear with inlets adequately separted from the outlet as reflected by a length to width ratio of 4:1. Flow through the site is mostly shallow flow through vegetation (as opposed to channelized flow). Some short-circuiting is suspected due to the proximity of a third inlet to the outlet; however, the magnitude of flow at this inlet is small relative to the contributions from the two main inlets. The wetland has an average residence time of 27.9 hours.

A study of the relative abundance of various plant species in the Chesterfield wetland was conducted. A composite of one-meter plots was used to determine the overall composition of the wetland. The figures do not include woody species or floating aquatic plants that can not be easily counted individually, such as Duckweed. The composite composition of vegetation at the Brooke wetland is as follows: Cattail (29%), Wool Grass (9%), Broom sedge (3%), Buttonbrush (3%), Soft rush (35%), Beaked spike rush (3%), Lurid sedge (10%), Sphagnum (7%), Smartweed (1%). Beaver activity presented problems for monitoring at this site. From late 1996 to June 1997, the beavers in the wetland constructed a large dam at the outflow from the wetland. While the additional storage created by the dam greatly increased stormwater retention, the dam impeded flow measurement and was detrimental to some of the less water-tolerant vegetation. The research team constructed and installed a pond leveler to subvert the beaver dam. Monitoring since August 1997 indicates excellent performance of the pond leveler.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Franklin Farm Pond - Created Wetland		
BMP Name	Franklin Wetland	**Watershed Name**	Franklin Wetland
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Chantilly	**Total Watershed Area**	39.81 ac
State/Country	VA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	143	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	1026		
Minimum Flow Volume	9.28 ac ft		
Maximum Flow Volume	8,833.46 ac ft		

Comments

The potential for an artificially created wetland to serve as a Best Management Practice (BMP) for the control and management of stormwater runoff was assessed. A 0.31 acre (12,481 ft2) artificially created wetland, dominated by species of Typha latifolia, Typha angustifolia, Eleocharis obtusa, Leersia oryzoides, Echinochloa crusgalli and Polygonum sp. received stormwater runoff from a 40 acre subdrainage basin of mixed land uses.

Water samples collected during baseflow periods and storm events were analyzed for a wide range of parameters, including suspended solids and various N and P species. Computer aided gauging stations, located at key points in the system, provided an accurate determination of water flow during sampling periods permitting mass balance and removal efficiency calculations to be made.

Dryfall ortho-phosphate and total soluble phosphorus deposition rates averaged 0.03 mg/m2/day, while total phosphorus depositions averaged slightly higher, 00.10 mg/m2/day. Dryfall nitrogen depositions ranged from 0.16 for ammonia-nitrogen to 0.60 mg/m2/day for total Kjeldahl nitrogen. Total nitrogen dryfall depositions averaged 0.95 mg/m2/day. Phosphorus wetfall deposition rates were very similar to those found in the dryfall, nitrogen depositions were however dissimilar. Ammonia-nitrogen averaged 0.90 mg/m2/day, total Kjeldahl nitrogen averaged 1.03 mg/m2/day, and total nitrogen wetfall depositions averaged 1.82 mg/m2/day.

Baseflow nutrient removals averaged 58 and 42 percent for ortho-phosphate and total soluble phosphorus, respectively. Total nitrogen and oxidizable nitrogen removals averaged 59 and 70 percent, respectively. A 56 percent increase in total Kjeldahl nitrogen was believed to be a result of continuously decaying organic material within the marsh system.

Forty-four storm events were also monitored, 23 of which were synoptic. The average storm event produced 54,500 ft3 of runoff and was a result of 0.85 to 1.1 inches of rainfall. Median storm event efficiencies for the entire synoptic data set were disappointing. Suspended solids removals averaged 71 percent, total nitrogen removals averaged 14 percent, and total phosphorus removals averaged 26 percent. When the synoptic storm data set was subset, according to storm event sizes, for those storms whose sizes were less than or equal to the capacity of the marsh removal efficiencies increased dramatically, while still maintaining comparable loading rates. Phosphorus removals ranged from a low of 25 percent for total soluble phosphorus to 58 percent for total phosphorus. Nitrogen removals ranged from a low of 19 percent for oxidizable nitrogen to 60 percent for total Kjeldahl nitrogen. Total nitrogen removals were estimated to be 45 percent.

Average Pollutant Removal Efficiencies *See notes at end of report.

NITROGEN, TOTAL (MG/L AS N)	3 %
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	3 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	13 %
PHOSPHORUS, TOTAL (MG/L AS P)	23 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	5 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	-14 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	74 %

Test Site Name Hank Aaron Stadium - NW Wetland

BMP Name NW - Wetland Basin

BMP Type Wetland - Basin With Open Water Surfaces

City Mobile

State/Country AL/US

BMP Installation Date

Number of Flow Records 9

Number of Water Quality Records 45

Minimum Flow Volume 494.57 ac ft

Maximum Flow Volume 855.86 ac ft

Watershed Name Dog River Watershed - NW Wetla

Watershed Type Test

Total Watershed Area 10.80 ac

Watershed Area Disturbed 0.00 ac

Avg Annual Rainfall 49.05 Inches

Avg Annual Storm Duration 8.00 Hour(s)

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools).

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Hank Aaron Stadium - SW Wetland

BMP Name	SW - Wetland Basin	**Watershed Name**	Dog River Watershed - SW Wetla
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	17.90 ac
State/Country	AL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	45		
Minimum Flow Volume	729.88		
Maximum Flow Volume	1,824.17		

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools). The wetland basin consists of 7 inflows and 1 outflow. No flow measurements were estimates were made for the first three storm events. Flows were estimated for the 11/10/1998 flow event, but were only quantified for two of the seven inflows. For the purpuse of simplifying calculations the provided total flow volume for the 2 separate inflows was just divided by 2 and split evenly bewtween the 2 inflow points. It is important to not that the total inflow for the 11/10 event was less than the total outlfow. This can be accounted for by neglecting to calculate the flows from the remaining five inflows. Neglecting these flows results in an underestimate of the total removal efficiency of the wetland basin for the 11/10/1998 sampling event.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Hidden River Corporate Office Park

BMP Name	Hidden River Wetland	**Watershed Name**	Hidden River (Total Area)
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Tampa	**Total Watershed Area**	21.09 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	46.86 Inches
Number of Flow Records	960	**Avg Annual Storm Duration**	5.50 Hour(s)
Number of Water Quality Records	5312		
Minimum Flow Volume	0.00 ac ft		
Maximum Flow Volume	3,711.86 ac ft		

Comments

This research project was an in-depth analysis of a three acre isolated natural herbaceous wetland (marsh) in Tampa, Florida used to treat stormwater runoff from a 15 acre drainage basin. Nearly half of the drainage basin was impervious area connected directly to two pretreatment ponds (sedimentation basins). Stormwater runoff flowed to these basins before entering the marsh. The purpose of the study was to evaluate the effectiveness of the marsh to treat stormwater, to compare water quality results to state water quality standards and to document the effects of stormwater management on marsh vegetation and sediment.

Stormwater entered the marsh directly via weirs from two constructed sedimentation basins (east basin and west basin) and from rainfall. East basin received runoff from a central roadway while west basin received runoff from a parking lot and a portion of an office building. Data recording stations were installed at the two inflows and at the single outflow to measure the quality and quantity of stormwater that discharged to and from the marsh. Extensive water quality and hydrologic data for 81 storms events during the 30 month (1991-1993) study were collected and analyzed.

Removal efficiencies (the sum of pollutant load from rainfall and surface water inputs compared to the pollutant load at the outflow) were calculated to evaluate the marsh's ability to reduce pollutants. Most water quality samples collected at the site were measured using flow-weighted composite samples. However, flow-weighted discrete samples were collected during different stages across the hydrograph for six storm events to better understand the processes taking place in runoff at the inflow stations. Water quality constituents measured during the storm events include TSS, TOC, ammonia, total organic nitrogen, nitrite+nitrate, total phosphorus, Ortho phosphates, lead, copper, zinc, cadmium, chromium, manganese, iron and nickel. Physical water quality parameters measured periodically include dissolved oxygen, pH, oxidation-reduction potential, temperature and conductivity. Detailed vegetation analyses were conducted to document changes to wetland vegetation as well as the area adjacent to the marsh. Sediment samples were also collected at two depths within the sediment profile at thirteen stations and were analyzed for chemical constituent concentrations (metal, nutrients, pesticide and PCBs) and sediment particle size.

The marsh effectively reduced most pollutants associated with urban stormwater runoff on an annual mass loading basis (cadmium by 92%, inorganic nitrogen, suspended solids and zinc by at least 85%, and cooper and phosphorus by 71%).
Pollutant removal efficiencies were generally better during the dry season than the wet season which was a function of the reduced discharge volume during the dry season. The marsh was clearly ineffective in reducing loads of sodium, manganese, magnesium, iron and chloride. From discrete sampling analysis, the "first flush" effect was not pronounced in water entering the marsh from the sedimentation basins because some treatment had occurred in the basin and pollutant concentrations were usually low. The field measurements revealed that stormwater entering the marsh from the sedimentation basins had significantly higher levels of pH, DO, and conductivity than the marsh, and the data collected near a marsh inflow compared to outflow data indicated stormwater might be increasing the pH and conductivity in the marsh and might be depressing DO. The detailed vegetation study documented the introduction and invasion of nuisance plant species into the march caused by anthropogenic influences. Analysis of sediment chemistry identified the soil in the marsh as mineral. The accumulation of toxic levels of zinc in the basin receiving runoff directly from a parking lot and building was noted.

This report seems to be a very good document on the study of wetlands used for stormwater treatment. It also provides some insights in the future long-term effects on stormwater management.

Although the two sedimentation basins served as pre-treatment systems for stormwater in this study, the main purpose of the project was designed to study the effectiveness of the marsh as a natural wetland to reduce stormwater pollutants. As a result, the effectiveness of the sedimentation basins in pollutant removal were not documented and the sedimentation basins were not recorded as BMPs in the database.

At least three discrete flow weighted samples were taken for twelve rain events to determine the "First Flush" effect. The sampling results were divided into four categories depending on when the samples were taken during the storm hydrograph: on the rising limb, during peak flow, on the falling limb and during the trailing end. Table 17 on pages 72-73 of the report presented the sampling results. Since the sampling times were not specified in the table or elsewhere in the report, the information in table 17 were not input into the database.

Average Pollutant Removal Efficiencies *See notes at end of report.

CARBON, TOTAL ORGANIC (MG/L AS C)	-191 %
LEAD, TOTAL (UG/L AS PB)	25 %
POTASSIUM, TOTAL MG/L AS K)	10 %
NITROGEN, TOTAL (MG/L AS N)	-30 %
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	-54 %
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	19 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	-54 %
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	76 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	68 %
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	70 %
IRON, TOTAL (UG/L AS FE)	-22 %
HARDNESS, TOTAL (MG/L AS CACO3)	57 %
CALCIUM (MG/L AS CACO3)	43 %
SODIUM, TOTAL (MG/L AS NA)	-190 %
COPPER, TOTAL (UG/L AS CU)	31 %
CHLORIDE,TOTAL IN WATER MG/L	-163 %
SULFATE, TOTAL (MG/L AS SO4)	25 %
CADMIUM, TOTAL (UG/L AS CD)	26 %
PHOSPHORUS, TOTAL (MG/L AS P)	61 %
MANGANESE, TOTAL (UG/L AS MN)	-22 %
MAGNESIUM, TOTAL (MG/L AS MG)	-124 %
ZINC, TOTAL (UG/L AS ZN)	67 %

Test Site Name Mays Chapel Wetland Basin

BMP Name Mays Chapel Wetland Basin

BMP Type Wetland - Basin With Open Water Surfaces

City Mays Chapel

State/Country MD /US

BMP Installation Date

Number of Flow Records

Number of Water Quality Records 243

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Mays Chapel Wetland Basin

Watershed Type Test

Total Watershed Area 98.30 ac

Watershed Area Disturbed

Avg Annual Rainfall 39.41 Inches

Avg Annual Storm Duration 10.60 Hour(s)

Comments

This paper describes a large project initiated in 1984 to retrofit several flood control basins to function as water quality detention basins. Of the 24 basins targeted for retrofit, only 5 were completed because of perceived liability and maintenance issues on the part of private landowners on whose property the basins were located. Retrofit included extending the detention time of the basins for smaller flows while maintaining their flood control ability for larger flows. This was accomplished by the installation of a low flow restricting orifice at the outflow that would detain 1 yr. (or 50% of 1 yr.) storm volume for 6 to 24 hours. Larger flows bypassed the orifice. Sufficient data was collected to calculate removal efficiencies for: Suspended Solids (TSS), Dissolved Phosphorus (DP), Total Phosphorus (T-P), Nitrite+Nitrate Nitrogen (NO3+NO2-N), and Ammonia Nitrogen (NH3-N) in 2 of the 5 basins. Also discussed in detail is the rationale used to select detention time for the basins.

The Mays Chapel detention basin watershed area is approximately 98.6 acres and consists primarily of townhouses and single family residences. The basin had 2 inlets and 1 outlet. A small stream near one of the inlets provides a permanent source of water to the basin (0.1 to 0.2 ft^3/sec) which results in a 2 ft deep wetland pond near the outlet structure. Approximately 50% of the pond was less than 1 ft. deep. The permanent pool of the pond had an area of 0.7 acres and a volume of 30,476 ft^3. Flows were measured at the outflow stations with a broad-crested weir and an H-flume. Stages were measured with pressure transducers. Water quality samples were flow weighted composites collected by ISCO automated samplers for most parameters. The pH, dissolved oxygen and temperature were continuously monitored with a Hydrolab Surveyor II water quality data system. Retrofit of Mays Chapel basin included the installation of a flow-restricting orifice designed to provide 24 hrs. detention for 50% of the 1 yr. storm.

The Mays Chapel detention pond showed moderate storm removals for all parameters: suspended solids (46%), ammonia nitrogen (51%), dissolved phosphorus (52%), total phosphorus (26%), and nitrate + nitrite nitrogen (23%). When combined with base flow data, however, removal efficiencies for the basin are much lower: suspended solids (11%), ammonia nitrogen (22%), dissolved phosphorus (29%), total phosphorus (-7%), and nitrate + nitrite nitrogen (28%). The author concluded that the low or negative pollutant removal efficiencies obtained for dry weather flows were partially a result of increased biological activity (primary production of algae) which would account for 4 to 7% of the total nutrients discharged during these periods.

Appendix F in the document provided the raw data used to calculate the mean pollutant concentrations. However, due to the manner in which the data was presented, individual storm events (listed by date in the raw data) could not be linked to the storm event EMC's (listed by storm number) that were given. No precipitation data could be found in the document.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Prince George's Pond

BMP Name Prince George's Pond

BMP Type Wetland - Basin With Open Water Surfaces

City Clinton

State/Country MD /US

BMP Installation Date

Number of Flow Records 49

Number of Water Quality Records 431

Minimum Flow Volume 69.41 ac ft

Maximum Flow Volume 15,826.17 ac ft

Watershed Name Prince George's Watershed

Watershed Type Test

Total Watershed Area 100.00 ac

Watershed Area Disturbed

Avg Annual Rainfall 39.41 Inches

Avg Annual Storm Duration 10.60 Hour(s)

Comments

This study measured the treatment efficiencies of two constructed wetland stormwater basins from August 1987 through November 1989. Samples were analyzed for the following constituents: total suspended solids (TSS), total organic nitrogen (TON), total organic phosphorous (TOP), total particulate nitrogen (TPN), total particulate phosphorous (TPP), nitrate+nitrite nitrogen (NO3+NO2), nitrate nitrogen (NO3-N), nitrite nitrogen (NO2-N), total nitrogen (TN), ammonia nitrogen (NH3-N), total dissolved nitrogen (TDN), total dissolved phosphorous (TDP), total phosphorous (TP), and phosphate (PO4).

The Queen Anne's county constructed wetland is a 0.6 acre basin that collected runoff from a 16 acre drainage area. The Queen Anne (QA) site includes the structure and parking areas for a high school; therefore, the watershed is mostly impervious. The Prince George county (PG) wetland is 3 acres in total area and collected runoff from a 100 acre drainage area. The PG watershed is occupied by a business park and is 100% impervious. Flows were continuously recorded at both sites using ISCO 2300 flow-meters with pressure transducers. At Queen Anne, H-flumes were attached to the inlet and outlet structures to measure flows. At the Prince George site, Palmer-Bowlus flumes were used. Sampling was done using ISCO 2700 automatic programmable samplers at pre-determined flow intervals (2000 ft^3, 3000 Ft^3, 6000 Ft^3 or 9000 Ft^3) depending on the sample site. The Queen Anne wetland was planted with various types of emergent vegetation (Bull Rush, Lizard Tail, Duck Potato) while the PG wetland was left un-vegetated; however, by the end of the study, both wetlands experienced colonization by invasive plants (primarily Cattail).

Several technical difficulties were experienced at both sites limiting the amount of usable data collected. Freezing problems with the H-flumes, sand buildup in the Palmer-Bowlus flumes, infiltration and exfiltration, and the infiltration of TSS from a nearby construction site at the PG site were most notable. Removal efficiencies estimated for the Queen Anne site were: 65% for TSS, 7% for TPN, 55% for NO2-NO3, 56% for NH4, 69% for PO4, 6% for TOP, 5% for TPN, 7% for TPP, 23% for total-N, 39% for total-P, and there was a net export of total-organic nitrogen. Removal efficiencies were not calculated for the Prince George site .

Much of data for Prince George's Pond may not be useful. There are two inlets and one outlet. On only a few occasions were all three sampled during the same storm event. Additionally, there was no rainfall information for this site.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Queen Anne's Pond

BMP Name	Queen Anne's Pond	**Watershed Name**	Queen Anne's Watershed
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Centreville	**Total Watershed Area**	16.00 ac
State/Country	MD/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	39.41 Inches
Number of Flow Records	135	**Avg Annual Storm Duration**	10.60 Hour(s)
Number of Water Quality Records	1211		
Minimum Flow Volume	8.56 ac ft		
Maximum Flow Volume	4,858.91 ac ft		

Comments

This study measured the treatment efficiencies of two constructed wetland stormwater basins from August 1987 through November 1989. Samples were analyzed for the following constituents: total suspended solids (TSS), total organic nitrogen (TON), total organic phosphorous (TOP), total particulate nitrogen (TPN), total particulate phosphorous (TPP), nitrate+nitrite nitrogen (NO3+NO2), nitrate nitrogen (NO3-N), nitrite nitrogen (NO2-N), total nitrogen (TN), ammonia nitrogen (NH3-N), total dissolved nitrogen (TDN), total dissolved phosphorous (TDP), total phosphorous (TP), and phosphate (PO4).

The Queen Anne's county constructed wetland is a 0.6 acre basin that collected runoff from a 16 acre drainage area. The Queen Anne (QA) site includes the structure and parking areas for a high school; therefore, the watershed is mostly impervious. The Prince George county (PG) wetland is 3 acres in total area and collected runoff from a 100 acre drainage area. The PG watershed is occupied by a business park and is 100% impervious. Flows were continuously recorded at both sites using ISCO 2300 flow-meters with pressure transducers. At Queen Anne, H-flumes were attached to the inlet and outlet structures to measure flows. At the Prince George site, Palmer-Bowlus flumes were used. Sampling was done using ISCO 2700 automatic programmable samplers at pre-determined flow intervals (2000 ft^3, 3000 Ft^3, 6000 Ft^3 or 9000 Ft^3) depending on the sample site. The Queen Anne wetland was planted with various types of emergent vegetation (Bull Rush, Lizard Tail, Duck Potato) while the PG wetland was left un-vegetated; however, by the end of the study, both wetlands experienced colonization by invasive plants (primarily Cattail).

Several technical difficulties were experienced at both sites limiting the amount of usable data collected. Freezing problems with the H-flumes, sand buildup in the Palmer-Bowlus flumes, infiltration and exfiltration, and the infiltration of TSS from a nearby construction site at the PG site were most notable. Removal efficiencies estimated for the Queen Anne site were: 65% for TSS, 7% for TPN, 55% for NO2-NO3, 56% for NH4, 69% for PO4, 6% for TOP, 5% for TPN, 7% for TPP, 23% for total-N, 39% for total-P, and there was a net export of total-organic nitrogen. Removal efficiencies were not calculated for the Prince George site.

Much of data for Prince George's Pond may not be useful. There are two inlets and one outlet. On only a few occasions were all three sampled during the same storm event. Additionally, there was no rainfall information for this site.

Average Pollutant Removal Efficiencies *See notes at end of report.

NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	56 %
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	40 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	54 %
PHOSPHORUS, TOTAL (MG/L AS P)	34 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	54 %
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	-44 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	72 %
PHOSPHORUS, SUSPENDED (MG/L AS P)	12 %
NITROGEN, TOTAL (MG/L AS N)	-47 %

Test Site Name Rt. 211 Covington River

BMP Name	Rt 211 Mitigated Wetland	**Watershed Name**	Rt 211 Covington River
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Sperryville	**Total Watershed Area**	
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	37.46 Inches
Number of Flow Records	9	**Avg Annual Storm Duration**	10.00 Hour(s)
Number of Water Quality Records	40		
Minimum Flow Volume	3.02 ac ft		
Maximum Flow Volume	487.64 ac ft		

Comments

The primary source of surface water in the wetland is a small channel that runs through the wetland and then into the Covington River. This channel passes through a cow pasture immediately prior to entering the wetland. A spring within the wetland also supplies water. Soil conditions range from extremely dry on the western side of the wetland in a high marsh area to saturated conditions with shallow pools of standing water in the low marsh covering the remainder of the site. Unvegetated open water area accounts for less than 5 percent of the wetland area. Flow is very channelized with minimal obstruction from vegetation. The site has a length to width ratio of 5:3 and an average residence time of 8.5 hrs. The following removal efficiencies were calculated for this wetland:

1. EMC Reduction % and (standard deviation %)
TSS 29.02 (12.19)
TP 29.46 (8.37)
OP 15.38 (-----)
COD 50.33 (22.98)
Zn not detected
TN 18.42
NO3-N 54.38
FC 75.00

2. MRE % and (standard deviation %)
TSS 68.29 (30.77)
TP 71.22 (23.79)
OP 32.21 (-----)
COD 74.63 (74.63)
Zn not detected

3. SOL Removal %
TSS 62.45
TP 67.36
OP 32.21
COD 62.19
Zn not detected

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Swift Run Wetland

BMP Name	Swift Run Wetland	**Watershed Name**	Swift Run Wetland
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Ann Arbor	**Total Watershed Area**	1,207.10 ac
State/Country	MI/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	30.05 Inches
Number of Flow Records	12	**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	56		
Minimum Flow Volume	12,725.73 ac ft		
Maximum Flow Volume	87,923.19 ac ft		

Comments

Conducted in the Huron River Basin, the objectives of this project were to evaluate the effectiveness of BMP's in reducing pollutant loads present in urban stormwater runoff. Two documents, (1.3.0.028) and (1.3.0.029), cover the same project which was part of the larger NURP program.

Pollutant loads and removals were evaluated for 3 separate BMP's, including; 1) a retention basin, 2) a surface detention basin, and 3) a natural wetland. Parameters evaluated were: Suspended Solids (TSS), Total Phosphorus (T-P), Total Kjeldahl Nitrogen (TKN), Total Iron (T-Fe), and Total Lead (T-Pb). The Swift Run wetland is a naturally occurring wetland that receives runoff from an area of approximately 1207 acres.

About 42% of the drainage area is rural and pasture land, 30% is agricultural land, 15 % is parkland and 13 % is residential, commercial or industrial. At a maximum depth of 3 feet above the outlet weir, the wetland has an estimated capacity of 2,621,000 ft^3 , a surface area of 1,077,000 ft^2 and affords the wetland a two hr. detention time for 25 yr., 24 hr. storm flows.

Five storm events and one snow melt event were sampled for the parameters listed above. Event mean concentration and adjusted (for baseflow conditions, see Pittsfield Retention Pond) pollutant removal efficiencies were calculated.

Some valuable information may be gleaned from this study; however, the results obtained must be carefully considered because: 1) none of the BMP's evaluated were designed specifically for the use to which they were put, 2) design problems may have contributed to increased pollutant loads from the Pittsfield and Traver Creek retention basins, 3) the Traver Creek and the Swift Creek watersheds were rural rather than urban, and were dominated by agricultural land uses, not the primary focus of this study. The above mentioned factors may make it difficult to compare the results obtained in this study to those obtained from projects with similar BMP's.

Average Pollutant Removal Efficiencies *See notes at end of report.

PHOSPHORUS, TOTAL (MG/L AS P)	45 %
IRON, TOTAL (UG/L AS FE)	52 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	75 %
LEAD, TOTAL (UG/L AS PB)	80 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	-91 %

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Dem. Urban SW Treatment (DUST) Marsh

BMP Name	DUST Marsh Debris Basin	**Watershed Name**	DUST Marsh Watershed
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Fremont	**Total Watershed Area**	1,198.04 ac
State/Country	CA /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	17.06 Inches
Number of Flow Records	131	**Avg Annual Storm Duration**	13.30 Hour(s)
Number of Water Quality Records	3506		
Minimum Flow Volume	67.10 ac ft		
Maximum Flow Volume	29,047.04 ac ft		

Comments

The Demonstration Urban Stormwater Treatment (DUST) Marsh at Coyote Hills Regional Park in Fremont (Alameda County), California was designed as a prototype system and research facility to study wetland creation for stormwater treatment in the San Francisco Bay Area. The design of the marsh was intended to test various system configurations for water treatment effectiveness, to maintain and enhance other uses of the area such as flood control and wildlife habitat, and to demonstrate the practicality of constructing a treatment wetland.

The project site is approximately 55 acres and it receives urban runoff from a 4.6 sq. mi area within the city of Fremont, California. Runoff water enters the initial Debris Basin and is divided among two parallel flow systems (a lagoon and a pond system) that may be operated independently. The two systems discharge into a common third system (a marsh system).

The treatment performance of the DUST Marsh over 7 monitored storms during Winter 1985-1986 and on a seasonal mass loading basis showed the following removal rates: TSS -64%; oil and grease -11%; Nitrate-nitrogen -15%; Ortho-phosphates -56%; chromium -68%; copper -31%; lead -88%; and zinc -33%. No detectable concentrations of selenium were found in the selection of water samples. Overall, the third system which supported a well developed marsh system with mature vegetation provided the best treatment of metals, suspended solids, and oil and grease. The first system, a lagoon, provided good treatment of suspended solids, ortho-phosphate, and chromium. The second system, an overland flow/pond system, provided the best treatment of copper and Nitrate-nitrogen.

Overall, the DUST Marsh was effective in the reduction of suspended solids, inorganic nitrogen, phosphorous, cadmium, and lead regardless of the system. As the marsh becomes more established, the differences in treatment levels in the three systems that are due to design variations will become more apparent.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

%

%

Test Site Name	Hank Aaron Stadium - NW Detention Basin		
BMP Name	NW - Detention Basin	**Watershed Name**	Dog River Watershed - NW Deten
BMP Type	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	10.80 ac
State/Country	AL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	9	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	23		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools). This site was originally desinged as an extended dry pond facility.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Hank Aaron Stadium - NW Wetland

BMP Name	NW - Wetland Basin	**Watershed Name**	Dog River Watershed - NW Wetla
BMP Type	Wetland - Basin With Open Water Surfaces	**Watershed Type**	Test
City	Mobile	**Total Watershed Area**	10.80 ac
State/Country	AL/US	**Watershed Area Disturbed**	0.00 ac
BMP Installation Date		**Avg Annual Rainfall**	49.05 Inches
Number of Flow Records	9	**Avg Annual Storm Duration**	8.00 Hour(s)
Number of Water Quality Records	45		
Minimum Flow Volume	494.57 ac ft		
Maximum Flow Volume	855.86 ac ft		

Comments

This wetland was "retro-fitted" from a retention pond. The modifications of this basin consisted of creating typical zones desired for stormwater treatment including: high marsh, low marsh and deep marsh (micropools).

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Hidden Lake Wetland

BMP Name Hidden Lake Wetland

BMP Type Wetland - Channel With Wetland Bottom

City Sanford

State/Country FL/US

BMP Installation Date

Number of Flow Records 24

Number of Water Quality Records 2242

Minimum Flow Volume

Maximum Flow Volume

Watershed Name Hidden Lake Wetland Watershed

Watershed Type Test

Total Watershed Area 55.40 ac

Watershed Area Disturbed

Avg Annual Rainfall 47.15 Inches

Avg Annual Storm Duration 5.90 Hour(s)

Comments

The movement and fate of phosphorus inputs from residential stormwater runoff were investigated in a 1.0 hectare section of hardwood wetland near Sanford, FL. Nutrient and metals concentrations from stormwater runoff were measured in the surface waters as they entered the wetland and at several points along the primary path of flow. Groundwater and sediments throughout the wetland were sampled to determine the fate of pollutants that enter the system. The typical chemical associations that bind the nutrients and heavy metals to the soil were examined.

This 1.0 hectare section (bay) of a much larger (48.4 Ha) natural hardwood wetland collected stormwater runoff from a residential community as it flowed into a nearby lake. The hydraulic regime of the wetland changed seasonally and ranged from no surface discharge in the winter to a direct hydraulic connection to the lake in the summer. The total drainage to the 1.0 ha sector of wetland was 22.4 ha of which 26% was estimated to be impervious. A weir was placed at the inlet where stormwater flow was measured. Surface water quality samples were taken at the weir and at points 10, 25, 50, 75, 100, 125, and 150 meters distant from the weir along the primary path of flow.

Specific conductance, pH, dissolved oxygen, oxidation/reduction potential (ORP) and alkalinity concentrations in the surface water tended to decrease as the distance from the input increased. Ortho-phosphorus and total phosphorus concentrations increased along the path of flow and were found to be closely related to decreases in ORP and pH. Water quality characteristics in the groundwater beneath the flow path were similar to surface water characteristics. Patterns of accumulation and deposition of sediment bound phosphorus were found to increase along the flow path up to a distance of 50 m. from the inlet, after which, they declined slightly throughout the remainder of the wetland. Also apparent was the attenuation of phosphorus concentration with increased sediment depth, with the majority of the phosphorus being retained in the top 10 cm. The removal potential for dissolved ortho-phosphorus was found to be greatest in flow through systems with the majority of the phosphorus being removed in the first 24 hrs. of contact with wetland sediments.

This is not a well defined wetland in that the boundaries are not distinct and inputs are not controlled, and the author of the study makes no attempt to determine the removal efficiency of the system. Even so, there is some very good information about the spatial distribution of pollutants as stormwater travels through the wetland which may be useful to the project. Valuable missing information includes the flow data and the depth, dimensions and hydraulic retention time of the wetland.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Lake McCarrons Wetland Treatment System		
BMP Name	Lake McCarrons Sedimentation Basin	**Watershed Name**	Lake McCarrons Wetland Ouflow
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Roseville	**Total Watershed Area**	636.05 ac
State/Country	MN /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	25.52 Inches
Number of Flow Records	144	**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	1449		
Minimum Flow Volume	40.32 ac ft		
Maximum Flow Volume	17,486.67 ac ft		

Comments

The McCarrons Wetland Treatment System (MWTS) is a surface water management facility consisting of a detention pond followed by six "chambered" wetlands and discharging to the northwest end of Lake McCarrons.

Water quality monitoring of the MWTS has shown the system to be very effective in the removal of solids-associated pollutants and moderately effective in removing soluble nutrients. Most of the reduction in pollutants occurs in the detention pond because of the highly concentrated manner in which runoff enters.

Performance conclusions are based on results from 21 monitored events of the 57 rainfall events and four periods of snowmelt. Climatic conditions and the precipitation during the 21 months of study were not "normal", but rather reflective of a mild, dry period within which a major event and two very wet months occurred.

The detention pond is performing at the best level that can be expected. The pond has lost 18% of its permanent pool volume (5% of crest volume) in 21 months of operation. Attributes that are thought to contribute positively to treatment levels in the pond include diffuse inflow from three separate tributaries, a low total dissolved-to-total phosphorous ratio (TDP:TP) in entering runoff water, and newly exposed peat soils with a high affinity for attracting TP. The pond did not respond well to snowmelt loading during the melt of 1988 because of an ice layer that forced flow either under the ice in a turbulent manner or over the ice where settling depth was insufficient and turbulence was high. Changes in the design of the outlet structure could improve the effectiveness of the detention pond in treating snowmelt.

Hydrologic variables that appear to be important to the performance of the detention pond include rainfall intensity, hydraulic detention time, total amount of precipitation in the event, and time since last rainfall over 0.1 inch. These variables seem to be related to the transport of solids-related pollutants to the pond and the amount of time that quiescent settling occurs between events.

The post-detention wetland system was intended to "polish" outflows form the detention pond before the water discharges to the lake. The wetlands continues the good job of solids settling begun in the pond, but is somewhat less effective for soluble nutrients. Even though nutrient removal in the wetland
is not high, there is a net reduction, so the wetland is performing in the manner intended.

Average Pollutant Removal Efficiencies *See notes at end of report.

NITROGEN, TOTAL (MG/L AS N)		27 %
COD, .025N K2CR2O7	MG/L	64 %
LEAD, TOTAL (UG/L AS PB)		70 %
PHOSPHORUS, DISSOLVED (MG/L AS P)		14 %
PHOSPHORUS, TOTAL (MG/L AS P)		55 %
NITRATE NITROGEN, TOTAL (MG/L AS N)		16 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)		84 %
RESIDUE, TOTAL VOLATILE (MG/L)		84 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)		30 %
RESIDUE, TOTAL VOLATILE (MG/L)		78 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)		83 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)		56 %

NITRATE NITROGEN, TOTAL (MG/L AS N)		54 %
PHOSPHORUS, TOTAL (MG/L AS P)		56 %
PHOSPHORUS, DISSOLVED (MG/L AS P)		46 %
LEAD, TOTAL (UG/L AS PB)		80 %
NITROGEN, TOTAL (MG/L AS N)		56 %
COD, .025N K2CR2O7	MG/L	62 %

Test Site Name Megginnis Creek

BMP Name	Megginis Ck. Marsh	**Watershed Name**	Megginnis Ck. Marsh/Snd Filter
BMP Type	Wetland - Channel With Wetland Bottom	**Watershed Type**	Test
City	Tallahassee	**Total Watershed Area**	2,730.50 ac
State/Country	FL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	62.95 Inches
Number of Flow Records	37	**Avg Annual Storm Duration**	7.10 Hour(s)
Number of Water Quality Records	2798		
Minimum Flow Volume	67.42 ac ft		
Maximum Flow Volume	1,097,396.07 ac ft		

Comments

The report investigated the efficiency of a sand filter and an artificial marsh in removing solids and nutrients from runoff originating from a highly commercialized area in Tallahassee. The BMPs are located on Megginnis Arm Creek which flows into Lake Jackson. The BMPs were monitored for 11 storm events from 1983-1987.

Additional information/studies that were included in the report, but not entered into the database are as follows:
1. Kinetics of nutrient uptake by the marsh
2. Effect of the treatment system on long-term chlorophyll concentrations in Megginnis Arm Creek and Lake Jackson
3. Effects of bypass on the quality of the effluent from the treatment system
4. Effect of different filter fabric materials (fabric between sand and limestone) on particle removal

The sand filter removed more than 90% solids. Filter removal efficiency reduced over time due to plugging. The effluent from the filter showed an increase in calcium, magnesium and nitrate. Nitrifying bacteria in the impoundment basin oxidized ammonia to nitrate which in turn produced nitric acid and dissolved the calcium and magnesium in the limestone filter underdrain. The artificial marsh removed an average of 60-65% of dissolved nutrients.

The data report is comprehensive. Most essential database field information is included, but some important information such as the BMP catchment area and a description of how the flow data were collected is missing. Most of the studies in the report were not included in the database. Very good QA/QC protocol.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Shop Creek Wetland-Pond (1990-94)

BMP Name	Shop Creek Pond (90-94)	**Watershed Name**	Shop Creek Watershed (90-94)
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Aurora	**Total Watershed Area**	550.02 ac
State/Country	CO /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	13.74 Inches
Number of Flow Records	114	**Avg Annual Storm Duration**	11.20 Hour(s)
Number of Water Quality Records	1876		
Minimum Flow Volume	338.27 ac ft		
Maximum Flow Volume	32,832.60 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Shop Creek Wetland-Pond (1995-97)

BMP Name	Shop Creek Pond (95-97)	**Watershed Name**	Shop Creek Watershed (95-97)
BMP Type	Retention Pond (Wet) - Surface Pond With a Permanent Pool	**Watershed Type**	Test
City	Aurora	**Total Watershed Area**	550.02 ac
State/Country	CO / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	13.74 Inches
Number of Flow Records	69	**Avg Annual Storm Duration**	11.20 Hour(s)
Number of Water Quality Records	2064		
Minimum Flow Volume	14.58 ac ft		
Maximum Flow Volume	24,842.93 ac ft		
Comments			

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Silver Star Rd Det./Wtlnd System

BMP Name Silver Star Rd Detention Pond

Watershed Name Silver Star Rd Det. Watershed

BMP Type Retention Pond (Wet) - Surface Pond With a Permanent Pool

Watershed Type Test

City Orlando

Total Watershed Area 41.61 ac

State/Country FL/US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 47.15 Inches

Number of Flow Records 37

Avg Annual Storm Duration 5.90 Hour(s)

Number of Water Quality Records 767

Minimum Flow Volume 185.93 ac ft

Maximum Flow Volume 2,664.97 ac ft

Comments

The study examines the efficiency of a detention pond/wetland system for temporary storage of urban stormwater runoff from a Florida Department of Transportation roadway. The system is an online temporary storage pond-wetland system in series. The study documents the regression efficiency for 22 constituents. 13 storms were monitored.

The author concludes that the pond generally reduced suspended constituent loads (TSS, 65%, suspended Pb, 41%, suspended Zn, 37%, Suspended N, 17%, and suspended P, 21%). Additionally, the wetland was generally effective in reducing suspended constituent loads. (TSS, 66%, Pb 75%, Zn, 50%, N, 30%, P, 19%), and dissolved loads (TDS, 38%, Pb, 54%, Zn, 75%, N, 13%, P, 0%). The system was quite effective at reducing pollutant loads.

One of the most interesting aspects of the article is the use of an efficiency calculation method termed the "regression efficiency". This method is carried out by regressing loads-out as a function of loads-in with the intercept of the regression constrained to the origin. The regression efficiency is thus defined as unity minus the regression slope. The regression efficiency assumes that the efficiency is the same for all storms and that the storms monitored are representative of all storms for the BMP.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Tanners Lake Wetland

BMP Name	Tanners Lake Wetland	**Watershed Name**	Tanners Lake Wetland Watershed
BMP Type	Wetland - Channel With Wetland Bottom	**Watershed Type**	Test
City	Oakdale	**Total Watershed Area**	536.96 ac
State/Country	MN /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	25.52 Inches
Number of Flow Records	26	**Avg Annual Storm Duration**	9.80 Hour(s)
Number of Water Quality Records	187		
Minimum Flow Volume	231.81 ac ft		
Maximum Flow Volume	11,378.94 ac ft		

Comments

The Metropolitan Council has been studying the occurrence and control of non-point source pollution, since 1976. It became apparent that little data existed to evaluate the effectiveness of BMP's, and as a result the council began a program to document such practices. In the area, the two most common techniques for runoff control are wetlands and detention ponds. The council decided to study four management facilities, all located within the Ramsey Washington Metro Watershed District. The facility researched within this site was the Tanners Lake Wetland.

A wetland area tributary to Tanners Lake was altered to detain runoff for a longer period of time. The District undertook the project because the wetland, with channelized flow, was ineffective in treating runoff coming from the largest single area draining to the lake. The project consisted of the installation of two permeable weirs or leaky check dams perpendicular to the flow. There is no permanent storage in the wetland.

The facility was not complete and stable until early summer of 1988. As a result the site was monitored for less than one year, plus a baseflow sample taken in March 1988.

Appropriate adjustments have been made in presenting the data because flow was not sufficient enough to overflow a mid-watershed wetland.

Average Pollutant Removal Efficiencies *See notes at end of report.

PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	62 %
PHOSPHORUS, DISSOLVED (MG/L AS P)	19 %
RESIDUE, TOTAL VOLATILE (MG/L)	63 %
PHOSPHORUS, TOTAL (MG/L AS P)	29 %
NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	11 %
NITRATE NITROGEN, TOTAL (MG/L AS N)	22 %
RESIDUE, TOTAL NONFILTRABLE (MG/L)	72 %
LEAD, DISSOLVED (UG/L AS PB)	0 %
LEAD, TOTAL (UG/L AS PB)	63 %
NITROGEN, TOTAL (MG/L AS N)	11 %

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Bower's Hill Wetland

BMP Name	Bower's Mitigated Wetland	**Watershed Name**	Route 460
BMP Type	Wetland - Basin Without Open Water (Wetland Meadow Type)	**Watershed Type**	Test
City	Chesapeake	**Total Watershed Area**	
State/Country	VA / US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	42.28 Inches
Number of Flow Records	16	**Avg Annual Storm Duration**	9.90 Hour(s)
Number of Water Quality Records	72		
Minimum Flow Volume	0.74 ac ft		
Maximum Flow Volume	2,829.86 ac ft		

Comments

The Bower's Hill site is a 0.70 ha mitigated wetland in Chesapeake, VA surrounded on all sides by highways. The primary sources of runoff for the wetland are the eastbound lanes of I-64 and an exit ramp from the westbound lane. While some dry areas exist, soil conditions are mainly saturated, evidenced by shallow standing water covering much of the site. Dense vegetation at this site includes Cattail, Giant Cane Grass, and woody species including Red Maple, Swamp Chesnut Oak, and Water Oak.

At this site, the inlet draining an exit ramp of I-64 is within 10 meters of the outlet structure; therefore short circuiting is believed to occur. Flow path (even for water traveling from the farthest spaced inlet and outlet) at this site is minimized as the length to width ratio is only 1:1. When calculating mean performance, It should be noted that the data for this site includes data from Hurricane Bertha, an extremely large event that had the effect of "flushing out" a lot of debris from the wetland.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Rio Hill Detention Basin

BMP Name	Rio Hill Detention Basin	**Watershed Name**	Rio Hill Shopping Center
BMP Type	Wetland - Basin Without Open Water (Wetland Meadow Type)	**Watershed Type**	Test
City	Charlottesville	**Total Watershed Area**	74.13 ac
State/Country	VA/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	38.26 Inches
Number of Flow Records	20	**Avg Annual Storm Duration**	10.90 Hour(s)
Number of Water Quality Records	400		
Minimum Flow Volume	38.40 ac ft		
Maximum Flow Volume	2,349.00 ac ft		

Comments

This site is a stormwater detention basin with emergent vegetation. Runoff to the basin is supplied from a shopping center with an extensive parking area and from a nearby intersection (ADT 33,000 vehicles). There is ongoing construction in the area. Unvegetated open water area accounts for less than 5% of the wetland area. The lower section of the basin usually has shallow standing water and is dominated by moderately dense emergent vegetation. Woody vegetation and shrubs are moderately dense in the high marsh areas along the banks. Black Willow is dense along the main channel. No record for initial planting was available for this site; however, the abundance of species observed (greater than 20) is far greater than that of a typical planting plan. As mentioned, density of vegetation at this site was moderate; however, scattered stands were very dense, and only a small, dry section along the southeastern bank was sparsely vegetated.

This detention basin has 7 inlets spread out around the perimeter. (Note: the total flow volumes given in this report do not match the imported raw data, because the inflow and outflow totals were adjusted to account for flow from the 5 unmonitored inlets.) The position of the inlets with respect to the outlet causes a great deal of short circuiting in the wetland and channelization further decreases residence time. A length to width ratio based on an average of distances between inlets and the outlet is 5:8 and residence time for this site averages 4.4 hours.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

BMP Test Site Summary Information

Test Site Name Bellevue, Lake Hills, Active CB, SC

BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Active CB, SC
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA /US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	50	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	440		
Minimum Flow Volume	45.58 ac ft		
Maximum Flow Volume	5,159.70 ac ft		

Comments

Bellevue in Lake Hills, The catchbasins were active and street cleaning was being conducted

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Active CB, No SC
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Reference
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA /US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	50	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	440		
Minimum Flow Volume	45.58 ac ft		
Maximum Flow Volume	5,159.70 ac ft		

Comments

Bellevue in Lake Hills. The catchbasins were active and street cleaning was being conducted

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Bellevue, Lake Hills, Full CB, SC

BMP Name USGS12119725

Watershed Name Lake Hills, Full CB, SC

BMP Type Maintenance Practices - Catch Basin Cleaning

Watershed Type Test

City Bellevue

Total Watershed Area 101.81 ac

State/Country WA /US

Watershed Area Disturbed 101.81 ac

BMP Installation Date

Avg Annual Rainfall 34.31 Inches

Number of Flow Records 79

Avg Annual Storm Duration 14.60 Hour(s)

Number of Water Quality Records 688

Minimum Flow Volume 29.15 ac ft

Maximum Flow Volume 5,622.46 ac ft

Comments

Lake Hills in Bellevue, the catchbasins had reached their capacity and street cleaning operations were being conducted during this period.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when

accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Full CB, No SC
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Reference
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA /US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	79	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	688		
Minimum Flow Volume	29.15 ac ft		
Maximum Flow Volume	5,622.46 ac ft		

Comments

Lake Hills in Bellevue, the catchbasins had reached their capacity and street cleaning operations were being conducted during this period.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

---

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Bellevue, Surrey Downs, Active CB, SC

BMP Name USGS12119725

Watershed Name Lake Hills, Active CB, No Sc

BMP Type Maintenance Practices - Catch Basin Cleaning

Watershed Type Reference

City Bellevue

Total Watershed Area 101.81 ac

State/Country WA/US

Watershed Area Disturbed 101.81 ac

BMP Installation Date

Avg Annual Rainfall 34.31 Inches

Number of Flow Records 31

Avg Annual Storm Duration 14.60 Hour(s)

Number of Water Quality Records 257

Minimum Flow Volume 28.00 ac ft

Maximum Flow Volume 3,711.28 ac ft

Comments

Surrey Downs watershed in Bellevue. The catchbasins were active and there was street cleaning operation.

The Bellevue, WA. NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when

accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Active CB
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA/US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	31	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	257		
Minimum Flow Volume	28.00 ac ft		
Maximum Flow Volume	3,711.28 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins were active and there was street cleaning operation.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.

Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Bellevue, Surrey Downs, Full CB, SC

BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Full CB, No SC
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Reference
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA/US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	48	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	427		
Minimum Flow Volume	70.80 ac ft		
Maximum Flow Volume	9,463.31 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins have reached their capacity and there were street cleaning opeations.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when

accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.

Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Full CB, SC
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA/US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	48	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	427		
Minimum Flow Volume	70.80 ac ft		
Maximum Flow Volume	9,463.31 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins have reached their capacity and there were street cleaning opeations.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

---

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Castro Valley

BMP Name Knox Station after urban area

BMP Type Maintenance Practices - Street Sweeping

City Castro Valley

State/Country CA /US

BMP Installation Date

Number of Flow Records 80

Number of Water Quality Records 1687

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 438,327.32 ac ft

Watershed Name Knox station (USGS 11181006)

Watershed Type Test

Total Watershed Area 1,542.00 ac

Watershed Area Disturbed 909.00 ac

Avg Annual Rainfall 17.06 Inches

Avg Annual Storm Duration 13.30 Hour(s)

Comments

Knox station after urban area in Castro Valley

This study was conducted as part of the US EPA's Nationwide Urban Runoff Program (NURP). The funding years for the project was from 1979 through 1983. The cost for conducting the street cleaning tests was about $150,000.

The study area had an upstream rural/developing area of 615 acres. The Seaview monitoring station was located along Castro Valley Creek at this rural boundary to the downstream urban area. The downstream monitoring station (Knox) was located downstream of the 909 acres urban study area, plus the 615 acre rural area. The urban component is therefore determined by subtracting the upstream Seaview data from the downstream Knox data. The urban area was comprised of about 93% medium density residential land uses, with the remaining area made up of institutional, strip commercial and freeway areas. About 40% of the urban area was impervious, and had a general land slope of about 10%. The landscaping in the urban area was typical residential lawns, and the urban soils were mostly of loam to clay texture.

The stormwater control practice investigated was street cleaning in the urban area only. A full-block experimental design allowed comparisons of periods of no street cleaning with periods of light to intensive street cleaning. The following lists the street cleaning activities actually conducted during this project:

Week (Urban area only)	Cleaning program (# of passes per week)	No street cleaning
11/20 to 24/78	1	
11/27 to 12/1/78		X
12/4 to 12/8	4	
12/11/78 to 1/12/79		X
1/15 to 2/9/79	1/3*	
2/12 to 16/79		X
2/19 to 23/79	1/3	
2/26 to 3/2/79	1	
3/5 to 9/70	1/3	
3/12 to 16/79	1	
3/19 to 5/11/79	1/3	
5/14 to 18	1	
5/21 to 6/1/79	1/3	
6/4 to 8/79		X
6/11 to 15/79	1	
6/16 to 10/29/79		X
10/30 to 11/30/79	1	
12/1/79 to 2/3/80		X
2/4 to 8/80	4	
2/11 to 15/80	2	
2/16 to 24/80		X
2/25 to 29/80	2	
3/1 to 3/9/80		X
3/10 to 14/80	2	

* one pass per week was conducted in only 1/3 of the urban area

The average annual rainfall in the study area is about 24 inches per year, with no snow. Castro Valley Creek was completely monitored during this 2 year period, at the upstream rural station and downstream from the urban portion. Pollutant mass (and calculated concentrations) are available from a total of 22 complete data sets during the study period (representing 85 and 94% of the total runoff that occurred during each year). During the dry fall months (and some other times), many of the rains produced very small flow increases at the Seaview monitoring station. Several of these flows were not sufficient to trip the automatic water samplers, although the flows were measured. However, the downstream Knox station water sampler was tripped because of the larger flow increases at that location. The database therefore includes these small, relatively dry weather events, but the Seaview water quality data was approximated by using the closest dry-weather flow data available (collected once a month during a 24-hr compositing period). The dates where the dry-weather flow water quality data were used to approximate the conditions were: Nov. 19, 1978; Dec. 1, 17, 1978; Jan. 3, 7, 9, 17, 1979; April 16, 23, 1979; May 6, 1979; Oct. 18, 25, 1979; Nov. 3, 16, 22, 1979; Dec 19, 30, 1979.

Detailed project information is available from the final NURP project report at:

Pitt, R. and G. Shawley. A Demonstration of Non-Point Source Pollution Management on Castro Valley Creek. Alameda County Flood Control and Water Conservation District and the U.S. Environmental Protection Agency Water Planning Division (Nationwide Urban Runoff Program). Washington, D.C. June 1982.

The EPA NURP report also has project information:

EPA (U.S. Environmental Protection Agency). Results of the Nationwide Urban Runoff Program. Water Planning Division, PB 84-185552, Washington, D.C., December 1983.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name Seaview Station before urban area

Watershed Name Seaview

BMP Type Maintenance Practices - Street Sweeping

Watershed Type Test

City Castro Valley

Total Watershed Area 633.02 ac

State/Country CA/US

Watershed Area Disturbed

BMP Installation Date

Avg Annual Rainfall 17.06 Inches

Number of Flow Records 80

Avg Annual Storm Duration 13.30 Hour(s)

Number of Water Quality Records 1687

Minimum Flow Volume 0.00 ac ft

Maximum Flow Volume 438,327.32 ac ft

Comments

Knox station after urban area in Castro Valley

This study was conducted as part of the US EPA's Nationwide Urban Runoff Program (NURP). The funding years for the project was from 1979 through 1983. The cost for conducting the street cleaning tests was about $150,000.

The study area had an upstream rural/developing area of 615 acres. The Seaview monitoring station was located along Castro Valley Creek at this rural boundary to the downstream urban area. The downstream monitoring station (Knox) was located downstream of the 909 acres urban study area, plus the 615 acre rural area. The urban component is therefore determined by subtracting the upstream Seaview data from the downstream Knox data. The urban area was comprised of about 93% medium density residential land uses, with the remaining area made up of institutional, strip commercial and freeway areas. About 40% of the urban area was impervious, and had a general land slope of about 10%. The landscaping in the urban area was typical residential lawns, and the urban soils were mostly of loam to clay texture.

The stormwater control practice investigated was street cleaning in the urban area only. A full-block experimental design allowed comparisons of periods of no street cleaning with periods of light to intensive street cleaning. The following lists the street cleaning activities actually conducted during this project:

Week (Urban area only)	Cleaning program (# of passes per week)	No street cleaning
11/20 to 24/78	1	
11/27 to 12/1/78		X
12/4 to 12/8	4	

12/11/78 to 1/12/79		X
1/15 to 2/9/79	1/3*	
2/12 to 16/79		X
2/19 to 23/79	1/3	
2/26 to 3/2/79	1	
3/5 to 9/70	1/3	
3/12 to 16/79	1	
3/19 to 5/11/79	1/3	
5/14 to 18	1	
5/21 to 6/1/79	1/3	
6/4 to 8/79		X
6/11 to 15/79	1	
6/16 to 10/29/79		X
10/30 to 11/30/79	1	
12/1/79 to 2/3/80		X
2/4 to 8/80	4	
2/11 to 15/80	2	
2/16 to 24/80		X
2/25 to 29/80	2	
3/1 to 3/9/80		X
3/10 to 14/80	2	

* one pass per week was conducted in only 1/3 of the urban area

The average annual rainfall in the study area is about 24 inches per year, with no snow. Castro Valley Creek was completely monitored during this 2 year period, at the upstream rural station and downstream from the urban portion. Pollutant mass (and calculated concentrations) are available from a total of 22 complete data sets during the study period (representing 85 and 94% of the total runoff that occurred during each year). During the dry fall months (and some other times), many of the rains produced very small flow increases at the Seaview monitoring station. Several of these flows were not sufficient to trip the automatic water samplers, although the flows were measured. However, the downstream Knox station water sampler was tripped because of the larger flow increases at that location. The database therefore includes these small, relatively dry weather events, but the Seaview water quality data was approximated by using the closest dry-weather flow data available (collected once a month during a 24-hr compositing period). The dates where the dry-weather flow water quality data were used to approximate the conditions were: Nov. 19, 1978; Dec. 1, 17, 1978; Jan. 3, 7, 9, 17, 1979; April 16, 23, 1979; May 6, 1979; Oct. 18, 25, 1979; Nov. 3, 16, 22, 1979; Dec 19, 30, 1979.

Detailed project information is available from the final NURP project report at:

Pitt, R. and G. Shawley. A Demonstration of Non-Point Source Pollution Management on Castro Valley Creek. Alameda County Flood Control and Water Conservation District and the U.S. Environmental Protection Agency Water Planning Division (Nationwide Urban Runoff Program). Washington, D.C. June 1982.

The EPA NURP report also has project information:

EPA (U.S. Environmental Protection Agency). Results of the Nationwide Urban Runoff Program. Water Planning Division, PB 84-185552, Washington, D.C., December 1983.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Congress/Lincoln, High Density Res.

BMP Name	Congress	**Watershed Name**	Congress (Test Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Milwaukee	**Total Watershed Area**	32.99 ac
State/Country	WI/US	**Watershed Area Disturbed**	32.99 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	76	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1140		
Minimum Flow Volume	52.70 ac ft		
Maximum Flow Volume	8,920.05 ac ft		

Comments

Milwaukee, WI, Congress, high density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage

(Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	Lincoln	**Watershed Name**	Lincoln (Control Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Reference
City	Milwaukee	**Total Watershed Area**	36.10 ac
State/Country	WI/US	**Watershed Area Disturbed**	36.10 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	76	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1140		
Minimum Flow Volume	52.70 ac ft		
Maximum Flow Volume	8,920.05 ac ft		

Comments

Milwaukee, WI, Congress, high density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.

Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.

Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.

Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.

Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.

Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.

Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.

Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.

Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.

Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.

Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.

Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.

SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Hasting/Burbank Med. Density Residential

BMP Name	Burbank	**Watershed Name**	Burbank (control site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Reference
City	Milwaukee	**Total Watershed Area**	62.59 ac
State/Country	WI/US	**Watershed Area Disturbed**	62.59 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	102	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1530		
Minimum Flow Volume	5.27 ac ft		
Maximum Flow Volume	11,885.38 ac ft		

Comments

Milwaukee, WI, Hastings, medium density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology, Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	Hastings	**Watershed Name**	Hastings (Test Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Milwaukee	**Total Watershed Area**	32.79 ac
State/Country	WI/US	**Watershed Area Disturbed**	32.79 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	102	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1530		
Minimum Flow Volume	5.27 ac ft		
Maximum Flow Volume	11,885.38 ac ft		

Comments

Milwaukee, WI, Hastings, medium density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning

Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Milwaukee, WI, Rustler study site

BMP Name	Post Office	**Watershed Name**	Post Office (Control Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Reference
City	Milwaukee	**Total Watershed Area**	12.40 ac
State/Country	WI/US	**Watershed Area Disturbed**	12.40 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	154	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	2309		
Minimum Flow Volume	4.30 ac ft		
Maximum Flow Volume	3,537.31 ac ft		

Comments

Milwaukee, WI, Rustler, parking lot, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage

(Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	Rustler	**Watershed Name**	Rustler (Test Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Milwaukee	**Total Watershed Area**	12.40 ac
State/Country	WI/US	**Watershed Area Disturbed**	12.40 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	154	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	2309		
Minimum Flow Volume	4.30 ac ft		
Maximum Flow Volume	3,537.31 ac ft		

Comments

Milwaukee, WI, Rustler, parking lot, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of ahout 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.

SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	NURP, Champaign ILL, John St. North		
BMP Name	John St. North Street Sweeping	**Watershed Name**	John St. North
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bondville	**Total Watershed Area**	54.38 ac
State/Country	IL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	33.00 Inches
Number of Flow Records		**Avg Annual Storm Duration**	9.10 Hour(s)
Number of Water Quality Records	1		
Minimum Flow Volume			
Maximum Flow Volume			

Comments

The objective of this study was to evaluate the effectiveness of street sweeping as BMP for stormwater management. Both quantitative and qualitative analysis were done on dry solids collected from the street surface and from stormwater runoff for a full suite of chemical and biological parameters. Paired areas of similar size, land use and topography were identified. One of the areas was designated as the control and the other as the experiment. Both sites were initially cleaned. Solids were allowed to accumulate for a period. The experiment site was swept and solids were allowed to accumulate further at the control site. Street dirt samples were taken at both locations at regular intervals. It is not clear exactly the procedure interval used for solids sampling and no specific information about stormwater runoff sampling is given.

The John St. North site was given the Site ID (Basin5) in the document tables. The contributing area was 54.38 acres of low density land use areas and had an imperviousness of 18.48%. This site was paired with John St. South (Basin4). A street sweeping frequency of 61 days is given for both John St. locations, however, one of the sites was the control site that was not swept. Examination of the actual data may help sort this out.

The conclusion drawn at the end of the program was, while street sweeping may produce some aesthetic benefits, it is not an effective means of controlling the washoff of non-point pollutants from an urban area. This may be due to the fact that mechanical street sweeping (as opposed to vacuum-assisted sweeping) typically removes only the larger solids and coarser particulates from the street surface. Many of the pollutants that are of concern are more closely associated with the finer particulate matter

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name NURP, Champaign ILL. John St. South

BMP Name	John St. South Street Sweeping	**Watershed Name**	John St. South
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bondville	**Total Watershed Area**	39.21 ac
State/Country	IL /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	33.00 Inches
Number of Flow Records		**Avg Annual Storm Duration**	9.10 Hour(s)

Number of Water Quality Records 1

Minimum Flow Volume

Maximum Flow Volume

Comments

The objective of this study was to evaluate the effectiveness of street sweeping as BMP for stormwater management. Both quantitative and qualitative analysis were done on dry solids collected from the street surface and from stormwater runoff for a full suite of chemical and biological parameters. Paired areas of similar size, land use and topography were identified. One of the areas was designated as the control and the other as the experiment. Both sites were initially cleaned. Solids were allowed to accumulate for a period. The experiment site was swept and solids were allowed to accumulate further at the control site. Street dirt samples were taken at both locations at regular intervals. It is not clear exactly the procedure interval used for solids sampling and no specific information about stormwater runoff sampling is given.

The John St. North site was given the Site ID (Basin5) in the document tables. The contributing area was 54.38 acres of low density land use areas and had an imperviousness of 18.48%. This site was paired with John St. South (Basin4). A street sweeping frequency of 61 days is given for both John St. locations, however, one of the sites was the control site that was not swept. Examination of the actual data may help sort this out.

The conclusion drawn at the end of the program was, while street sweeping may produce some aesthetic benefits, it is not an effective means of controlling the washoff of non-point pollutants from an urban area. This may be due to the fact that mechanical street sweeping (as opposed to vacuum-assisted sweeping) typically removes only the larger solids and coarser particulates from the street surface. Many of the pollutants that are of concern are more closely associated with the finer particulate matter

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	NURP, Champaign ILL, Mattis Ave N.		
BMP Name	Mattis Ave N. Street Sweeping	**Watershed Name**	Mattis Ave N.
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bondville	**Total Watershed Area**	16.66 ac
State/Country	IL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	33.00 Inches
Number of Flow Records	26	**Avg Annual Storm Duration**	9.10 Hour(s)
Number of Water Quality Records	1281		
Minimum Flow Volume	2.07 ac ft		
Maximum Flow Volume	100.01 ac ft		

Comments

The objective of this study was to evaluate the effectiveness of street sweeping as BMP for stormwater management. Both quantitative and qualitative analysis were done on dry solids collected from the street surface and from stormwater runoff for a full suite of chemical and biological parameters. Paired areas of similar size, land use and topography were identified. One of the areas was designated as the control and the other as the experiment. Both sites were initially cleaned. Solids were allowed to accumulate for a period. The experiment site was swept and solids were allowed to accumulate further at the control site. Street dirt samples were taken at both locations at regular intervals. It is not clear exactly the procedure interval used for solids sampling and no specific information about stormwater runoff sampling is given.

The South Mattis Avenue site was given the Site ID (Basin2) in the document tables. The contributing area was 27.63 acres of low density and commercial land use areas and had an imperviousness of 51.39%. This site was paired with North Mattis Avenue (Basin1). A street sweeping frequency of 61 days is given for both Mattis Ave. sites, however, one of the sites was the control site that was not swept. Examination of the actual data may help sort this out.

The conclusion drawn at the end of the program was, while street sweeping may produce some aesthetic benefits, it is not an effective means of controlling the washoff of non-point pollutants from an urban area. This may be due to the fact that mechanical street sweeping (as opposed to vacuum-assisted sweeping) typically removes only the larger solids and coarser particulates from the street surface. Many of the pollutants that are of concern are more closely associated with the finer particulate matter

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name NURP, Champaign ILL, Mattis Ave S.

BMP Name	Mattis Ave S. Street Sweeping	**Watershed Name**	Mattis Ave S.
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bondville	**Total Watershed Area**	27.63 ac
State/Country	IL/US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	33.00 Inches
Number of Flow Records	25	**Avg Annual Storm Duration**	9.10 Hour(s)
Number of Water Quality Records	1207		
Minimum Flow Volume	1.01 ac ft		
Maximum Flow Volume	60.93 ac ft		

Comments

The objective of this study was to evaluate the effectiveness of street sweeping as BMP for stormwater management. Both quantitative and qualitative analysis were done on dry solids collected from the street surface and from stormwater runoff for a full suite of chemical and biological parameters. Paired areas of similar size, land use and topography were identified. One of the areas was designated as the control and the other as the experiment. Both sites were initially cleaned. Solids were allowed to accumulate for a period. The experiment site was swept and solids were allowed to accumulate further at the control site. Street dirt samples were taken at both locations at regular intervals. It is not clear exactly the procedure interval used for solids sampling and no specific information about stormwater runoff sampling is given.

The South Mattis Avenue site was given the Site ID (Basin2) in the document tables. The contributing area was 27.63 acres of low density and commercial land use areas and had an imperviousness of 51.39%. This site was paired with North Mattis Avenue (Basin1). A street sweeping frequency of 61 days is given for both Mattis Ave. sites, however, one of the sites was the control site that was not swept. Examination of the actual data may help sort this out.

The conclusion drawn at the end of the program was, while street sweeping may produce some aesthetic benefits, it is not an effective means of controlling the washoff of non-point pollutants from an urban area. This may be due to the fact that mechanical street sweeping (as opposed to vacuum-assisted sweeping) typically removes only the larger solids and coarser particulates from the street surface. Many of the pollutants that are of concern are more closely associated with the finer particulate matter

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name NURP,Winston Salem Ardmore Subdivision

BMP Name	Ardmore Subdivision Street Sweeping	**Watershed Name**	Ardmore Subdivision
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Winston-Salem Ardmore	**Total Watershed Area**	324.11 ac
State/Country	NC /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.12 Inches
Number of Flow Records	5	**Avg Annual Storm Duration**	9.60 Hour(s)
Number of Water Quality Records	11730		
Minimum Flow Volume	3.91 ac ft		
Maximum Flow Volume	328.12 ac ft		

Comments

One of the NURP reports, the objective of this study was to evaluate the effectiveness of street sweeping on the removal of non-point source water pollution associated with stormwater runoff. Defined watersheds were monitored for; street solids accumulation and related particle size, chemical constituency, street sweeper effectiveness, precipitation, runoff, water quality, wet and dry atmospheric deposition, and loading rates. Discharges were measured at 5-minute intervals and automatic flow-weighted samples were collected during storm events. Street surface loadings were analyzed on a quarterly basis. During the quarter when no street sweeping was done, curb to crown sampled were collect by vacuum over 1 foot wide stretch of roadway. These dry solids were analyzed for load, chemical constituents and size. During quarters when street sweeping was implemented, samples were taken both before and after storm events.
The author concluded that non-point source pollution resulting from stormwater runoff is a significant problem in the watershed. Street sweeping, event though it improved the aesthetics of the area, is not an effective treatment practice. Depending on the nature of the contaminant, it appears that street sweeping may actually increase the concentration of a pollutant in stormwater by removing the larger particles that inhibit runoff.
Could not identify which samples were taken prior to, or after, street sweeping. The text indicates that street sweeping was done for one quarter and the following quarter was a control. All the sample data appears to be aggregated. The text indicates that dry solids were collected prior to and following street sweeping but this sample data did not appear to be included in the data file.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	NURP,Winston Salem Central Business Dist		
BMP Name	Central Business Dist. Street Sweeping	**Watershed Name**	Central Business District
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Winston-Salem Central Business District	**Total Watershed Area**	22.70 ac
State/Country	NC /US	**Watershed Area Disturbed**	
BMP Installation Date		**Avg Annual Rainfall**	40.12 Inches
Number of Flow Records	7	**Avg Annual Storm Duration**	9.60 Hour(s)
Number of Water Quality Records	10062		
Minimum Flow Volume	1.44 ac ft		
Maximum Flow Volume	173.58 ac ft		

Comments

One of the NURP reports, the objective of this study was to evaluate the effectiveness of street sweeping on the removal of non-point source water pollution associated with stormwater runoff. Defined watersheds were monitored for; street solids accumulation and related particle size, chemical constituency, street sweeper effectiveness, precipitation, runoff, water quality, wet and dry atmospheric deposition, and loading rates. Discharges were measured at 5-minute intervals and automatic flow-weighted samples were collected during storm events. Street surface loadings were analyzed on a quarterly basis. During the quarter when no street sweeping was done, curb to crown sampled were collect by vacuum over 1 foot wide stretch of roadway. These dry solids were analyzed for load, chemical constituents and size. During quarters when street sweeping was implemented, samples were taken both before and after storm events.

The author concluded that non-point source pollution resulting from stormwater runoff is a significant problem in the watershed. Street sweeping, event though it improved the aesthetics of the area, is not an effective treatment practice. Depending on the nature of the contaminant, it appears that street sweeping may actually increase the concentration of a pollutant in stormwater by removing the larger particles that inhibit runoff.

Could not identify which samples were taken prior to, or after, street sweeping. The text indicates that street sweeping was done for one quarter and the following quarter was a control. All the sample data appears to be aggregated. The text indicates that dry solids were collected prior to and following street sweeping but this sample data did not appear to be included in the data file.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Wood Center/State Fair Comm. High Dens.

BMP Name	State Fair	**Watershed Name**	State Fair (Test Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	West Allis	**Total Watershed Area**	29.01 ac
State/Country	WI/US	**Watershed Area Disturbed**	29.01 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	118	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1770		
Minimum Flow Volume	33.87 ac ft		
Maximum Flow Volume	11,699.48 ac ft		

Comments

Milwaukee, WI, State Fair, commercial/high density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	Wood Center	**Watershed Name**	Wood Center (Control Site)
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Reference
City	West Allis	**Total Watershed Area**	44.90 ac
State/Country	WI/US	**Watershed Area Disturbed**	44.90 ac
BMP Installation Date		**Avg Annual Rainfall**	30.02 Inches
Number of Flow Records	118	**Avg Annual Storm Duration**	10.10 Hour(s)
Number of Water Quality Records	1770		
Minimum Flow Volume	33.87 ac ft		
Maximum Flow Volume	11,699.48 ac ft		

Comments

Milwaukee, WI, State Fair, commercial/high density residential, with increased street cleaning

The Milwaukee, WI, street cleaning demonstration project included in this database entry was part of the EPA's Nationwide Urban Runoff Program (NURP). This project was jointly conducted by the Wisconsin Department of Natural Resources and the USGS, and was conducted between 1979 and 1983. The total water sampling and monitoring effort cost about $400,000, while another $800,000 was used to operate and test the street cleaning equipment.

The climate in Milwaukee is characterized by cold and snowy winters (average of 25 inches of snow a year) and relatively mild summers (average annual precipitation of about 35 inches).

Eight watersheds were tested and monitored during this project, ranging in size from about 12 to 63 acres each. The imperviousness of each area ranged from about 35 to 100%, and the land slope was as steep as 5%. The soil was mostly clayey. The eight watersheds were paired: 2 commercial strip areas, 2 commercial parking lots, 2 high density residential areas, and 2 medium density residential areas. The paired areas were each tested, one with typical levels of street cleaning (control), and the other with increased street cleaning (experimental). Periods of little street cleaning were therefore compared to periods of more intensive street cleaning. Complete outfall data is available from each site during these periods. Each site had from 39 to 82 storm events monitored, and a total of 464 events were completely evaluated. About half of all events were successfully monitored, automatic sampler equipment failures were responsible for most of the missed events. Flow and rainfall were also extensively monitored and are reported. Street dirt data was also collected, but is not included in this database.

The following table shows the land use and number of events monitored at each of the 8 study areas, plus the street cleaning programs conducted:

Study area name	Area (acres)	Land use	Number of events sampled	Type of street cleaning site	Street cleaning frequency
Lincoln Creek	36.1	High density residential	39	Control	monthly
Congress*	33	High density residential	57	Experimental	2 or 3 per week
Burbank	62.6	Medium density residential	52	Control	monthly
Hastings	32.8	Medium density residential	47	Experimental	1 or 2 per week
Wood Center	44.9	Commercial/high density residential	66	Control	weekly
State Fair	29	Commercial/high density residential	51	Experimental	2 or 3 per week
Post Office	12.4	Parking lot	82	Control	bi-monthly
Rustler	12.4	Parking lot	70	Experimental	weekly or bi-weekly

*Backwater conditions at the Congress monitoring station caused inaccurate flow measurements, and settling of some stormwater pollutants before sampling.

For more information, see the final Milwaukee NURP report:

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I. Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983 (also see the other volumes in this report, this citation is only the summary report).

Other important reports and papers describing Wisconsin stormwater issues include the following (also see other database entries covering the Monroe St. wet detention pond in Madison, the Minocqua MCTT (multi-chambered treatment tank), the Ruby Garage (Milwaukee) MCTT, and the Madison Stormceptor evaluation projects):

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich -Mahoney and B. Abrams. "The IJC Menomonee River Watershed Study - Surface Water Monitoring Data". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Bannerman, R., D.W. Owens, R.B. Dodds, and N.J. Hornewer (1993) Sources of pollutants in Wisconsin stormwater. Water Science and Technology. Vol. 28, No. 3-5, pp. 241-259.
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. Sources of pollutants in Wisconsin stormwater. Water Science & Technology. 28 (3-5): 241-259. 1993.
Bannerman, R.T., A.D. Legg, and S.R. Greb. Quality of Wisconsin Stormwater, 1989-94. U.S. Geological Survey. Open-file report 96-458. Madison, WI. 26 pgs. 1996.
Legg, A.D., R.T. Bannerman, and J. Panuska. Variation in the Relation of Rainfall to Runoff from Residential Lawns in Madison, Wisconsin, July and August 1995. U.S. Geological Survey. Water-resources investigations report 96-4194. Madison, Wisconsin. 11 pgs. 1996.
Masterson, J.P. and R.T. Bannerman. 1994. Impacts of stormwater runoff on urban streams in Milwaukee County, Wisconsin. National Symposium on Water Quality, American Resources Association, pp. 123-133.
Novotny, V., D. Balsiger, R. Bannerman, J. Konrad, D. Cherkauer, G. Simsiman and G. Chesters. "The IJC Menomonee River Watershed Study - Simulation of Pollutant Loadings and Runoff Quality". EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.
Novotny, V., H.M. Sung, R. Bannerman, and K. Baum. "Estimating non-point pollution from small urban watersheds." Journal of Water Pollution Control Federation, vol. 57, no 4, pp 339-348. 1985.
Pitt, R. "Runoff controls in Wisconsin's priority watersheds," Conference on Urban Runoff Quality - Impact and Quality Enhancement Technology, Henniker, New Hampshire, Edited by B. Urbonas and L.A. Roesner, Proceedings published by the American Society of Civil Engineering, New York, June 1986.
Roa-Espinosa, A. and R. Bannerman. "Monitoring BMP effectiveness at industrial sites." Proc Eng Found Conf Stormwater NPDES Related Monitoring Needs, Proceedings of the Engineering Foundation Conference on Stormwater NPDES Related Monitoring Needs. Aug 7-12 1994. Sponsored by: U.S. Environmental Protection Agency; The Engineering Foundation; U.S. Geological Survey; Water Environment Federation; American Institute of Hydrology, ASCE. pp 467-486. 1994.
Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.
Southeastern Wisconsin Planning Commission (SEWRPC). A Comprehensive Plan for the Menomonee River Watershed. Planning

Report No. 26. Waukesha, Wisconsin, 1976.
SWRPC (Southeastern Wisconsin Regional Planning Commission). Costs of Urban Nonpoint Source Water Pollution Control Measures. Technical report Number 31. SWRPC. Waukesha, WI. 1991.

Average Pollutant Removal Efficiencies *See notes at end of report.

%

***Notes:** Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.*

BMP Test Site Summary Information

Test Site Name Bellevue, Lake Hills, Active CB, SC

BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Active CB, SC
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA /US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	50	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	440		
Minimum Flow Volume	45.58 ac ft		
Maximum Flow Volume	5,159.70 ac ft		

Comments

Bellevue in Lake Hills, The catchbasins were active and street cleaning was being conducted

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

BMP Name USGS12120005

BMP Type Maintenance Practices - Catch Basin Cleaning

City Bellevue

State/Country WA/US

BMP Installation Date

Number of Flow Records 50

Number of Water Quality Records 440

Minimum Flow Volume 45.58 ac ft

Maximum Flow Volume 5,159.70 ac ft

Watershed Name Surrey Downs, Active CB, No SC

Watershed Type Reference

Total Watershed Area 95.14 ac

Watershed Area Disturbed 95.14 ac

Avg Annual Rainfall 34.31 Inches

Avg Annual Storm Duration 14.60 Hour(s)

Comments

Bellevue in Lake Hills, The catchbasins were active and street cleaning was being conducted

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were

being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.

Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name Bellevue, Lake Hills, Full CB, SC

BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Full CB, SC
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA/US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	79	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	688		
Minimum Flow Volume	29.15 ac ft		
Maximum Flow Volume	5,622.46 ac ft		

Comments

Lake Hills in Bellevue, the catchbasins had reached their capacity and street cleaning operations were being conducted during this period.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

BMP Name USGS12120005

BMP Type Maintenance Practices - Catch Basin Cleaning

City Bellevue

State/Country WA/US

BMP Installation Date

Number of Flow Records 79

Number of Water Quality Records 688

Minimum Flow Volume 29.15 ac ft

Maximum Flow Volume 5,622.46 ac ft

Watershed Name Surrey Downs, Full CB, No SC

Watershed Type Reference

Total Watershed Area 95.14 ac

Watershed Area Disturbed 95.14 ac

Avg Annual Rainfall 34.31 Inches

Avg Annual Storm Duration 14.60 Hour(s)

Comments

Lake Hills in Bellevue, the catchbasins had reached their capacity and street cleaning operations were being conducted during this period.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being

conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

---

Average Pollutant Removal Efficiencies *See notes at end of report.

%

Test Site Name	Bellevue, Surrey Downs, Active CB, SC		
BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Active CB, No Sc
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Reference
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA /US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	31	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	257		
Minimum Flow Volume	28.00 ac ft		
Maximum Flow Volume	3,711.28 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins were active and there was street cleaning operation.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when

accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Active CB
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA/US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	31	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	257		
Minimum Flow Volume	28.00 ac ft		
Maximum Flow Volume	3,711.28 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins were active and there was street cleaning operation.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Test Site Name Bellevue, Surrey Downs, Full CB, SC

BMP Name	USGS12119725	**Watershed Name**	Lake Hills, Full CB, No SC
BMP Type	Maintenance Practices - Catch Basin Cleaning	**Watershed Type**	Reference
City	Bellevue	**Total Watershed Area**	101.81 ac
State/Country	WA /US	**Watershed Area Disturbed**	101.81 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	48	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	427		
Minimum Flow Volume	70.80 ac ft		
Maximum Flow Volume	9,463.31 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins have reached their capacity and there were street cleaning opeations.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when

accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.
Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

BMP Name	USGS12120005	**Watershed Name**	Surrey Downs, Full CB, SC
BMP Type	Maintenance Practices - Street Sweeping	**Watershed Type**	Test
City	Bellevue	**Total Watershed Area**	95.14 ac
State/Country	WA/US	**Watershed Area Disturbed**	95.14 ac
BMP Installation Date		**Avg Annual Rainfall**	34.31 Inches
Number of Flow Records	48	**Avg Annual Storm Duration**	14.60 Hour(s)
Number of Water Quality Records	427		
Minimum Flow Volume	70.80 ac ft		
Maximum Flow Volume	9,463.31 ac ft		

Comments

Surrey Downs watershed in Bellevue. The catchbasins have reached their capacity and there were street cleaning opeations.

The Bellevue, WA, NURP project was conducted to characterize Pacific Northwest stormwater quality, and to evaluate the effectiveness of street cleaning and catchbasin cleaning. In addition, a small sub-study was conducted by the USGS to investigate the effectiveness of a small dry detention pond. The data presented in these 8 separate database files for Bellevue focuses on the effectiveness of the street cleaning and catchbasin cleaning programs.

There were two study areas examined: Lake Hills and Surrey Downs, both similar medium density residential areas. Each study area was examined with four separate experimental conditions: no controls, street cleaning alone, catchbasin cleaning alone, and both street cleaning and catchbasin cleaning together. This research was therefore conducted in a replicated complete block design, allowing runoff quality comparisons between periods having these different public works practices. The design of this database requires that each of the resulting 8 project phases for this one research project be listed as 8 separate data files. When evaluating the effectiveness of these practices, one must therefore compare the results from the separate data files. These eight data files are labeled as follows:

1. Bellevue, Lake Hills, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

2. Bellevue, Lake Hills, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

3. Bellevue, Lake Hills, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

4. Bellevue, Lake Hills, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

5. Bellevue, Surrey Downs, Active CB, No SC (catchbasins were accumulating material, but no street cleaning operations were being conducted during this project period).

6. Bellevue, Surrey Downs, Active CB, SC (catchbasins were accumulating material, and street cleaning operations were being conducted during this project period).

7. Bellevue, Surrey Downs, Full CB, No SC (catchbasins were full and not accumulating material, and no street cleaning operations were being conducted during this project period).

8. Bellevue, Surrey Downs, Full CB, SC (catchbasins were full and not accumulating material, street cleaning operations were being conducted during this project period).

The use of the two study areas was necessary because different time periods were obviously used for each of these project phases. The two separate areas were therefore needed to account for variations in rainfall, and other seasonal factors, that may have affected the results and confused the effects of the public works activities.

A note should be made concerning the catchbasin "cleaning" study phases. Obviously, catchbasins were present during the complete study period. They were cleaned and surveyed at the beginning of the project. The accumulation of material was then monitored through periodic measurements. The project periods were therefore categorized as "active" or "full." The active periods were when accumulation was taking place in the catchbasins, while the full periods were when the catchbasins were at an equilibrium, with no additional accumulation of material. See the final project report for complete information and descriptions:

Pitt, R. Characterizing and Controlling Urban Runoff through Street and Sewerage Cleaning. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory. EPA/600/S2-85/038. PB 85-186500. Cincinnati, Ohio. 467 pgs. June 1985.

Pitt, R. and P. Bissonnette. Bellevue Urban Runoff Program Summary Report, U.S. Environmental Protection Agency, Water Planning Division. PB84 237213. Washington, D.C. 173 pgs. 1984.

The USGS and the University of Washington also produced several project reports. The above Pitt and Bissonnette 1984 report summarized all of the project reports, while the Pitt 1985 report focused on the street cleaning and catchbasin cleaning information included in this database. These reports may be available from the EPA Clariton website, by searching for the PB numbers, at: http://www.epa.gov/clariton/clhtml/pubord.html

Average Pollutant Removal Efficiencies *See notes at end of report.

%

%

Notes: Average pollutant removal efficiencies are calculated based on the average inflow event mean concentration (EMC) and the average outflow EMC for the period of record at each BMP (1-[Avg. Inflow EMC/Avg. Outflow EMC]).In the case where multiple inflow (and/or outflow) points exist, the average EMC for the inflow was calculated by flow-weighting the EMCs at each inflow point. Concentrations below detection limits were replaced with one-half of the detection limit for purposes of calculating percent removal. This measure of evaluating BMP efficiency may not be appropriate in all cases and should never be used as the sole basis for predicting BMP performance. For example, low influent concentrations typically yield low pollutant removal efficiencies.

APPENDIX B

Responses to Best Management Practice Goal Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: Randy Johnson
Organization: FNSB - Public Works
Date: November 9, 2005

We request you assistance with our stormwater Best Management Practice (BMP) effectiveness study that we are conducting. For the first part, we need you to think about your stormwater system. Stormwater BMPs can be utilized for many purposes. Several of these purposes, or goals, are presented below. Considering just your system, please rank the five most important potential goals that a BMP might be utilized in your system. A ranking of 1 should be given to the most important goal and a ranking of 5 should be given to the fifth most important goal.

		Ranking				
Hydraulics	Improve flow characteristics upstream and/or downstream of BMP	1	2	3	4	5
Hydrology	Flood mitigation, improve runoff characteristics (peak shaving)	1	2	3	4	5
Water Quality	Reduce downstream pollutant loads and concentrations of pollutants	1	2	(3) circled	4	5
	Improve/minimize downstream temperature impact	1	2	3	4	5
	Achieves desired pollutant concentration at outfall	1	2	3	4	5
	Removal of litter and debris	1	2	3	4	5
Toxicology	Reduce acute toxicity of runoff	1	2	3	4	5
	Reduce chronic toxicity of runoff	1	2	3	4	5
Regulatory	Compliance with NPDES permit	(1) circled	2	3	4	5
	Meet federal, state, or federal water quality criteria	1	2	3	4	5
Implementation Feasibility	For non-structural BMPs, ability to function within management and oversight structure	1	2	3	4	5
Cost	Capital, operation, and maintenance costs	1	2	3	(4) circled	5
Aesthetic	Improve appearance of site	1	2	3	4	5
Maintenance	Operate within maintenance, and repair schedule and requirements	1	2	3	4	5
	Ability of system to be retrofit, modified or expanded	1	2	3	4	5
Longevity	Long-term functionality	1	2	3	4	5
Resources	Improve downstream aquatic environment/ erosion control	1	2	3	4	5
	Improve wildlife habitat	1	2	3	4	5
	Multiple use functionality	1	2	3	4	5
Safety, Risk, and Liability	Function without signficant risk or liability	1	2	3	4	(5) circled
	Ability to function with minimal environmental risk downstream	1	2	3	4	5
Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts	1	(2) circled	3	4	5

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: Randy Johnson
Organization: FNSB - Public Works
Date: November 9, 2005

For part two, please identify which BMPs that you are aware have been utilized for your stormwater system and the extent of its use. If you are aware of BMPs that are in use and are not presented in this list, please add them in the space provided. Please be as specific as you can.

Best Management Practice	Level of Use			
Sediment filters and sediment chambers	**Rare**	Limited	Common	Extensive
Vegetated buffers	Rare	Limited	**Common**	Extensive
Grass lined channels (conveyance)	Rare	Limited	**Common**	Extensive
Infiltration basins	Rare	**Limited**	Common	Extensive
Oil-water separators	Rare	**Limited**	Common	Extensive
Catch basins	Rare	**Limited**	Common	Extensive
Manufactured products for storm water inlets	Rare	Limited	**Common**	Extensive
Groundwater injection (dry wells, Class V wells)	**Rare**	Limited	Common	Extensive
Buffer zones	Rare	**Limited**	Common	Extensive
Grass lines swales (storage)	Rare	Limited	**Common**	Extensive
Stormwater wetlands	Rare	Limited	**Common**	Extensive
Sand and organic filters	**Rare**	Limited	Common	Extensive
In-line storage or baffle structures	Rare	**Limited**	Common	Extensive
Elimination of curbs and gutters	**Rare**	Limited	Common	Extensive
Storm drain system cleaning	**Rare**	Limited	Common	Extensive
Parking lot and street cleaning	Rare	**Limited**	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: TRENT [illegible]
Organization: FNSB
Date: 11/8/05

We request you assistance with our stormwater Best Management Practice (BMP) effectiveness study that we are conducting. For the first part, we need you to think about your stormwater system. Stormwater BMPs can be utilized for many purposes. Several of these purposes, or goals, are presented below. Considering just your system, please rank the five most important potential goals that a BMP might be utilized in your system. A ranking of 1 should be given to the most important goal and a ranking of 5 should be given to the fifth most important goal.

		Ranking				
Hydraulics	Improve flow characteristics upstream and/or downstream of BMP	1	2	3	4	5
Hydrology	Flood mitigation, improve runoff characteristics (peak shaving)	1	2	3	4	5
Water Quality	Reduce downstream pollutant loads and concentrations of pollutants	1	2	(3)	4	5
	Improve/minimize downstream temperature impact	1	2	3	4	5
	Achieves desired pollutant concentration at outfall	1	2	3	4	5
	Removal of litter and debris	1	2	3	4	5
Toxicology	Reduce acute toxicity of runoff	1	2	3	4	5
	Reduce chronic toxicity of runoff	1	2	3	4	5
Regulatory	Compliance with NPDES permit	(1)	2	3	4	5
	Meet federal, state, or federal water quality criteria	1	2	3	4	5
Implementation Feasibility	For non-structural BMPs, ability to function within management and oversight structure	1	2	3	4	5
Cost	Capital, operation, and maintenance costs	1	2	3	(4)	5
Aesthetic	Improve appearance of site	1	2	3	4	5
Maintenance	Operate within maintenance, and repair schedule and requirements	1	2	3	4	5
	Ability of system to be retrofit, modified or expanded	1	2	3	4	5
Longevity	Long-term functionality	1	2	3	4	(5)
Resources	Improve downstream aquatic environment/ erosion control	1	2	3	4	5
	Improve wildlife habitat	1	2	3	4	5
	Multiple use functionality	1	2	3	4	5
Safety, Risk, and Liability	Function without signficant risk or liability	1	2	3	4	5
	Ability to function with minimal environmental risk downstream	1	2	3	4	5
Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts	1	(2)	3	4	5

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name:
Organization:
Date:

For part two, please identify which BMPs that you are aware have been utilized for your stormwater system and the extent of its use. If you are aware of BMPs that are in use and are not presented in this list, please add them in the space provided. Please be as specific as you can.

Best Management Practice	Level of Use			
Sediment filters and sediment chambers	Rare	Limited	Common	Extensive
Vegetated buffers	Rare	Limited	Common	Extensive
Grass lined channels (conveyance)	Rare	Limited	Common	Extensive
Infiltration basins	Rare	Limited	Common	Extensive
Oil-water separators	Rare	Limited	Common	Extensive
Catch basins	Rare	Limited	Common	Extensive
Manufactured products for storm water inlets	Rare	Limited	Common	Extensive
Groundwater injection (dry wells, Class V wells)	Rare	Limited	Common	Extensive
Buffer zones	Rare	Limited	Common	Extensive
Grass lines swales (storage)	Rare	Limited	Common	Extensive
Stormwater wetlands	Rare	Limited	Common	Extensive
Sand and organic filters	Rare	Limited	Common	Extensive
In-line storage or baffle structures	Rare	Limited	Common	Extensive
Elimination of curbs and gutters	Rare	Limited	Common	Extensive
Storm drain system cleaning	Rare	Limited	Common	Extensive
Parking lot and street cleaning	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: James Bemitz
Organization: City of North Pole
Date: 11/14/05

We request you assistance with our stormwater Best Management Practice (BMP) effectiveness study that we are conducting. For the first part, we need you to think about your stormwater system. Stormwater BMPs can be utilized for many purposes. Several of these purposes, or goals, are presented below. Considering just your system, please rank the five most important potential goals that a BMP might be utilized in your system. A ranking of 1 should be given to the most important goal and a ranking of 5 should be given to the fifth most important goal.

			Ranking				
			1	2	3	4	5
	Hydraulics	Improve flow characteristics upstream and/or downstream of BMP	1	2	3	4	5
	Hydrology	Flood mitigation, improve runoff characteristics (peak shaving)	1	2	3	4	5
3	Water Quality	Reduce downstream pollutant loads and concentrations of pollutants	1	2	(3)	4	5
		Improve/minimize downstream temperature impact	1	2	3	4	5
		Achieves desired pollutant concentration at outfall	1	2	3	4	5
		Removal of litter and debris	1	2	3	4	5
	Toxicology	Reduce acute toxicity of runoff	1	2	3	4	5
		Reduce chronic toxicity of runoff	1	2	3	4	5
1	Regulatory	Compliance with NPDES permit	(1)	2	3	4	5
		Meet federal, state, or federal water quality criteria	1	2	3	4	5
	Implementation Feasibility	For non-structural BMPs, ability to function within management and oversight structure	1	2	3	4	5
5	Cost	Capital, operation, and maintenance costs	1	2	3	4	(5)
	Aesthetic	Improve appearance of site	1	2	3	4	5
4	Maintenance	Operate within maintenance, and repair schedule and requirements	1	2	3	(4)	5
		Ability of system to be retrofit, modified or expanded	1	2	3	4	5
	Longevity	Long-term functionality	1	2	3	4	5
	Resources	Improve downstream aquatic environment/ erosion control	1	2	3	4	5
		Improve wildlife habitat	1	2	3	4	5
		Multiple use functionality	1	2	3	4	5
2	Safety, Risk, and Liability	Function without signficant risk or liability	1	(2)	3	4	5
		Ability to function with minimal environmental risk downstream	1	2	3	4	5
	Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts	1	2	3	4	5

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: JAMES REMITZ
Organization: CITY OF NORTH POLE
Date: 11/14/05

For part two, please identify which BMPs that you are aware have been utilized for your stormwater system and the extent of its use. If you are aware of BMPs that are in use and are not presented in this list, please add them in the space provided. Please be as specific as you can.

Best Management Practice	Level of Use			
Sediment filters and sediment chambers	**Rare**	Limited	Common	Extensive
Vegetated buffers	Rare	**Limited**	Common	Extensive
Grass lined channels (conveyance)	Rare	Limited	**Common**	Extensive
Infiltration basins	Rare	**Limited**	Common	Extensive
Oil-water separators	**Rare**	Limited	Common	Extensive
Catch basins	Rare	**Limited**	Common	Extensive
Manufactured products for storm water inlets	**Rare**	Limited	Common	Extensive
Groundwater injection (dry wells, Class V wells)	Rare	Limited	Common	Extensive
Buffer zones	Rare	**Limited**	Common	Extensive
Grass lines swales (storage)	Rare	Limited	**Common**	Extensive
Stormwater wetlands	**Rare**	Limited	Common	Extensive
Sand and organic filters	**Rare**	Limited	Common	Extensive
In-line storage or baffle structures	**Rare**	Limited	Common	Extensive
Elimination of curbs and gutters	**Rare**	Limited	Common	Extensive
Storm drain system cleaning	**Rare**	Limited	Common	Extensive
Parking lot and street cleaning	Rare	Limited	**Common**	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive

479-5691

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: CHRIS HAIGH
Organization: CITY OF FAIRBANKS
Date: NOV 17, 05

We request you assistance with our stormwater Best Management Practice (BMP) effectiveness study that we are conducting. For the first part, we need you to think about your stormwater system. Stormwater BMPs can be utilized for many purposes. Several of these purposes, or goals, are presented below. Considering just your system, please rank the five most important potential goals that a BMP might be utilized in your system. A ranking of 1 should be given to the most important goal and a ranking of 5 should be given to the fifth most important goal.

		Ranking				
Hydraulics	Improve flow characteristics upstream and/or downstream of BMP	1	2	(3)	4	5
Hydrology	Flood mitigation, improve runoff characteristics (peak shaving)	1	(2)	3	4	5
Water Quality	Reduce downstream pollutant loads and concentrations of pollutants	1	(2)	3	4	5
	Improve/minimize downstream temperature impact	1	(2)	3	4	5
	Achieves desired pollutant concentration at outfall	1	(2)	3	4	5
	Removal of litter and debris	(1)	2	3	4	5
Toxicology	Reduce acute toxicity of runoff	1	(2)	3	4	5
	Reduce chronic toxicity of runoff	1	(2)	3	4	5
Regulatory	Compliance with NPDES permit	(1)	2	3	4	5
	Meet federal, state, or federal water quality criteria	(1)	2	3	4	5
Implementation Feasibility	For non-structural BMPs, ability to function within management and oversight structure	1	(2)	3	4	5
Cost	Capital, operation, and maintenance costs	(1)	2	3	4	5
Aesthetic	Improve appearance of site	1	2	(3)	4	5
Maintenance	Operate within maintenance, and repair schedule and requirements	1	(2)	3	4	5
	Ability of system to be retrofit, modified or expanded	1	(2)	3	4	5
Longevity	Long-term functionality	(1)	2	3	4	5
Resources	Improve downstream aquatic environment/ erosion control	1	2	(3)	4	5
	Improve wildlife habitat	1	2	(3)	4	5
	Multiple use functionality	1	(2)	3	4	5
Safety, Risk, and Liability	Function without signficant risk or liability	1	(2)	3	4	5
	Ability to function with minimal environmental risk downstream	1	(2)	3	4	5
Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts	1	(2)	3	4	5

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: CHRIS HAIGH
Organization: CITY OF FAIRBANKS
Date: NOV 17, 05

For part two, please identify which BMPs that you are aware have been utilized for your stormwater system and the extent of its use. If you are aware of BMPs that are in use and are not presented in this list, please add them in the space provided. Please be as specific as you can.

Best Management Practice	Level of Use			
Sediment filters and sediment chambers	**Rare**	Limited	Common	Extensive
Vegetated buffers	Rare	**Limited**	Common	Extensive
Grass lined channels (conveyance)	Rare	Limited	**Common**	Extensive
Infiltration basins	Rare	**Limited**	Common	Extensive
Oil-water separators	Rare	**Limited**	Common	Extensive
Catch basins	Rare	Limited	Common	**Extensive**
Manufactured products for storm water inlets	**Rare**	Limited	Common	Extensive
Groundwater injection (dry wells, Class V wells)	Rare	**Limited**	Common	Extensive
Buffer zones	**Rare**	Limited	Common	Extensive
Grass lines swales (storage)	Rare	**Limited**	Common	Extensive
Stormwater wetlands	Rare	Limited	**Common**	Extensive
Sand and organic filters	**Rare**	Limited	Common	Extensive
In-line storage or baffle structures	**Rare**	Limited	Common	Extensive
Elimination of curbs and gutters	Rare	**Limited**	Common	Extensive
Storm drain system cleaning	Rare	Limited	Common	**Extensive**
Parking lot and street cleaning	Rare	Limited	**Common**	Extensive
Stormceptor	Rare	**Limited**	Common	Extensive
Deeper [illegible] Catch basins	Rare	Limited	**Common**	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: Brian M. Adams
Organization: Dept of Army, Directorate of Public Works
Date: 11-6-2005

We request you assistance with our stormwater Best Management Practice (BMP) effectiveness study that we are conducting. For the first part, we need you to think about your stormwater system. Stormwater BMPs can be utilized for many purposes. Several of these purposes, or goals, are presented below. Considering just your system, please rank the five most important potential goals that a BMP might be utilized in your system. A ranking of 1 should be given to the most important goal and a ranking of 5 should be given to the fifth most important goal.

		Ranking				
Hydraulics	Improve flow characteristics upstream and/or downstream of BMP	1	(2)	3	4	5
Hydrology	Flood mitigation, improve runoff characteristics (peak shaving)	1	(2)	3	4	5
Water Quality	Reduce downstream pollutant loads and concentrations of pollutants	(1)	2	3	4	5
	Improve/minimize downstream temperature impact	(1)	2	3	4	5
	Achieves desired pollutant concentration at outfall	(1)	2	3	4	5
	Removal of litter and debris	(1)	2	3	4	5
Toxicology	Reduce acute toxicity of runoff	(1)	2	3	4	5
	Reduce chronic toxicity of runoff	1	(2)	3	4	5
Regulatory	Compliance with NPDES permit	(1)	2	3	4	5
	Meet federal, state, or federal water quality criteria	(1)	2	3	4	5
Implementation Feasibility	For non-structural BMPs, ability to function within management and oversight structure	1	(2)	3	4	5
Cost	Capital, operation, and maintenance costs	1	2	(3)	4	5
Aesthetic	Improve appearance of site	1	(2)	3	4	5
Maintenance	Operate within maintenance, and repair schedule and requirements	(1)	2	3	4	5
	Ability of system to be retrofit, modified or expanded	1	(2)	3	4	5
Longevity	Long-term functionality	(1)	2	3	4	5
Resources	Improve downstream aquatic environment/ erosion control	(1)	2	3	4	5
	Improve wildlife habitat	1	(2)	3	4	5
	Multiple use functionality	1	2	(3)	4	5
Safety, Risk, and Liability	Function without signficant risk or liability	(1)	2	3	4	5
	Ability to function with minimal environmental risk downstream	(1)	2	3	4	5
Public Perception	Information is available to clarify public understanding of runoff quality, quantity, and impacts	1	(2)	3	4	5

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Best Management Practice Goal Worksheet

Name: BRIAN M. ADAMS
Organization: DIRECTORATE OF PUBLIC WORKS, DEPT OF ARMY
Date: 11-6-2005

For part two, please identify which BMPs that you are aware have been utilized for your stormwater system and the extent of its use. If you are aware of BMPs that are in use and are not presented in this list, please add them in the space provided. Please be as specific as you can.

MOTOR POOL

Best Management Practice	Level of Use			
Sediment filters and sediment chambers	Rare	Limited	Common	Extensive
Vegetated buffers	Rare	**Limited**	Common	Extensive
Grass lined channels (conveyance)	Rare	Limited	Common	**Extensive**
Infiltration basins	Rare	**Limited**	Common	Extensive
Oil-water separators SANITARY SEWAGE TREATMENT	Rare	Limited	Common	**Extensive**
Catch basins	Rare	Limited	Common	Extensive
Manufactured products for storm water inlets	Rare	**Limited**	Common	Extensive
Groundwater injection (dry wells, Class V wells)	Rare	Limited	Common	Extensive
Buffer zones	Rare	**Limited**	Common	Extensive
Grass lines swales (storage)	**Rare**	Limited	Common	Extensive
Stormwater wetlands	Rare	**Limited**	Common	Extensive
Sand and organic filters	Rare	Limited	Common	Extensive
In-line storage or baffle structures	Rare	Limited	Common	Extensive
Elimination of curbs and gutters	Rare	Limited	**Common**	Extensive
Storm drain system cleaning	Rare	Limited	**Common**	Extensive
Parking lot and street cleaning	Rare	Limited	**Common**	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive
	Rare	Limited	Common	Extensive

LOW FLOW IN SWALES DUE TO SNOW COVER

#4