Storm Water Quality Credit Package

City of Orem Public Works
Storm Sewer Utility
November 15,1996

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Overview

The City of Orem is unique among Wasatch Front municipalities in terms of how storm water is managed within the City limits. Rather than a traditional storm water system which consists of piping, detention and conveyance structures, a significant portion of the City's storm water system consists of hundreds of dry sumps which are located on both private and public property throughout the City. During storm events, much of the City's runoff is diverted into these dry sumps and infiltrated into the ground water system. The majority of these sumps are owned privately. Generally, storm water flow into sumps is not pretreated for the removal of pollutants, nor is the storm water effluent monitored for potential contaminants.

On May 14, 1996 the Orem City Council passed an ordinance that created a Storm Sewer Utility for the City. On May 26, 1996 the City Council passed a resolution that allows the Storm Sewer Utility to give water quality credits, which reduces the monthly bill, for any non-single family resident that qualifies for the credit. To qualify for the credit, a business may install a structure or device that reduces or eliminates pollutants from its storm water runoff before it enters a dry well (sump), irrigation ditch, city storm drain, or waters of the State of Utah.

The City of Orem selected Hansen, Allen & Luce, Inc. to assist them in identifying pollutants which may potentially be present in storm water runoff, developing a list of Best Management Practices (BMPs) which could be implemented to reduce the amount of pollutants entering the storm drainage system, and to assist the City in developing a fee credit program for businesses which implement storm water pollution control measures. HA&L was subsequently authorized by the City of Orem on August 23, 1996 to complete the storm water runoff pollution and control study. The storm water credit program is the result of that effort.

The purpose of the storm water credit program is to recognize the efforts of businesses in reducing and/or eliminating storm water pollution by granting storm water quality credits, which reduces the monthly bill, for any non-single family resident that qualifies for the credit. To qualify for the credit, a business must implement source and/or treatment controls that reduce or eliminate pollutants from its storm water runoff **before** it enters a dry well (sump), irrigation ditch, city storm drain, or waters of the State of Utah. **Storm water credits will not be granted for use of storm water sumps.**

This package will be your guide to applying for and renewing storm water credit.

Applying for Credit

To apply for storm water credit you will need to fill out the Application For Storm Water Credit. You can obtain a copy of the application at the Public Works Facility, 955 North 900 West, or you can use the application on the following page. You will need to read the section titled **Calculating Storm Water Credit** starting on **page 5**. If you have questions about the application please call (801) 229-7556 for help. When you have filled out the application, please mail or deliver it to:

City of Orem Public Works
Storm Sewer Utility
955 North 900 West
Orem UT 84057

A Storm Sewer representative will be in touch with you to review your application.

Renewing Credit

You will need to periodically renew your credit agreement (generally every 3 to 12 months). Your Storm Water Quality Credit will not continue if not renewed. To renew credits, please contact the Storm Sewer Utility at (801) 229-7556 to request an appointment with the Storm Water Quality Inspector. We will review your previous agreement and check for compliance. We will then make a new agreement based on your previous performance.

Your Storm Water Quality Credit is based on an agreement in which you promise to improve or protect the environmental quality of your storm water runoff in exchange for a reduction in your storm sewer bill. The agreement includes a promise to perform specific Best Management Practices (BMPs). Your credit may be reduced or revoked for failure to keep the terms of the agreement.

City of Orem Public Works
Storm Sewer Utility
955 North 900 West
Orem UT 84057

Credit ID____________

Application for Storm Water Quality Credit

Name of Applicant: ____
(Company Name or Responsible Party)

Site Location: ____
Street Address City State Zip Phone

City of Orem Utility Account Number: ____

Authorized Contact: ____

Contact Mailing Address: ____
Street Address City State Zip Phone

Business Type (**see page 14**): ____

Please indicate with a check mark, which Source BMPs are recommended for your type of business, as well as which ones you will use.

Source BMP		Page	Recommended	Will Use
A	Building & Grounds Maintenance	21		
B	Container Storage of Liquids, Wastes	22		
C	Employee Training	23		
D	Land Use/Planning	24		
E	Liquid Storage in Above Ground Tanks	25		
F	Loading & Unloading of Materials	26		
G	Maintenance of Storm Drain Facilities	27		
H	Outside Manufacturing Activities	28		
J	Outside Storage of Materials, Products	29		
K	Public Education	30		
L	Spill Prevention and Cleanup	31		
M	Street and Parking Lot Sweeping	32		
N	Vehicle and Equipment Fueling Stations	33		
P	Vehicle and Equipment Maintenance & Repair	34		
Q	Vehicle and Equipment Washing & Steam Cleaning	35		
R	Waste Management	36		
		Total		

Please indicate which Treatment BMPs you will use

Treatment BMP	Page	Rating	Will Use
Constructed Wetlands	39		
Infiltration	44		
Biofiltration	50		
Extended Detention	56		
Media Infiltration	60		
Oil/Water Separator	63		
	Total		

*Signature of Applicant*____ *Date*________________

For Office Use Only

A **Building and Grounds Maintenance**______________________________

B **Container Storage of Liquids and Wastes**______________________________

C **Employee Training**______________________________

D **Land Use and Planning**______________________________

E **Liquid Storage in Above Ground Tanks**______________________________

F **Loading and Unloading of Materials**______________________________

G **Maintenance of Storm Drain Facilities**______________________________

H **Outdoor Manufacturing Activities**______________________________

J **Outdoor Storage of Materials and Products**______________________________

K **Public Education**______________________________

L **Spill Prevention and Cleanup**______________________________

M **Street and Parking Lot Sweeping**______________________________

N **Vehicle and Equipment Fueling Stations**______________________________

P **Vehicle and Equipment Maintenance and Repair**______________________________

Q **Vehicle and Equipment Washing and Steam Cleaning**______________________________

R **Waste Management**______________________________

$$\text{Credit} = \_\_\_\% \times \left(\_\_\_\_\_\_\_\_ \right) + \_\_\_\% \times \_\_\_ = \_\_\_\%$$

Credit Approved By: ______________________________

Date Effective________________ **Date Expires**________________

Calculating Storm Water Credit

Storm Water Quality Credit is a function of three things: Risk (**next page**), Source Controls (**page 13**) and Treatment Controls (**page 18**). The amount of credit is governed by the Storm Water Credit Equation:

$$\textbf{Credit} = \mathbf{a_1} \cdot \boldsymbol{f}\textbf{(Source Control)} + \mathbf{a_2} \cdot \boldsymbol{g}\textbf{(Treatment Control)}$$

In order to calculate credit, a risk analysis must be performed. The risk analysis will determine how much of your credit can come from source controls and how much from treatment controls.

Risk Analysis

In order to assign a risk to each business and/or activity, a logical method was needed to objectively determine how one source may have a greater storm water contamination potential than another source. A priority setting scheme was employed similar to that used by EPA, as set forth in *Managing Ground Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach* (EPA, 1991). This approach is similar to that employed during development of the City's Drinking Water Source Protection Program. The risk of a particular contamination source is defined as a function of the likelihood of storm water contamination and of the severity of contamination, as follows:

$$\text{Risk} = f\,(\text{Likelihood (L), Severity (S)})$$

The ***likelihood*** of storm water contamination is defined as the probability that a pollutant will enter the storm water system. A particular business and/or activity has the likelihood of contributing to storm water pollution *if and only if* the contaminant is released from the source and reaches the storm water system. The likelihood of release at the source is a function of the type of business and/or activity, design and condition of storage containers (i.e. above/below ground, indoors/outdoors, age, duration of release, secondary containment, etc.).

The ***severity*** of storm water contamination reduces to a function of the quantity and toxicity of the contaminant. In general terms, the quantity of contaminant which has the potential to be released at the source is defined as a function of the volume of contaminant released, the number of storage tanks, and the nature of the contaminant. A single, large storage tank of contaminant has a greater risk of contaminating the storm water system than does a small source. To illustrate this point, consider two potential scenarios. Assume an identified business has a single, above ground 1,000 gallon fuel storage tank. Similarly, assume a second business has four, above ground 250 gallon fuel storage tanks. Both sites have equal total volume, and are equally carcinogenic and toxic. However, under risk analysis, the single 1000 gallon fuel storage tank would possess a higher risk due to the fact that the full 1,000 gallons could be discharged to the storm water system if the vessel should develop a leak. If a leak were to develop in one of the 250 gallon vessels, the contamination would be limited to 250 gallons. A similar analysis could be evaluated for two or more sites having equal volume, but with varying chemical and/or product contaminants.

Toxicity of a given chemical or product is a measure of the "potential health hazard posed by ingesting the contaminant" (EPA, 1991). Toxicity is further defined in terms of its carcinogenic nature. Simply stated, carcinogenic items pose a greater health risk than non-carcinogenic items, and items which are toxic to life pose a greater risk than less toxic items.

The risk assessment approach used in this report uses factors for likelihood and severity in establishing a total risk score for both chemicals and products. The risk scores assigned to each of the risk influencing factors and their contributing components are shown on Table 2 (**page 8**). For a list of chemicals that are considered hazardous see Table 3 (**page 11**). Figures 1 (**page 9**) and 2 (**page 10**) illustrate how the scoring is applied for chemicals and products, respectively. As shown in the figures, the initial three questions define the risk.

1. *Are chemicals and/or products used?*
2. *Are products used and/or stored outside?*
3. *If chemicals are stored indoors, is there the potential for direct infiltration into a dry sump within the building, or for spill/leakage outside of the building?*

If the answer to all of these questions is no, then the risk score equals zero. If the answer is yes, then additional information must be sought. As shown in Figures 1 (**page 9**) and 2 (**page 10**), the first issue becomes definition of the *severity*, or the quantity and toxicity of material that could impact storm water quality. These include items such as quantity (number and size of tanks, quantity of materials), carcinogenic nature, toxicity, and solubility. These questions are then followed by issues of *likelihood*. These include items such as storage location (above/below ground), whether secondary containment is provided, whether the potential hazard is covered, or whether runon diversion is provided which diverts storm water flows away from the potential hazard.

Although both above ground and below ground storage tanks pose equal threat to the waters of the State, above ground tanks pose a greater threat to the storm drainage system. When evaluating risk associated with fuel storage tanks, it is important to consider conditions where the fuel (or other product) is dispensed, as well as potential spills/leaks which may occur during filling of the storage tanks. For example, consider a gasoline station with below grade tanks. Significant accumulations of spilled materials can occur at the pumps over relatively short time periods due to overfilling, misuse, leaky hoses and fittings, etc. Although fuel pump areas are frequently covered, they do not provide secondary containment or runon diversion. In addition, information provided by City personnel indicates that fuel pump areas and parking lots are often sprayed with water and flushed directly into the storm drainage system.

Once a risk analysis is performed your business will rate as either a high, medium or low risk. Your risk score will determine your risk category as shown in Table 1 (**below**). Your risk category will determine the latitude that you have for selecting coefficients $\mathbf{a_1}$ and $\mathbf{a_2}$. The coefficients $\mathbf{a_1, a_2}$ are constants which are determined as shown in Table 1 (**below**) The sum of coefficients $\mathbf{a_1, a_2}$ shall not exceed 0.40.

Table 1
Source and Treatment Control Coefficients

RISK SCORE	SOURCE CONTROL COEFFICIENT, a_1	TREATMENT CONTROL COEFFICIENT, a_2
High (>61)	0.20	0.20
Medium (40-60)	0.15 - 0.25	0.25 - 0.15
Low (<40)	0.10 - 0.30	0.30 - 0.10

Table 2
Pollutant Risk Evaluation

Risk is measured on a scale of 0 to 100 (for Chemicals) and 0 to 75 (for Products), as shown below. **The total Risk Score equals the greater of the Chemical or Products individual risk** Where chemicals and products are not used and/or stored, Risk Score = 0.

CHEMICALS (Total Potential Score 100)

Likelihood of Release

Use Chemicals (A)	**Store Chemicals (B)**	**Storage Location (C)**	**If Inside, Potential for Exterior Spill/Leak (D)**
No = 0 Yes =10	No = 0 Yes = 10	Indoors = 0 Outside = 10	No = 0 Yes = 5
Above Ground (E)	**Secondary Containment (F)**	**Covered Storage Provided (G)**	**Runon Diversion Provided (H)**
No = 5 Yes = 10	No = 5 Yes = 0	No = 5 Yes = 0	No = 5 Yes = 0

Severity of Contamination

Number of Tanks (J)	**Tank Size (K)**	**Carcinogenic (L)**	**Toxic (M)**
1 = 2 2-3 = 4 4-5 = 6 6-10 = 8 11+ = 10	< 55 gallons = 2 55-1,000 gallons = 4 1,001-5,000 gallons = 6 5,001-10,000 gallons = 8 > 10,000 gallons = 10	No = 0 Yes = 10	No = 0 Yes = 10

PRODUCTS (Total Potential Score 75)

Likelihood of Release

Use Products (N)	**Store Products Outdoors (P)**	**Secondary Containment (Q)**	**Covered Storage Provided (R)**
No = 0 Yes = 10	No = 0 Yes = 10	No = 5 Yes = 0	No = 5 Yes = 0
Runon Diversion Provided (S)			
No = 5 Yes = 0			

Severity of Contamination

Quantity (T)	**Carcinogenic (U)**	**Toxic (V)**	**Soluble (W)**
< 50 cubic feet = 2 51-500 cubic feet = 4 501-5,000 cubic feet = 6 5,001-10,000 cubic feet = 8 > 10,000 cubic feet = 10	No = 0 Yes = 10	No = 0 Yes = 10	No = 0 Yes = 10

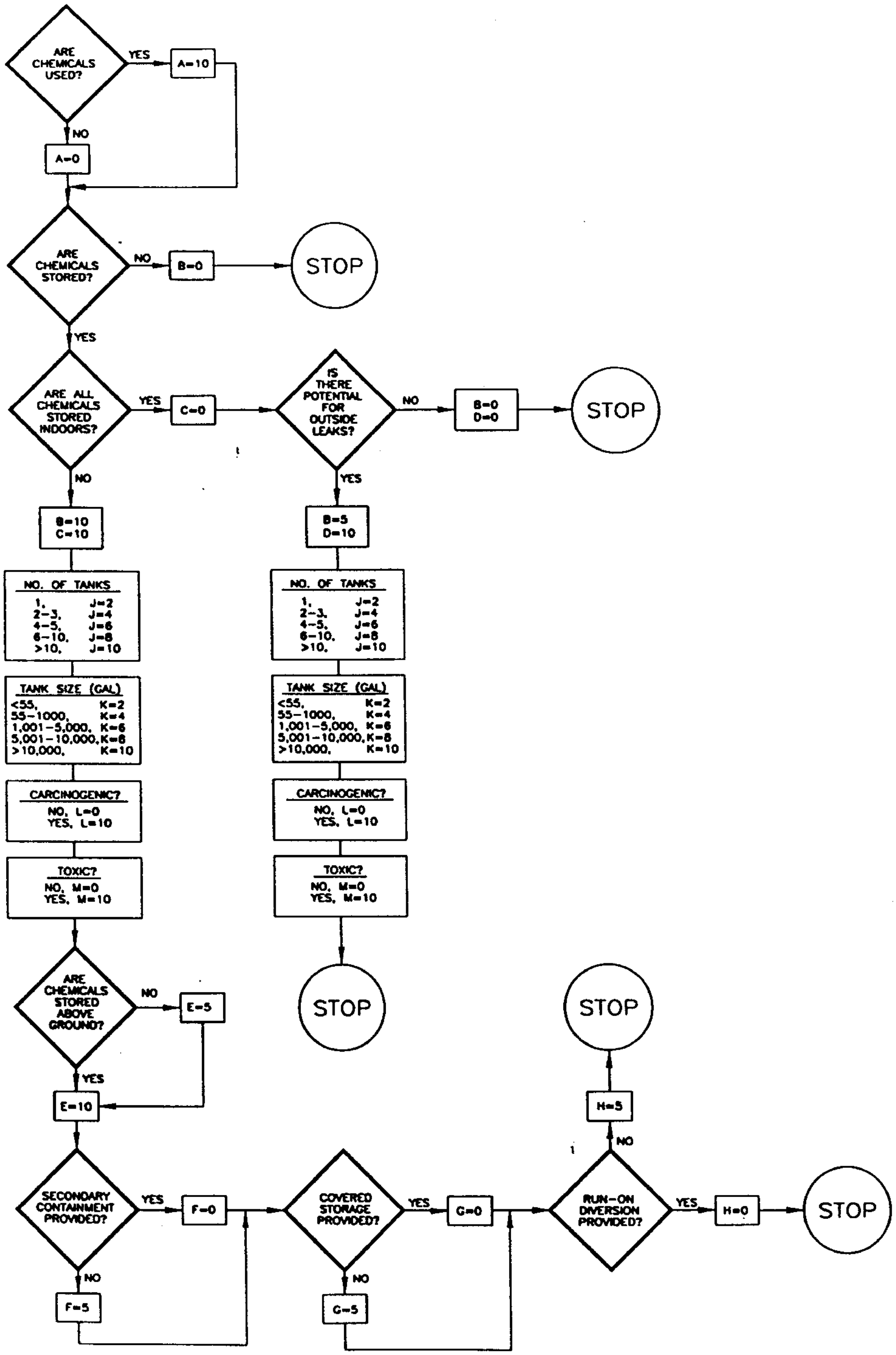


Figure 1 - Chemical Risk Analysis Flow Chart

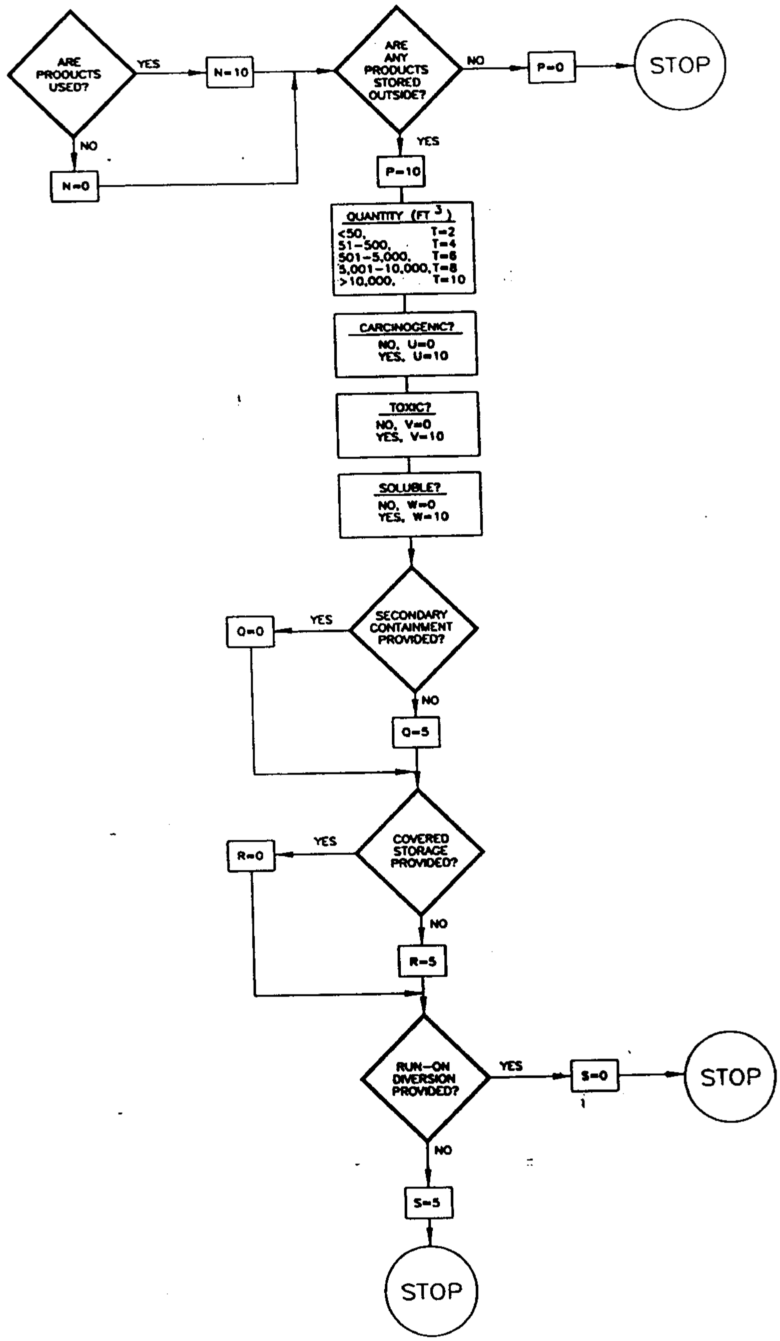


Figure 2 - Product Risk Analysis Flow Chart

Table 3 provides information related to the carcinogenic and toxic nature of some chemicals. Where a specific chemical is not listed, relative information may be obtained for the Material Safety Data Sheets (MSDS) for that particular chemical.

Table 3
Identification of Carcinogenic and Toxic Characteristics of Selected Chemicals

CONTAMINANT	CARCINOGENIC		TOXIC	
	YES	NO	YES	NO
1, 1, 1-Trichloroethane	✓		✓	
1, 1, 2, 2-Tetrachlorethane		✓		✓
1, 2-Dichlorobenzene	✓		✓	
1, 2-Trans-Dichloroethylene	✓			✓
2, 4, 5-TP Silvex		✓		
2, 4, 6-Trichlorophenol		✓		✓
2, 4-D	✓			✓
Acetic Acid	✓		✓	
Acetone	✓		✓	
Alachlor	✓			✓
Aldicarb	✓			✓
Antimony	✓			✓
Arsenic		✓		✓
Atrazine	✓			✓
Barium	✓		✓	
Bentazon	✓			✓
Benzene		✓		✓
Beryllium	✓			✓
Bis (2-ethylhexyl) phthalate		✓		✓
Boron	✓		✓	
Butylate	✓		✓	
Cadmium	✓			✓
Carbon Tetrachloride		✓		✓
Chloride	✓		✓	
Chloroform		✓		✓
Chromium	✓			✓
Cresol	✓		✓	
Cyanazine	✓			✓
Cyanide	✓			✓
Dicamba	✓			✓
Dichloroethane		✓		✓
Dichloromethane		✓		✓
Dinitro-butyl phthalate	✓		✓	
Endrin	✓			✓
EPTC+	✓			✓
Ethylbenzene	✓		✓	
Hexachlorobenzene		✓		✓

Hexachlorobutadiene		✔		✔
Iron	✔			✔
Lead	✔			✔
Lindane		✔		✔
Manganese	✔		✔	
Mercury	✔			✔
Methanol	✔		✔	
Methyl ethylketone	✔		✔	
Methoxychlor	✔			✔
Metolachor	✔		✔	
Metribuzin	✔			✔
M-xylene	✔		✔	
Naphthalene	✔		✔	
Nickel	✔			✔
Nitrate-Nitrogen	✔		✔	
Nitrobenzene	✔			✔
Phenol	✔		✔	
Selenium	✔			✔
Silver	✔			✔
Sulfuric Acid	✔		✔	
Tetrachloroethylene	✔			✔
Trichlorethylene		✔		✔
Tin	✔		✔	
Toluene	✔		✔	
Trifluralin		✔		✔
Vandium	✔			✔
Vinyl chloride		✔		✔
Xylene	✔		✔	
Zinc	✔		✔	

Note: The above table summarizes information provided on Form S.2 of the document entitled "*Managing Ground Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach*", EPA 570/9-91-023, Washington D.C. The indication of a toxic substance is based upon a risk score greater than zero, as reported on Form S.2 of the above referenced EPA document.

Source Controls

The Storm Water Credit Equation includes a term that is a function of Source Controls. The function of Source Controls is in bold type below.

$$\text{Credit} = a_1 \cdot \boldsymbol{f}\textbf{(Source Control)} + a_2 \cdot g(\text{Treatment Control})$$

The amount of Source Control credit your business can obtain depends on your type of business and your risk category. A number of Source BMPs are recommended for each type of business. The Source BMPs that are recommended for you type of business may be found in Table 4 (**page 14**). The amount of source credit will obtain depends on how many of the recommended BMPs you will implement.

$$\boldsymbol{f}\,\textbf{(SourceControl)} = \frac{\textbf{Number of BMPs implemented}}{\textbf{Number of BMPs recommended}}$$

Table 4
Source Controls Required for Source Treatment Credit

BUSINESS	RECOMMENDED SOURCE BMPs																Number of Recommended BMPs
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	
Manufacturing Business																	
Cement	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12
Chemicals	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12
Concrete Products	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	14
Electrical Products	✓	✓	✓		✓	✓	✓		✓		✓	✓			✓	✓	11
Food Products	✓	✓	✓		✓	✓	✓		✓		✓	✓			✓	✓	11
Class Products	✓	✓	✓		✓	✓	✓		✓		✓	✓			✓	✓	11
Industrial Machinery and Equipment	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	13
Metal Products	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12
Paper and Pulp Mills	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	13
Paper Products	✓	✓	✓		✓	✓	✓	✓	✓			✓			✓	✓	11
Petroleum Products	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	14
Printing and Publishing	✓	✓	✓		✓	✓	✓				✓	✓			✓	✓	10
Rubber and Plastic Products	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12
Wood Products	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12

BUSINESS	RECOMMENDED SOURCE BMPs																Number of Recommended BMPs
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	
Wood Treatment	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	12
Transportation and Communication																	
Airfields and Aircraft Maintenance	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12
Fleet Vehicle Yards	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12
Railroads	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12
Private Utility Corridors	✓	✓	✓				✓		✓			✓					6
Warehouses and Miniwarehouses	✓		✓		✓	✓	✓				✓	✓				✓	8
Other Transportation and Communication	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12
Wholesale and Retail Business																	
Gas Stations	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	13
Recyclers and Scrap Yards	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓			✓	✓	12
Restaurants/Fast Food	✓	✓	✓			✓	✓					✓				✓	7
Retail General Merchandise	✓	✓	✓				✓				✓	✓	✓	✓	✓	✓	10
Retail/Wholesale Vehicle and Equipment Dealers	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	13
Retail/Wholesale Nurseries and	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	U	12

BUSINESS	RECOMMENDED SOURCE BMPs																Number of Recommended BMPs
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	
Building Materials																	
Retail/Wholesale Chemicals and Petroleum	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	13
Retail/Wholesale Foods and Beverages	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12
Service Business																	
Animal Care Services	✓		✓				✓									✓	4
Commercial Car and Truck Washes	✓		✓				✓			✓	✓	✓	✓	✓	✓	✓	10
Equipment Repair	✓	✓	✓			✓	✓				✓	✓		✓	✓	✓	10
Laundries and Other Cleaning Services	✓	✓	✓		✓	✓	✓			✓	✓	✓				✓	10
Golf Courses and Parks	✓		✓									✓				✓	4
Miscellaneous Services	✓	✓	✓		✓	✓	✓				✓	✓				✓	9
Professional Services	✓		✓				✓					✓			✓	✓	6
Vehicle Maintenance and Repair	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	13
Multi-Family Residences	✓	✓	✓				✓					✓			✓	✓	7
Construction Business	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓	✓	✓	12

Source: Washington State Department of Ecology. (1992)

Treatment Controls

The Storm Water Credit Equation includes a term that is a function of Treatment Controls. The function of Treatment Controls is highlighted below.

$$\text{Credit} = a_1 \cdot f(\text{Source Control}) + a_2 \cdot \boldsymbol{g}(\textbf{Treatment Control})$$

The amount of Treatment Control credit your business can obtain depends on the type of Treatment Control you use and your risk category. The available types of Treatment Controls, and their ratings are found in Table 5 (**page 19**). The amount of Treatment Control credit your business will receive depends on the effectiveness of the BMP that you will use.

$$g(\textbf{Treatment Controls}) = \begin{cases} \textbf{1.0} & \text{for highly effective BMPs} \\ \textbf{0.75} & \text{for moderately effective BMPs} \\ \textbf{0.5} & \text{for low effectiveness BMPs} \end{cases}$$

The rating of each of these BMPs varies because their appropriateness varies with each circumstance. Storm Sewer Staff will review the effectiveness of a treatment BMP upon receipt of engineering calculations.

Table 5
Treatment Controls BMP Selection

Source Best Management Practices

As noted in Chapter II, storm water pollution may result from any number of elements. There are four general categories for source controls which may be used to reduce the potential for storm water pollution. These include altering the activity, enclosing and/or covering the activity, segregating the activity, and as a last resort discharging the storm water into a process wastewater treatment system.

Altering the activity is simply a change in management and operational procedures, whereby an alternate method for storing, using and/or disposing of potentially hazardous products is implemented. Examples of such modifications may be as simple as modifying loading and unloading procedures, use of drip pans where transfers of hazardous materials are performed, changing storage methods, improving cleanup procedures, replacing hazardous substances with inert materials (where possible), etc. Altering the activity is generally easy to implement, does not require large capital expenditures, and can commence without delays.

Enclosing and/or covering the activity is a method whereby storm water runoff is essentially eliminated in it's entirety. By eliminating the potential for precipitation and storm water runon, the potential for the transport of storm water pollutants is significantly reduced, if not eliminated in it's entirety.

Segregating the activity consists of physically moving hazardous substances apart from those which are non-hazardous. Segregation may result in two distinct benefits. First, source controls are required only for those hazardous substances. For example, if the selected BMP consists of enclosing the hazardous activity, the cost for enclosing only the hazardous activities will be less than the cost of covering all activities. Secondly, segregation of the hazardous activity provides a reminder to workers and others that special care and or consideration should be provided for these activities. This will result in fewer accidental and/or unintentional discharges to the storm water system.

Finally, where other source controls are not effective, an option may be to **discharge the contaminated storm water into a process wastewater treatment system**. However, discharge of polluted runoff and/or process effluent may require acquisition of a UPDES Permit. In all cases however, the City should be notified and authorization granted to the potential discharger prior to connection with the sanitary sewer system.

The following sections summarize information provided in the above listed references, and describe typical source controls which may be considered for implementation.

Building and Grounds Maintenance

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices, SC11, SC12
Construction Activity Best Management Practices, CA3

General

Building and grounds maintenance is an inexpensive BMP which can be highly effective for the prevention and/or reduction of pollutants from entering the storm water system. Elements which should be considered include, but are not limited to:

- Use of native vegetation to reduce water, fertilizer and pesticide needs.
- Use of alternative cleaners, chemicals, and less hazardous products to the extent possible.
- Proper use of pesticides and fertilizers. These products should only be used according to the manufacturer's label, and should be stored indoors to prevent accidental leakage to the storm water system.
- Sweeping of paved surfaces.
- Proper disposal of waste water, sweepings, and sediment. Make sure that all storm drains are properly marked to reduce the chance of inadvertent disposal of hazardous products.
- Soil erosion control.
- Proper use and storage of paints, thinners, solvents, etc. These products should be stored indoors so as to eliminate the potential for leakage to the storm water system. Drop cloths should be used to catch over spray and drippings, and all waste products should be disposed of according to local laws and regulations. Spills should be cleaned up as soon as possible.
- Clean the storm drainage system within work areas immediately following any construction or repair activities to remove sediments and/or debris.
- Inform all employees and off-site contractors of the need for good housekeeping. The concentrated effort of a group of individuals can be undone by the careless or unknowing action of a single person.

Cost and Maintenance

These BMPs are generally of low to moderate cost.

Limitations

- Alternative products may not be available, suitable, or effective for certain applications.

Container Storage of Liquids, Food Wastes or Dangerous Wastes

Reference

County of Alameda Public Works Department, 1993.
Construction Activity Best Management Practices. CA10
Municipal Best Management Practices. SC20,
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Material storage control can be an effective BMP by minimizing the storage of hazardous materials on site, designating specific storage areas for specific products, providing secondary containment, performing regular inspections, and training of employees in the proper procedures for storing liquids, food wastes and/or dangerous wastes. Examples of typical products which may be stored within an urban setting include pesticides and herbicides, fertilizers, petroleum products, paints, solvents, etc. The improper storage of these products can result in personal injury as well as contribute to groundwater, soil and storm water contamination. Appropriate BMPs may include, but not necessarily be limited to:

- Reduce the exposure of products and waste to precipitation and storm water runoff. This can be achieved by providing covered storage, secondary containment, paved storage surfaces, etc.
- Segregate hazardous materials from non-hazardous substances. The physical separation of hazardous products serves as a constant reminder to employees of the need for special storage and/or handling care.
- When spills do occur. Establish procedures which will allow for their rapid cleanup and prevent migration and/or contamination of facilities. Maintain sufficient quantities of spill cleanup products on hand at all times. Spilled products should be disposed of in accordance with all applicable laws and regulations.
- Store only the quantity of materials necessary. Storage of excess products results in an increased potential for leakage and/or outdating.
- Provide labels for all containers.
- Conduct regular inspections of the storage area for evidence of spills and/or leaks.
- Ensure that all products are stored in accordance with all applica ble laws and regulations.

Cost and Maintenance

The costs associated with construction of facilities and facility maintenance vary significantly with regards to the type of products stored and the size of facilities required. Costs are often controlled through the use of accurate and current inventories of all stored materials, proper use and labeling, and adequate employee training.

Limitations

- The principal limitation to the container storage of liquids, food wastes or dangerous wastes is improper employee training.

Employee Training

Reference
County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC14
Construction Activity Best Management Practices CA40

General

Employee training by itself is not a BMP. However, it is a highly effective management practice which is necessary for effective BMP operation. In many instances, BMPs may have reduced pollutant removal capabilities and/or become ineffective due to inadequate employee training. Effective employee training should include the following items:

- Provide a clear understanding of the purpose of preventing or reducing pollution transport or migration.
- Employees should have a general understanding of the type of products transported, stored and/or used. This training should also discuss the potential for pollution of the environment at each phase of the process.
- Outline the BMP which has been selected for use, including an explanation of how the BMP is intended to function, potential problems, maintenance schedule, etc.
- Educate employees about the need for immediate cleanup action. Where appropriate, employees should know evacuation procedures, and immediately notify appropriate personnel and/or agencies to initiate clean-up procedures.
- Continue training on a regular basis.

Cost and Maintenance

The cost of employee training is generally low, and the cost of initial training and refresher courses is dependent upon the number of employees, type of BMP(s) utilized, and nature of the potential pollutant. In many situations, BMP training can be performed concurrent with job training education.

Limitations

- There are no known limitations with this BMP.

Land Use/Planning

Reference

County of Alameda Public Works Department, 1993.
Municipal Best Management Practices

General

Although typically limited to new development and municipalities in general, land use planning can be an effective element of a storm water pollution plan for all new development. Land use planning as a BMP is described as being applicable to all land uses, and represents a highly effective pollution prevention practice. Elements of successful land use planning include establishment of water quality goals, identification of the planning area, the evaluation of alternate plans upon which the most effective solutions are selected, and alternate BMPs.

Cost and Maintenance

Costs associated with land use planning are proportionally related to the size of the area to be developed, environmental sensitivity of the area, and the type of proposed development. However, wise land use planning often yields significant cost savings over the long term by considering the impacts of various land use types and BMPs.

Limitations

- Land use planning may appear restrictive to the general public due to limitations on allowable land uses.

Liquid Storage in Above Ground Tanks

Reference

County of Alameda Public Works Department, 1993.
Municipal Best Management Practices SC20, SC41
Industrial/Commercial Best Management Practices SC6
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).

General

Liquid storage requirements for above ground tanks are intended to provide safeguards against accidental spills, unintentional releases and overtopping which may result in storm water pollution. The most common causes of accidental spills/leaks are related to installation problems, failure of the piping system, leaks in the piping used during filling of the tank, corrosion and structural failure, and spills and overfills due to negligence. BMPs which may be considered include, but are not limited to:

- Provide overfill protection to minimize the risk of spillage during loading.
- Perform regular inspection of the tank, hoses and nozzles to ensure their integrity.
- Provide secondary containment having a storage volume not less than 110% of the capacity of the largest above ground storage tank. Tanker trucks should also be parked in impervious areas where containment is provided for not less than 110% of the capacity of the largest tank. All fluids captured within the containment system should be treated using an appropriate treatment BMP.
- Outlets to the containment area should have a dead-end sump which is inspected and cleaned on a frequent basis.
- Tanks should be placed over an impervious surface, and be placed within a covered area where feasible.
- Tanks should be protected from vehicles through the use of bollards.
- Employee training.

Cost and Maintenance

Capital costs will vary depending upon the size of facilities required. Maintenance consists primarily of regular inspections to verify integrity of the tank system.

Limitations

- There are no significant limitations to this BMP

Loading and Unloading of Materials

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC5

General

Unintentional releases generally occur during handling of the product. Provisions should be made which eliminate and/or reduce the potential for contamination of the storm water system during loading and unloading of materials. Elements which should be considered include, but are not limited to:

- Tank trucks and delivery vehicles should be parked in areas which provide adequate containment.
- Loading/unloading docks may be covered to prevent exposure to the rain.
- Storm water runon should be diverted away from the loading/unloading area through the use of berms, curbs, redirection of roof drain downspouts, etc.
- Use of drip pans under all hoses and fittings.
- Employee training.

Cost and Maintenance

The cost is relatively low, with the exception of providing covered structures. This cost will vary depending upon the size of structure required.

Limitations

- All transfers may not be capable of being performed either indoors or under cover.

Maintenance of Storm Drainage Facilities

Reference

County of Alameda Public Works Department, 1993.
Municipal Best Management Practices SC71, SC73

General

Catch basins which have become clogged are not only ineffective, but may also act as a source of sediment and pollutant within the storm water system. Elements which should be considered include, but are not limited to:

- Public and private catch basins and sumps should be inspected on a regular basis.
- Storm drainage catch basins should be cleaned on a regular basis to remove pollutants, reduce high pollutant concentrations during the first flush of storms, prevent clogging, and restore the catch basins sediment trapping capacity. A basic rule of thumb is that catch basins be cleaned before they are 40% full.
- Sumps should be cleaned of silts and sediment. Silts and sediments can capture high levels of pollutants and also impede the design infiltration capacity of the sump.
- Flushing of lines may be required for "flat" lines subject to high sediment buildup and clogging potential. Debris flushed from the system should be collected and pumped to the sanitary sewer system (where applicable).
- Public education.

Cost and Maintenance

Maintenance may be relatively high depending upon the number of sumps involved. The frequency of cleaning will also be dependent upon the source of storm water entering the system and tributary area. Costs of disposal may also be significant if hazardous substances are identified.

Limitations

- Private sump owners may not have the equipment necessary to clean the sump and storm drainage catch basins, which will necessitate manual cleanout.
- Sediments, solids and debris removed from the storm water system must be disposed according to all applicable laws and regulations.
- Flushing is not effective in large diameter pipelines (>36" diameter), and requires a large volume of water for adequate flushing.

Outside Manufacturing Activities

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC7
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Outside manufacturing processes should be modified to prevent or reduce the potential of storm water pollution. Elements which should be considered include, but are not limited to:

- Alter the activity to reduce the amount of waste generated.
- Provide cover over the activity to eliminate precipitation falling directly onto the activity.
- Certain parts of the activity may provide the highest concentration of pollutants. These portions may be segregated from the less hazardous activities.
- Provide curbing or berms which divert storm water runon away from the activity.
- Clean the work area on a regular basis.
- Provide secondary containment, where appropriate. Drip pans should also be provided at all joints and fittings where leaks and/or spills may potentially occur.

Cost and Maintenance

The costs associated with this BMPs will vary significantly depending upon the size of facility and nature of the work activity. Certain parts of the activity may provide the highest concentration of pollutants. By segregating activities, covering or enclosing the highest risk areas will significantly reduce the overall cost of this BMP.

Limitations

- Space limitations and type of work activity may preclude the possibility of covering the activity.

Outside Storage of Raw Materials, By-Products, or Finished Products

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC8
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Provisions for the outside storage of raw materials, by-products or finished products should be implemented which prevent or reduce the potential of storm water pollution. Storm water can become contaminated when materials and/or residues wash off, spills and leaks occur, and solubles dissolve in water. Products which may be considered for source control within this BMP include sand and gravel products, compost, lumber and building materials, logs, concrete and metal products, canisters, barrels, etc. Recommended BMP elements should include, but are not limited to:

- Protect the materials from rainfall, runon and wind dispersal.
- Provide paved surfaces for the storage of materials, with drainage sloped away towards the perimeter of the facility and into a storm water collection/treatment area.
- Provide secondary containment, where appropriate.
- Provide curbing and/or berms to prevent storm water runon.

Cost and Maintenance

The cost of these BMPs are generally low, except where large areas need to be covered and/or paved.

Limitations

- Space limitations may preclude covering of all products and wastes.

Public Education

Reference

County of Alameda Public Works Department, 1993.
Municipal Best Management Practices. SC0
Horner et. al. 1994

General

Public education by itself is not a BMP, rather it is a method which is critical to successful implementation of the other BMPs described within this report. An effective public education program provides the opportunity for reaching a large number of people about concerns related to storm water protection. Increasing the awareness of storm water pollutants and their sources has proven to be a significant aid in the prevention and/or reduction of many storm water pollutants. Some of the key elements which should be considered in an effective public education program include, but are not limited, to the following:

- Provide a clear understanding of the problems and solutions. A lack of viable solutions will diminish the effectiveness of any public education program.
- Identify the responsible parties. It is important to remind the public that everyone's help is necessary, including residences, business, industry and government
- Utilize multimedia to reach all the public.
- Provide accurate, concise information that is easily understood.
- Invite the public to participate by providing input regarding potential problems and solutions.
- Post notices in public locations as continual reminders.
- Provide updates on a regular basis which report successes and remind the public of the on-going effort.

Cost and Maintenance

The cost of this practice is relatively low, but varies with the level of advertising which may be utilized.

Limitations

- There are no significant limitations to the application of public education.

Spill Prevention and Cleanup

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices: SC10
Construction Activity Best Management Practices: CA12
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Spill prevention is the desired goal for all products with the potential for entering the storm water system. However, spills and accidental releases may occur. Proper planning towards remediation of the spill will reduce the potential for storm water pollution. Elements of a successful spill prevention and cleanup BMP may include, but not be limited, to:

- Establish procedures which identify remedial action plans. These plans may be based upon the size of the spill, type of contaminant spilled, sub-base conditions, etc.
- Provide adequate supplies of spill cleanup materials in a location where they can be readily accessed.
- Train employees in proper spill handling procedures. Employees should know who to contact in case of spill or accidental release, and emergency procedures.
- Clean up spills as quickly as possible to prevent migration and seepage.
- Use towels, rags, mops, or adsorbent products for cleanup. These items should then be disposed (or cleaned) in an appropriate manner.
- Water should never be used due to it's ability to transport the contaminant over a much larger area.
- Certain types of spills will also require notification of local, state and/or federal agencies.

Cost and Maintenance

The cost associated with spill prevention is initially very low. Costs of cleanup are however related to the type of product spilled and/or accidentally released and the quantity of material released.

Limitations

- There are no significant limitations to spill prevention and cleanup.

Street and Parking Lot Sweeping

Reference

County of Alameda Public Works Department, 1993.
Municipal Best Management Practices. SC70
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Street and parking lot sweeping can effectively reduce the potential for contamination of the storm water system from street and parking lot runoff. The effectiveness of any sweeping program is the ability of the sweeper to remove accumulated dust, dirt and debris from impervious surfaces. Elements of a successful street and parking lot sweeping BMP may include, but not necessarily be limited to:

- Sweeping must be performed with a vacuum or regenerative air sweeper**. No credit will be given for mechanical or broom sweeping.**
- Perform sweeping procedures when the number of parked cars is at a minimal.
- Perform sweeping on a regular basis as indicated in Table 6 (**below**).
- Salts used for melting ice on roadways and parking lots should be removed as soon as practical to prevent their migration to the storm water system.
- Sweeper performance is significantly affected by the speed at which sweeping is performed. Operators should be trained in proper sweeper speed, brush adjustment, sweeping pattern, ability to maneuver around parked vehicles, disposal methods, etc.
- Studies performed indicate that particulate loading from parking lots and streets may be decreased in excess of 50% through sweeping efforts. However, sweeping does not effectively remove oil and grease.

Cost and Maintenance

Costs associated with street sweeping are directly related to the frequency of which the streets and parking areas are swept, and the type of sweeper used. Average costs range between $70-100/hr.

Limitations

- Vacuum or regenerative air sweepers are more effective at removing fine sediments which are prone to bind with metals.
- Mechanical sweepers are more effective at removing large debris and cleaning wet streets, however they generate more airborne dust that the vacuum or regenerative air sweepers and are less efficient at picking up fine sediments.

Table 6
Minimum Sweeping Frequencies

		Accumulation of Debris and Sediment		
		Low	Medium	High
Volume of Cars	Low	Twice Monthly	Twice Monthly	Weekly
	Medium	Weekly	Weekly	Daily
	High	Daily	Daily	Daily

Vehicle and Equipment Fueling Stations

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC2
Construction Activity Best Management Practices CA31
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

The proper design and inclusion of fueling station BMPs can significantly reduce the potential for storm water pollution resultant from fueling stations. Elements of an effective BMP may include, but not be limited to:

- Design fueling area such that area is covered, has positive drainage towards the center of the fueling area and is paved with concrete rather than asphalt. Runon should be controlled and diverted away from the fueling area.
- Provide oil/water separator for all dead end sumps.
- Use secondary containment for all storage tanks and tanker transfer points. Provide drip pans on all transfer hoses and fittings.
- Discourage topping off of fuel tanks to reduce the potential for spills.
- Use adsorbent material for cleaning of spills rather than hosing the area with water.
- Employee training.

Cost and Maintenance

Retrofitting of existing facilities is expensive. The most cost effective means of implementing these measures are during initial design and/or during renovation/replacement of facilities.

Limitations

- Oil/Water separators are effective BMPs for fueling stations. However, their effectiveness can be significantly impaired through lack of maintenance.

Vehicle and Equipment Maintenance and Repair

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC4
Construction Activity Best Management Practices CA32

General

Implementation of vehicle equipment maintenance and repair BMPs can significantly reduce the potential for storm water pollution resultant. Elements of an effective BMP may include, but not be limited to:

- Keep vehicles clean. Don't allow excessive build-up of oil and grease.
- Maintain vehicles on an impervious surface. Provide drip pans as required for spill containment from leaking vehicles.
- Perform maintenance in a designated area. Provide drip pans as required for spill containment during transfer and/or filling of vehicles.
- Segregate and recycle oil and fuel products. Store indoors on an impervious surface where possible.
- Clean up spills as soon as possible.
- Dispose of all oil products and oil filters in accordance with all laws and regulations. Oil products should not be disposed within the municipal land fill.
- Educate employees.

Cost and Maintenance

Capital costs can vary significantly depending upon the level of protection desired.

Limitations

- Pretreatment of wash water may be required.

Vehicle and Equipment Washing and Steam Cleaning

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices SC3
Construction Activity Best Management Practices CA3
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual)

General

Implementation of vehicle and equipment washing and steam cleaning BMPs can significantly reduce the potential for storm water pollution resultant. Elements of an effective BMP may include, but not be limited to:

- Use commercial washing and steam cleaning businesses.
- Limit washing to a designated area. Where possible provide cover and berms to reduce the impact of precipitation and storm water runon.
- Establish procedures for filtering and/or recycling wash water.
- Discharge wash water in accordance with all applicable laws and regulations.

Cost and Maintenance

Capital costs can vary significantly depending upon the level of protection desired.

Limitations

- Pretreatment of wash water may be required.

Waste Management

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices: SC9
Construction Activity Best Management Practices: CA3
Municipal Best Management Practices: SC30, SC31, SC32

General

Implementation of an effective waste management BMP can significantly reduce the potential for storm water pollution resultant. Elements of an effective BMP may include, but not be limited to:

- Recycle materials whenever possible.
- Maintain current record of the quantity and type of waste handled and disposed of.
- Provide segregation of waste.
- Where possible, cover or enclose all waste products to reduce precipitation and prevent runon.
- Promote use of non-hazardous products.
- Provide employee training.

Cost and Maintenance

These BMPs are generally of low to moderate cost.

Limitations

- Alternate products may not be available for use.

Treatment Best Management Practices

Treatment controls may become necessary for the treatment of contaminated storm water runoff where source controls are either inadequate and/or non-existent. Horner et. al. (1994) indicates the following regarding all types of treatment controls:

"*A factor to consider in the functioning of all mechanisms is time. The effectiveness of settling a solid particle is directly related to the time provided to complete sedimentation at the particle's characteristic settling velocity. Time is also a crucial variable to determine the degree that chemical and biological mechanisms operate...water residence time is the most basic variable to apply effective treatment practice technology*".

Table 6 (**page 38**) summarizes the principal mechanisms that capture, hold and transform the various types of urban storm water runoff, as well as the factors which promote their effectiveness. Each of the mechanisms shown within the table have been proven effective in reducing pollutants associated with storm water.

Another factor to consider in regards to treatment control is that of discharge. Discharge control refers to the capability of the treatment structure to pass, detain, and/or retain storm water runoff from large precipitation events. While most treatment controls adequately control runoff from small events, they are not effective for large events. For example, oil/water separators are generally designed to treat low volume runoff. Flows greater than that of the design event must be diverted away from the oil/water separator to prevent overtopping of the structure and spilling of the previously capture pollutants. Similar conditions may exist with the use of treatment controls.

Each of the mechanisms shown within the table have been proven effective in reducing pollutants from storm water effluent. The following sections summarize the available information and describe typical treatment controls which may be considered for implementation. Detailed information relating to the specifics of design and site applicability may be obtained from the references provided for each BMP.

Table 7
Summary of Pollutant Removal Mechanisms

MECHANISM	POLLUTANTS AFFECTED	REMOVAL EFFICIENCIES PROMOTED BY
Physical sedimentation	Solids, BOD, pathogens, particulate COD, phosphorous, nitrogen, metals, synthetic organics	Low turbulence
Filtration	Same as physical sedimentation	Fine, dense herbaceous plants; constructed filters
Soil incorporation	All	Medium-Fine texture
Chemical precipitation	Dissolved phosphorous, metals	High alkalinity
Adsorption	Dissolved phosphorous, metals, synthetic metals	High soil Al, Fe high soil organics (metals), circumneutral pH
Ion Exchange	Dissolved metals	High soil cation exchange capacity
Oxidation	COD, petroleum hydrocarbons and synthetic organics	Aerobic conditions
Photolysis	Same as oxidation	High light
Volatilization	Volatile petroleum hydrocarbons and synthetic organics	High temperature and air movement
Biological microbial decomposition	BOD, COD, petroleum hydrocarbons, synthetic organics	High plant surface area and soil organics
Plant uptake and metabolism	Phosphorous, nitrogen, metals	High plant activity and surface area
Natural die-off	Pathogens	Plant excretions
Nitrification	NH_3-N	Dissolved oxygen > 2 mg/L, low toxicants, temperature > 5.7 C, circumneutral pH
Denitrification	NO_3+NO_2-N	Anaerobic, low toxicants, temperature >15 C

Source: Table 8.5 Horner et. al. (1994)

Constructed Wetlands

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices TC3
Municipal Best Management Practices TC3

Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical annual).

Horner et. al. 1994.
Fundamentals of Urban Runoff Management - Technical and Institutional Issues

USEPA. 1993b
Urban Runoff Pollution Prevention and Control Planning

General

Constructed wetlands are artificial wetlands which are constructed on a previously dry site. A schematic of a wetland pond is as shown on Figure 3 (**page 42**). Although similar in nature to wet extended detention basins (as will be discussed in a later section of this chapter), constructed wetlands generally encompass larger surface areas, contain significant quantities of vegetation, and have a lower average water depth. When properly planned, constructed wetlands can provide additional recreational activities, increased wildlife habitat and be aesthetically pleasing.

Wetlands are generally capable of removing pollutants through the processes of sedimentation, filtration, adsorption, microbial decomposition, and vegetative uptake. With this broad capability, they are generally able to remove sediments, nutrients, oil and grease, bacteria, metals and the denitrification of water with moderate success. Because of it's affinity for sediments, wetlands are capable of intercepting lead with great success, and are fairly capable of removing ammonia, total phosphorous and zinc. A summary table of wetland pollutant removal efficiencies, as prepared by Horner et. al. (1994) is as shown on Table 7 (**page 40**). The values shown reflect removal efficiencies for a pond/marsh system having a design depth of 2-3 feet.

Studies of existing ponds have shown that the ratio of basin volume to runoff volume significantly affects the effectiveness of pollutant removal within the wetland pool, as shown on Figure III-5. A significant amount of detail regarding design of constructed wetlands can be found within the above list of references. The information presented below is a summary of the general criteria for their utilization.

- Proper selection of vegetation is critical. Selection should be based upon climate, soil types, length of the growing season, tolerance to pollutants and ability to uptake nutrients, aesthetic appearance, etc.
- Consideration should be taken to minimize the potential for large variations in water levels. Extreme fluctuations can destroy vegetative growth.
- Pond configuration is essential. The wetlands should be designed to incorporate a deeper area near the inlet where sediments can settle out. The inlet should be designed as wide as possible to facility spreading of flow.
- Sideslopes should be designed no steeper than 3:1 (horizontal to vertical), and are preferred at 12:1 (horizontal to vertical).

- The recommended length to width ratio should be 5:1. Ratios less this tend to lead to "short circuiting" of the inflow to the outlet structure. Short circuiting is not desirable within a wetland environment because it decreases the overall detention time of the water. Short circuiting can be mitigated by including bends, islands, peninsulas, etc., within the wetland which result in longer flow paths and increased detention times.
- Plans should be provided, at the time of design submittal, which indicate cleanout procedures, sediment removal, harvesting of vegetation, etc.
- A constructed wetland must have time to develop before it is put into full use. Premature use of a constructed wetland will be non-effective and may disturb vegetative growth.
- Other factors which must be incorporated into the design include creation of a forebay, maintenance access to the forebay for cleaning, outlet and drainage piping, emergency spillway designed for the 100-year storm event, and site buffers.

Table 8
Projected Long-Term Removal Rates for Constructed Wetlands

POLLUTANT	REMOVAL RATE (%)
Total Suspended Solids	75
Total Phosphorous	65
Total Nitrogen	40
BOD, COD, TOC	15
Lead	75
Zinc	50

Maintenance

Regular maintenance also consists of sediment removal and the removal of dead vegetation. The average annual cost for maintenance of wetlands is estimated to be approximately 3-5% of the base construction cost. If oil/water separators are used ahead of the wetlands, they must also be cleaned regularly to prevent overspill.

Cost

Constructed wetlands are generally cost prohibitive for small developments due to their volume/tributary area requirements. However, on a large scale or regional planning basis they are quite cost effective. As a general rule of thumb, Schueler (1987) notes that the most cost effective wetland is generally 30-60% more expensive that an extended detention basin of similar stormwater capacity. Mitigating factors which must be considered when evaluating the cost of wetlands include aesthetics, wildlife habitat, recreational opportunities, landscape value, etc. Using base information provided by Schueler (1897), and adjusting the coefficient for 1996 dollars, the estimated construction cost for a wetland is as follows:

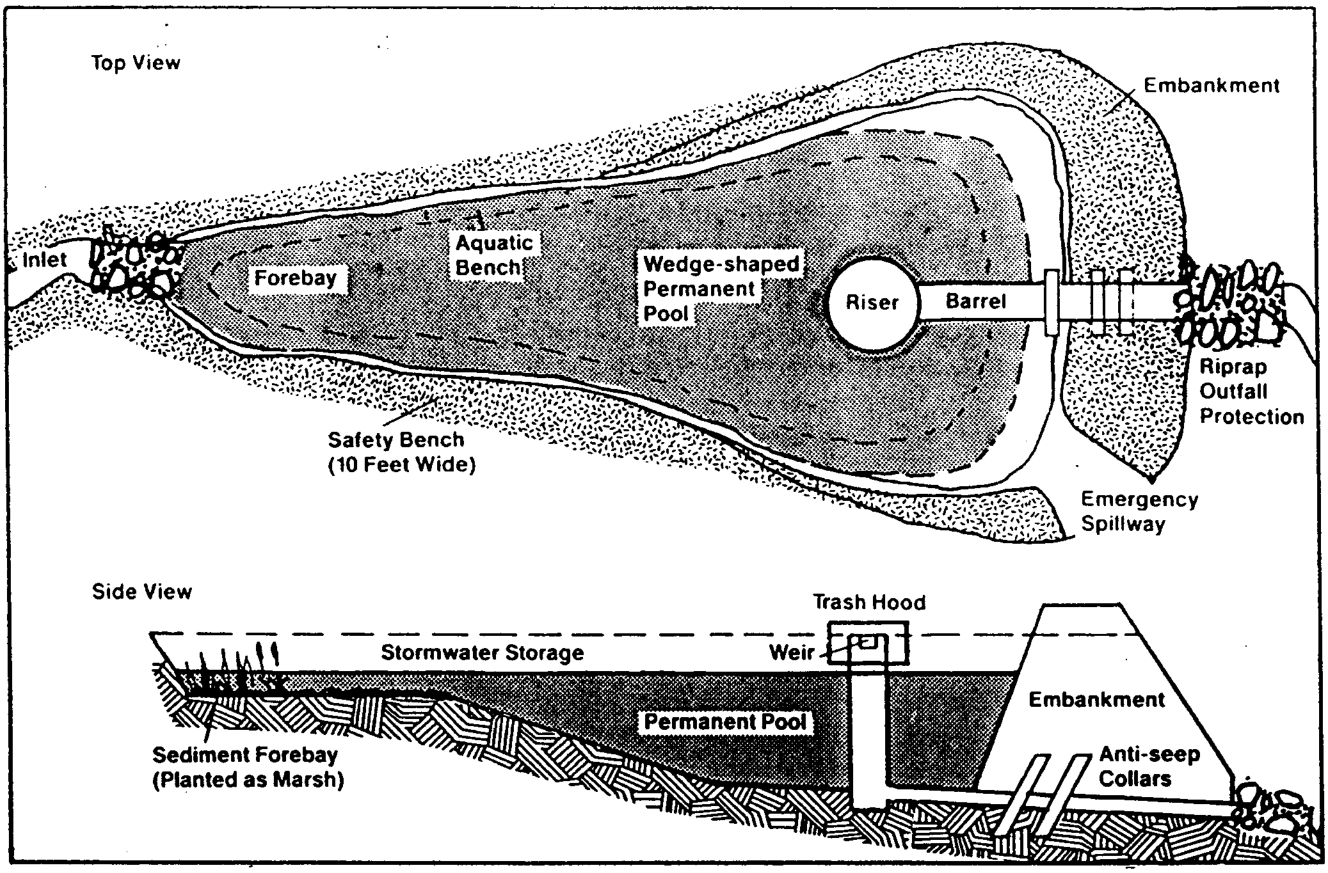
$$C = 9.4\ V_s^{0.75} \quad (\text{for } V_s < 100{,}000 \text{ cubic feet in volume})$$

$$C = 52.4\ V_s^{0.75} \quad (\text{for } V_s > 100{,}000 \text{ cubic feet in volume})$$

The above cost equations are based upon the estimated cost for construction of the wetland pond, and do not include the cost of land. The above costs should be increased by approximately 25% for engineering, permitting, construction management, etc.

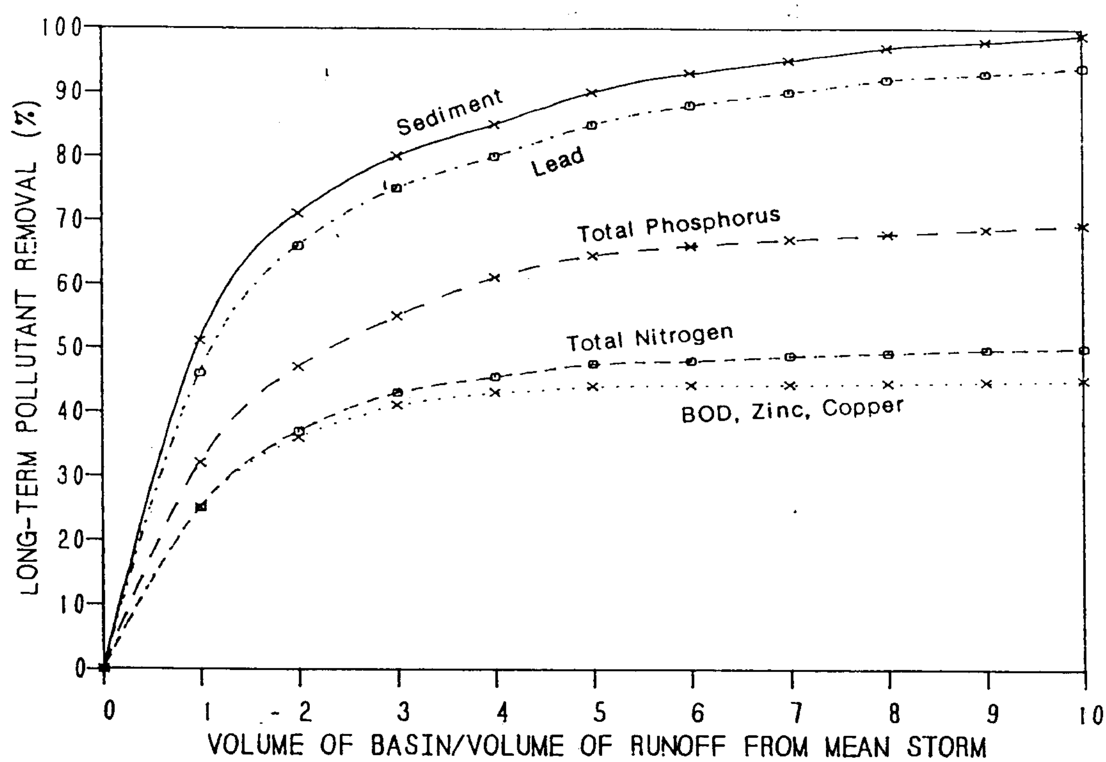
Limitations

- Large land requirements.
- Wetlands, once created, become subject to federal land restrictions which may preclude use of the land for future uses.
- Site conditions must be such that infiltration is minimized. Also, maintenance of soil and groundwater levels may be difficult to maintain. Soils must remain saturated during the entire growing season.
- A constant water supply is important for proper maintenance of the wetlands.



Source: Figure 4.1, Schueler (1987)

Figure 3 - Schematic of a Wetpond



NOTE: Average results from U.S. EPA (1986), and adapted to reflect modifications of Walker (1986).

Source: Figure 4.6, Schueler (1987)

Figure 4 - Estimated Removal of Selected Urban Pollutants as a Function of Permanent Pool Size

Infiltration

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices TC1
Municipal Best Management Practices TC1
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).
Horner et. al. 1994.
Fundamentals of Urban Runoff Management - Technical and Institutional Issues
Schueler, 1987.
Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs
USEPA. 1993b
Urban Runoff Pollution Prevention and Control Planning

General

The primary objective of infiltration structures is for the off-line capture of storm water for groundwater recharge. In many areas, these types of facilities are identified as retention structures. Primary outlet structures are not included within the design. Rather, it is the sole intent that all of the runoff infiltrate into the groundwater system. Efficiency at pollutant removal has shown that they are most effective when treating low intensity, high frequency storm events. As a result, the inlet structures to infiltration structures are designed with a weir and/or overflow device which diverts flow in excess of the design capacity back into the main storm water drainage.

Infiltration may occur through one of three main categories; *infiltration basins*, *infiltration trenches*, and *porous pavement*.

Infiltration basins, as shown on Figure 5 (**page 48**), are open impoundments which are designed for two principal purposes: infiltration of the storm water into the groundwater system and second, pollutant uptake by the root system and soils. In Figure 5 (**page 48**), the term "exfiltration storage" refers to that volume of water which exfiltrates from the basin and infiltrates into the ground water system. Although constructed by open pit excavation, they may also be constructed with the use of a dam for surface impoundment. Where vegetation cannot be sustained, the basins can be designed simply for infiltration purposes. Infiltration basins are most effective at removing bacteria, suspended solids, insoluble nutrients, oil and grease, and floating waste. They are less effective at removing dissolved nutrients, some toxic pollutants, and chlorides. Table 8 (**page 45**) summarizes the long term efficiency of infiltration basins at removing storm water pollutants.

Infiltration trenches, as shown on Figure 6 (**page 49**), are an alternate method which may be used for pollutant removal where insufficient land surface area is available for construction of an infiltration basin, or where additional infiltration capacity is desired beneath a biofilter. Infiltration trenches and sumps are below grade structures which utilize granular materials to enhance the infiltration process. Where infiltration trenches are installed, observation wells should be installed at an average spacing of 50 foot intervals along the length of the trench. Observation at these wells provides information relative to how quickly the trench dewaters and an indication of sediment buildup. As with all forms of infiltration basin, additional pretreatment is required for sediments, nutrients and other pollutants prior to direct infiltration. Table 9 (**this page**) illustrates the estimated long term pollutant removal rate for infiltration trenches

Table 9
Estimated Long-Term Pollutant Removal Rate for Infiltration Basins

POLLUTANT	PERCENT EFFICIENCY	
	0.5-IN RUNOFF/IMPERVIOUS ACRE	**RUNOFF FROM 1-INCH RAIN**
Total suspended solids	75	90
Total phosphorus	50-55	60-70
Total nitrogen	45-55	55-60
Metals	75-80	85-90
BOD	70	80
Bacteria	75	90

Source: Table 8.8 Horner et. al. (1994)

Table 10
Estimated Long-Term Pollutant Removal Rates for Infiltration Trenches

URBAN POLLUTANT	**REMOVAL RATE, PERCENT**	**LIMITING FACTOR**
Sediment	99	Should actually be trapped before reaching the trench.
Total Phosphorous	65-75	Leaching of remineralized organic phosphorous
Total Nitrogen	60-70	Leaching of soluble nitrate
Trace Metals	95-99	Behavior similar to sediments
BOD	90	Leaching of dissolved organic matter
Bacteria	98	Straining

(Source: Table 5.1. Schueler, 1987)

Porous pavement, the third main category of infiltration devices, has proven applicable in areas of the United States. However, their stability and effectiveness over time yields questions as to its appropriateness. As a result, porous pavement is not addressed further within this document. Additional information regarding the design and utilization of porous pavement can be located within the above listed references.

In general, infiltration structures are designed for the purpose of removing sediments from the storm water runoff. A significant amount of detail regarding design of infiltration structures can be found within the above list of references. The information presented below is a summary of the general criteria for utilization of infiltration basins.

- The infiltration rate should be designed at ½ the actual infiltration rate established during a soils investigation of the area.
- Infiltration basins should be designed to completely drain within 24-hours of the 6 month, 24 hour storm event to ensure that the necessary anaerobic conditions are maintained. If a settling basin precedes the infiltration basin, the combined drawdown time for both basins should be 24-hours.
- The ideal minimum time spacing between storm events is 3-days. Time periods less than 3 days may result in diminished soil pollutant removal capacity.
- Basin design should take into consideration maintenance. Side slopes should be designed to allow mowing of the vegetation, and access should also be provided to allow for cleaning, maintenance, etc.
- Selection of grasses will in part determine the amount of maintenance that will be required (i.e. number of mowings, fertilizer requirements, water requirements, etc.)
- Fertilizers should be used at a minimum. Over fertilization can result in leaching through the soil and increase the potential for groundwater contamination.
- During construction, special consideration should be made to minimize soil compaction.
- Infiltration trenches (and or infiltration sumps) are most effective when treating runoff from low intensity, frequent storm events. As a result, they are often installed off-line from the main storm water drainage system as shown in Figure III-10.

Cost

Using base information provided by Schueler (1987), and adjusting the coefficient for 1996 dollars, the estimated construction cost for a typical infiltration trench can be estimated using the following equation:

$$C_{trench} = 41.0\ V^{0.63}$$

Where C_{trench} is the estimated construction cost of an infiltration trench, and V is the storage volume of the void within the trench (40% of the excavated trench volume). This cost does not include the cost of purchasing the land, which will vary significantly depending upon location, or the cost of pretreatment such as oil/water separators, biofilters, etc. In areas of high inflow, infiltration trenches may have an life expectancy as short as 5-10 years, after which they become silted in and non-effective. Funds should therefore be allocated for replacement and/or cleanout at an annual rate of 10-15% the initial capital cost.

The estimated construction cost for a typical infiltration basin can be estimated using the following equation:

$$C_{basin} = 16.5\ V_s^{0.69}$$

This cost does not include the cost of purchasing the land, which will vary significantly depending upon location, or the cost of pretreatment such as oil/water separators, biofilters, etc. Annual maintenance costs are anticipated to be approximately 3-5% of the capital construction costs of the infiltration basin.

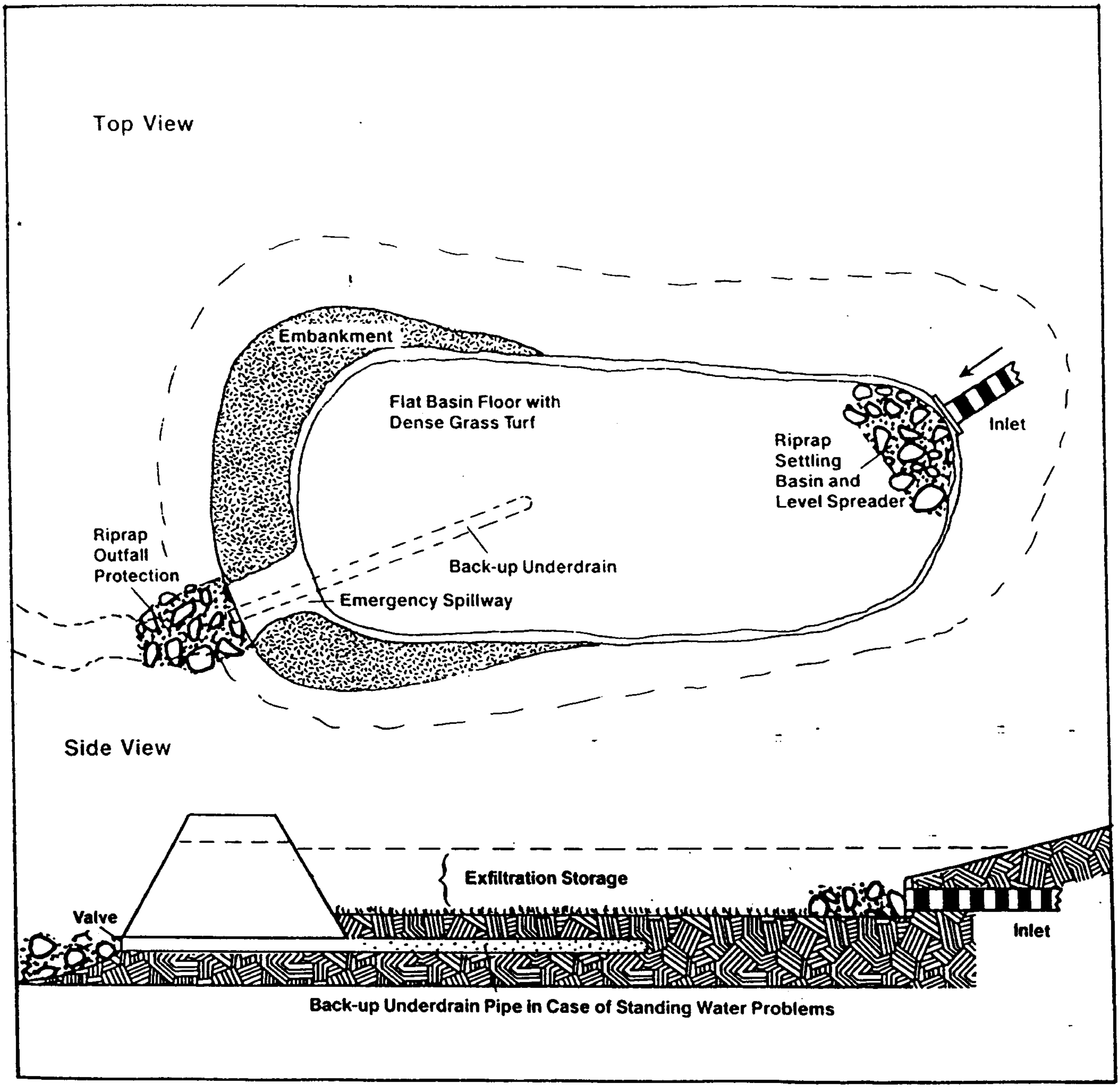
Maintenance

There are minimal ongoing maintenance costs associated with infiltration basins due to their closed design. However, as noted above, infiltration trenches have a typical life expectancy of 5-10 years, after which they must be reconstructed. Annual costs of 10-15% should therefore be allocated for reconstruction and/or replacement of the infiltration trench.

Infiltration basins require moderate to high levels of maintenance, which may consist of mowing, sediment removal, etc.

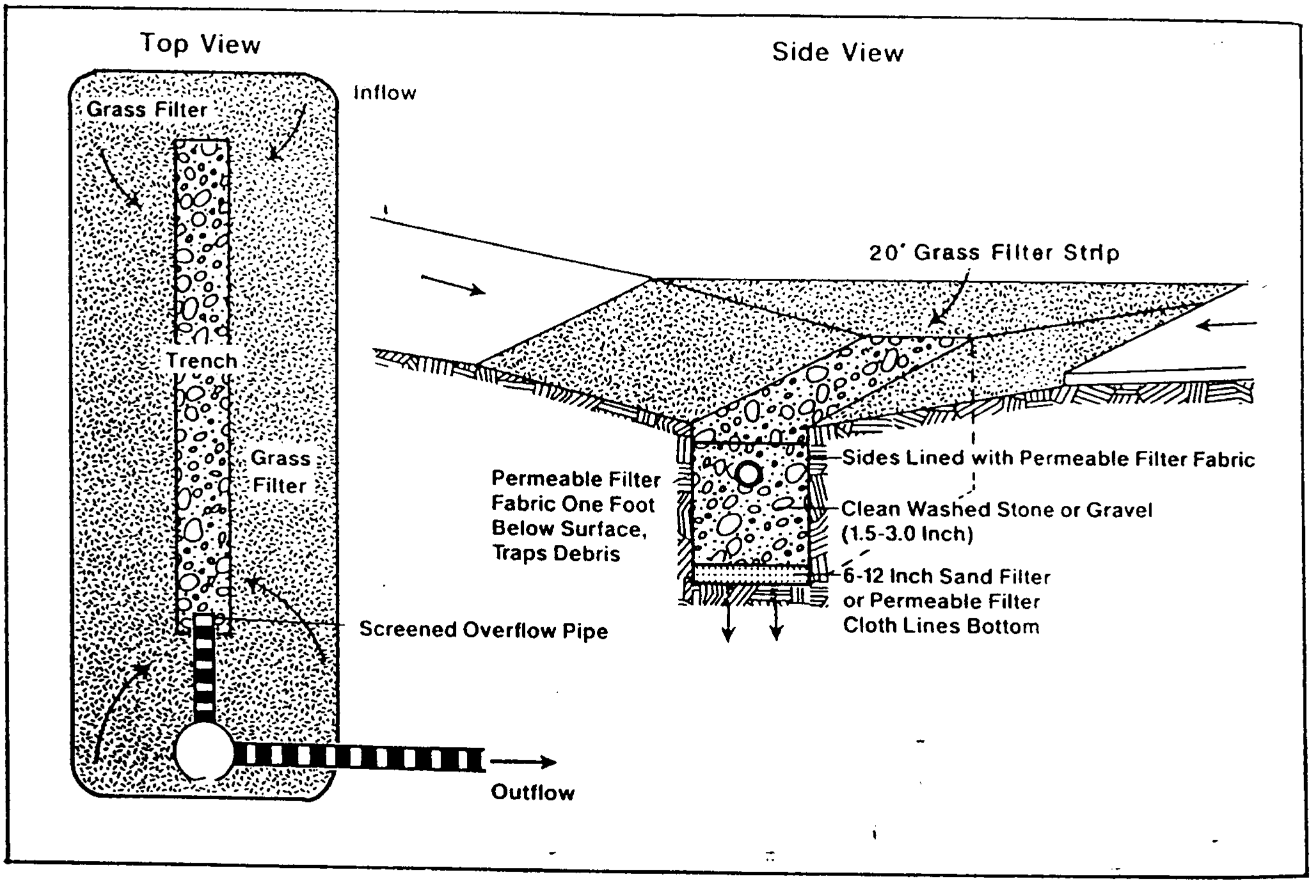
Limitations

- Infiltration basins are not appropriate for installation within "D" soils, as defined by the SCS soils group classification), or any soil with a clay content greater than 30%. "C" soils (silt loams and sandy clay loams) provide marginal infiltration rates, and soils with a combined silt/clay percentage greater than 40% by weight are susceptible to frost-heave and should also not be used where possible.
- Infiltration structures should not be used where the groundwater is within 2-4 feet of the bottom of the structure.
- As dissolved nutrients and metals are not entirely removed by infiltration, this type of BMP should not be used where the potential exists for re-emergence of the storm water as surface water, where used for drinking water purposes, or where there is a potential for ground water contamination.
- Prior to diversion into an infiltration basin, storm water inflow **must be treated** for sediment removal. Inadequate removal of sediments can lead to excessive sediment buildup within the infiltration basin and significantly decrease the permeability of the basin.



Source: Figure 6.1, Schueler (1987)

Figure 5 - Schematic of an Infiltration Basin



Source: Figure 5.2, Schueler (1987)

Figure 6 - Median Strip Trench Design

Biofilters

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices TC4
Municipal Best Management Practices TC4
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).
Horner et. al. 1994.
Fundamentals of Urban Runoff Management - Technical and Institutional Issues

General

Biofilters are a form of vegetated land treatment systems wherein storm water runoff is contained within the channel. Their principal benefit is that of removing sediments and some nutrients from the storm water runoff. They are often used as a pretreatment to infiltration. Although wetlands are often placed within this category the two principal types of biofilters are grassed **swales** and **filter strips**. Grassed swales are intended to replace conventional catch basin and drainage pipes in the conveyance of storm water. Filter strips are vegetative areas which are intended to enhance filtering and sedimentation prior to discharge into the receiving waters. Schematic drawings of a grassed swale and filtration strip are as shown on Figures 7 and 8 (**pages 52 and 53**), respectively.

The effectiveness of a biofilter is directly related to its ability to slow down the water, thereby increasing the potential for sedimentation and filtration. Biofilters have been proven to be effective tools for the removal of particulates and metals, that is to say metals that have bonded on the particles. They are not as effective for the removal of dissolved pollutants. Figure 9 (**page 54**) illustrates average pollutant removal capabilities of grass swales in the Seattle Washington area.

A significant amount of detail regarding design of biofilters can be found within the above listed references. The information presented below is a summary of the general criteria for utilization of biofilters.

- Water contact with the vegetation is essential for successful biofiltration of pollutants.
- The soils which underlie the biofilter should be loose, granular soils. Tilling of the upper layer of soil is recommended prior to seeding and/or sod placement to restore infiltration capabilities of the soil.
- Select vegetation on the basis of pollution control objectives, ability of the vegetation to survive the local climate, and the uptake capacity for nutrients. For general purposes, select fine, close-growing, water resistant vegetation.
- The design depth of flow within a grassed swale should not exceed one-third the grass height in infrequently mowed swales, or one half of the grass height in regularly mowed swales, up to a maximum of 3 inches. This is due to the fact that higher flow depths tend to flatten the grass, which increases flow velocity.
- The design depth of flow within vegetative strips should not exceed 0.5 inches.
- Channel slope should normally be between 2 and 4 percent. Slopes less than 2 percent can be used if sub-drains are provided to reduce ponding. Slopes greater than 4 percent may be used if check dams are constructed which will slow channel velocity.

- Swales will not be effective where flow velocities are greater than 1 fps.
- It is recommended that swales have a minimum length of 200 feet in order to provide optimal nutrient uptake. Where shorter lengths are required, the width should be adjusted to provide an equivalent water resident time. A minimum hydraulic residence time of 9-minutes is recommended.
- Prevent bare areas in vegetative growth by avoiding gravel, rocks, hardpan and heavy clays. Fertilizers are useful in stimulating growth. However, fertilizers should be used at their appropriate rates. Over fertilizing can result in leaching of nitrates and other nutrients into the groundwater system, negating the impact of the biofilter.
- Optimal design of vegetative strips requires sheet flow along the entire length of the paved area. Where this is not possible, a flow spreader should be installed at the head of the biofilter to spread flow evenly across the channel.
- Side slopes should be designed at a maximum of 3:1 (horizontal to vertical).
- For proper nutrient uptake, the vegetation must be mowed on a regular basis. Cuttings should not be left in place, rather should be removed as soon after mowing as possible.

Maintenance

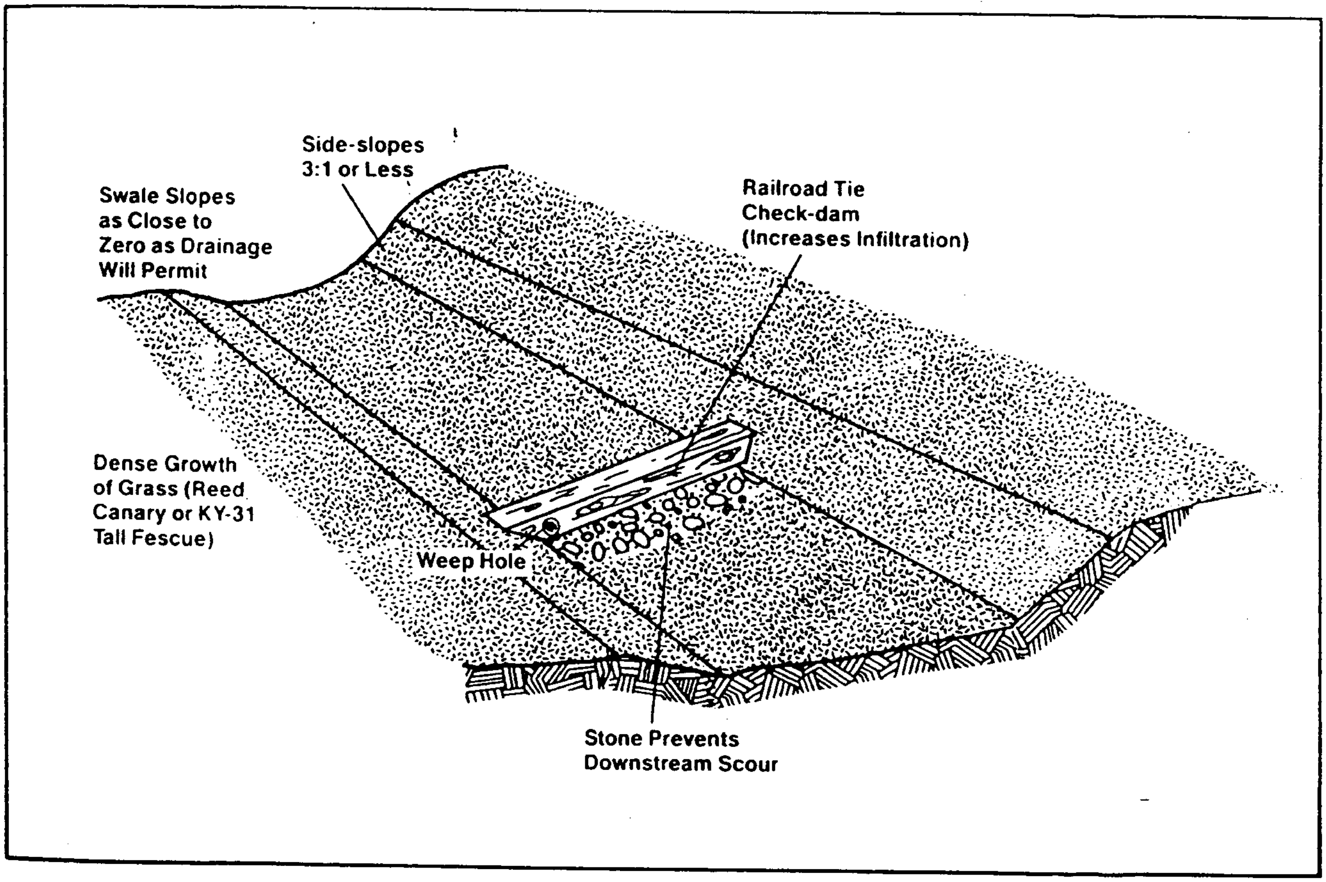
Biofilters require a moderate level of maintenance, primarily related to mowing, fertilizing (as required to promote and sustain growth), and removal of debris and sediments.

Cost

Presented in Table 10 (**page 55**), is a summary from Schueler (1987) which provides relative cost data for various forms of vegetative establishment. The cost values shown have been adjusted to 1996 dollars, and assume a 4% average annual inflation.

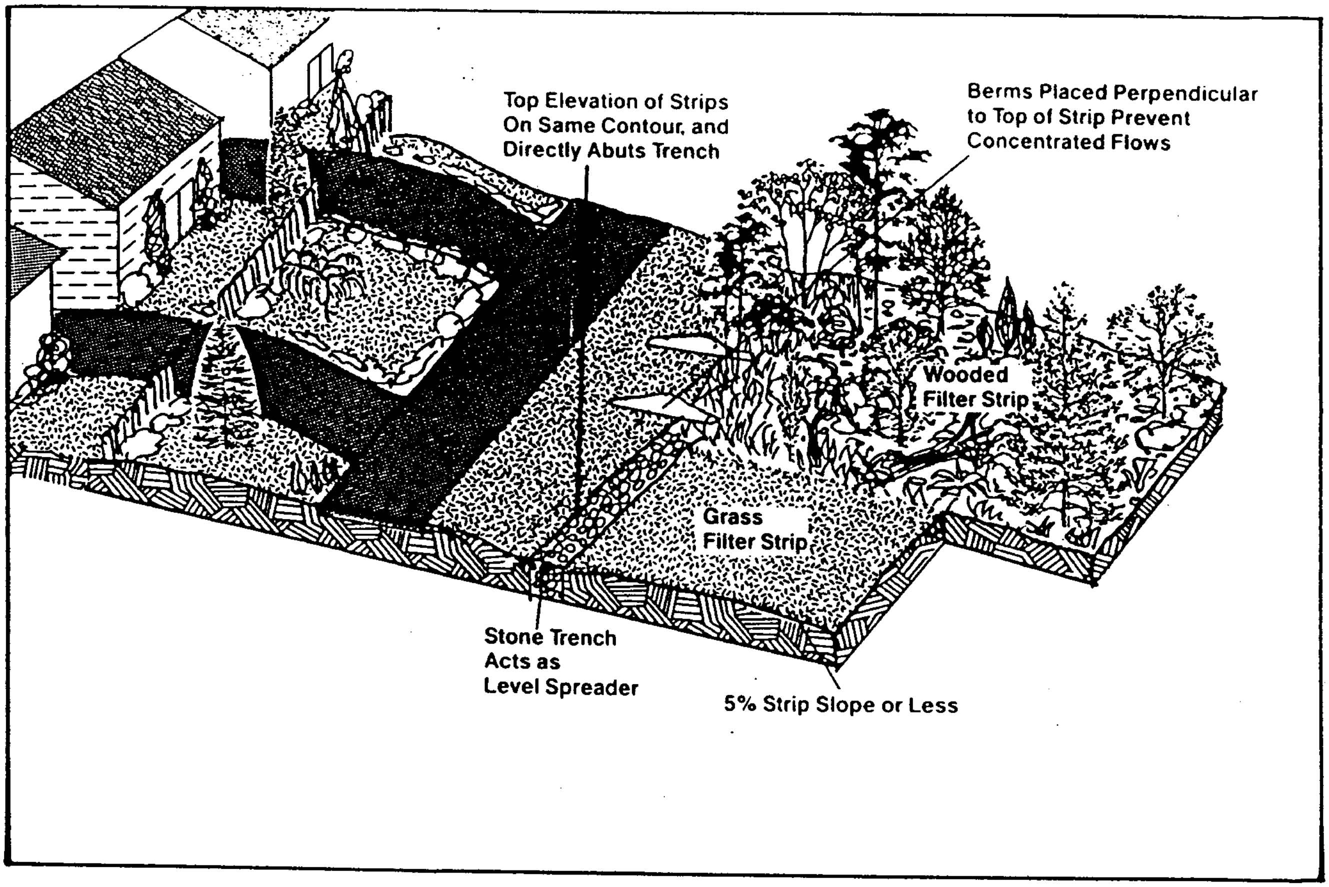
Limitations

- Topography. The success of biofiltration lies in its ability to slow down the water. The use of biofilters on steep slopes is not effective.
- Large areas may be required dependent upon the tributary area.
- Biofilters are designed for the removal of sediments, with marginal benefit at removing other contaminants.
- Vegetative growth is imperative. Therefore, gravelly soils, coarse sandy soils, and heavy clay soils will generally not support good vegetative growth.
- Biofilters should not be utilized where the groundwater is within 2 feet of the bottom of the filter.



Source: Figure 9.2, Schueler (1987)

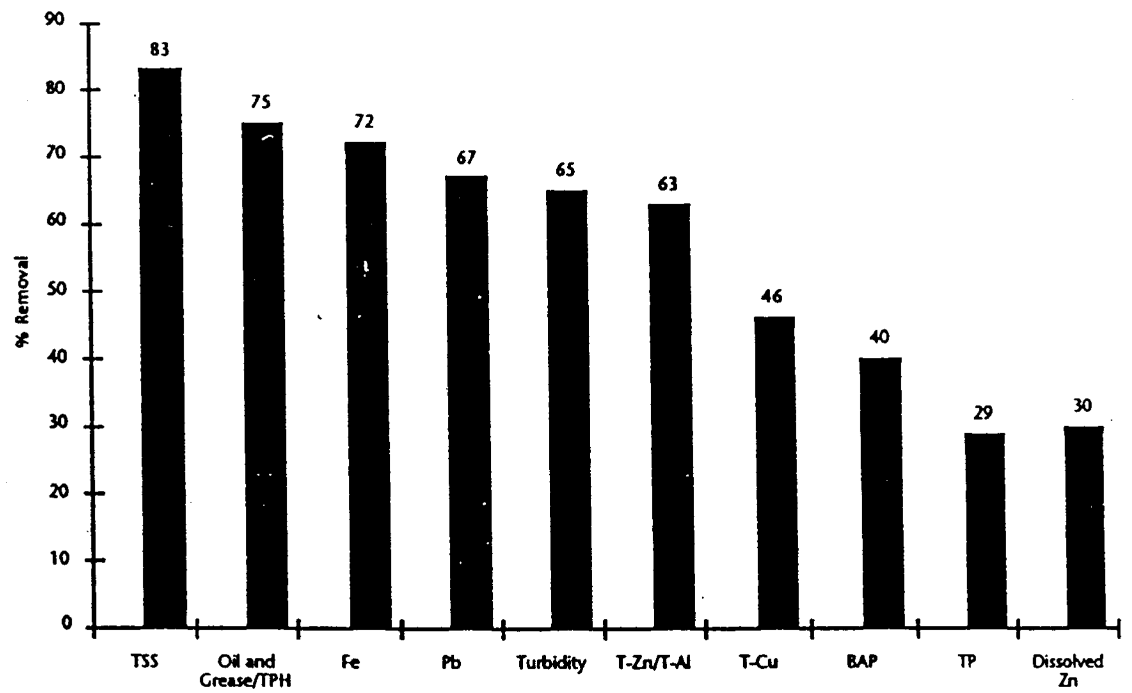
Figure 7 - Schematic of a Grassed Swale



Source: Figure 9.3, Schueler (1987)

Figure 8 - Schematic of a Filter Strip

Figure 8.5—Average pollutant removal over six storms in a grass swale with an average hydraulic residence time of nine minutes.



TPH = total petroleum hydrocarbons
T = total
BAP = biologically available phosphorus

Source: Municipality of Metro. Seattle, 1992.

Source: Figure 8.5, Horner et. al., (1994)

Figure 9 - Average Pollutant Removal Capabilities of Grassed Swales

Table 11
Average Cost for Vegetative Establishment

ESTABLISHED METHOD	AVERAGE COST PER ACRE			NOTES
	0-2 ac	2-5 ac	5+ ac	
Hydroseeding	$ 3,000	$ 2,700	$ 2,200	Permanent, guaranteed establishment, include seed bed preparation, mulch, anchoring, fertilizer, one post germination watering
Conventional Seeding	$ 2,700	$ 2,500	$ 2,200	Permanent, guaranteed establishment, include seed bed preparation, mulch, anchoring, fertilizer, one post germination watering
	$ 13,000	-	-	For highly erodible areas that need a blanket or net during germination
Sodding	$ 16,800			For Ky-31 Tall Fescue, Field Sod less costly; Bluegrass more costly
SWALES: Cost includes excavation and shaping, plus:				
For a 15-foot wide, 3:1 sideslope swale	$ 7.00/linear foot			seeding/straw mulch
	$ 12.75/linear foot			seeding/net anchoring
	$ 12.00/linear foot			sodding/stapling

Source: Table 9.1, Schueler (1987)

Extended Detention Basins (Wet/Dry)

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices TC3, TC5
Municipal Best Management Practices TC3, TC5
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).
Horner et. al. 1994.
Fundamentals of Urban Runoff Management - Technical and Institutional Issues
Schueler, 1987.
Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs
USEPA. 1993b
Urban Runoff Pollution Prevention and Control Planning

General

Detention basins are designed primarily for the purpose of providing storage from runoff and the control of downstream flow rates. Detention basins can also be used however, for pollutant treatment. In general, detention basins are classified as to whether they are *wet* or *dry*. The difference between these two are as the names suggest.

Dry extended detention basins, as shown on Figure 10 (**page 58**), are effective at removing suspended solids, and moderately effective at removing nutrients and other metals which have bonded with sediments. Lead is the only metal which is removed at a fairly high level due to its affinity towards sediments. They are not effective in the removal of dissolved pollutants.

Wet extended detention basins are constructed such that a designated volume of water is maintained at all times. Wet extended detention basins are more effective than dry basins due to their additional nutrient treatment capabilities, which can be further enhanced by establishing a shallow marsh within the permanent pond volume. Maintenance of this water environment is required for the effective removal of nutrients through plant root and soil uptake. Although the design water depth varies by location, a general rule of thumb is that 30-50% of the pond area have a depth of 6-inches or less.

A significant amount of detail regarding design of extended basins can be found within the above list of references. The information presented below is a summary of the general criteria for utilization of extended basins.

- Wet extended detention basins require larger areal extent than dry basins due to their need for shallow marsh areas. Dry extended detention basins require the smallest surface area.
- Wet extended detention basins should **not** be designed to allow for infiltration. The interior of the pond should be lined if infiltration is anticipated.
- The maximum depth of water within the permanent pool (wet ponds) should not exceed 6-feet. Water depths greater than 6-feet are subject to the development of anaerobic conditions. The development of anaerobic conditions is adverse in that pollutants which have been bound to sediments may return to a soluble state and dissolve into the water itself.

- The effectiveness of extended detention basins at pollutant removal is directly linked with the available detention time, as shown on Figure 11 (page 59).
- Detention basins are typically complimented by the use of upstream structures for the removal of coarse sediments, and biofilters at the outlet to supplement nutrient removal.

Maintenance

Maintenance of extended detention ponds is an ongoing process, and consists of mowing, debris and litter removal and periodic nuisance and pest control.

Cost

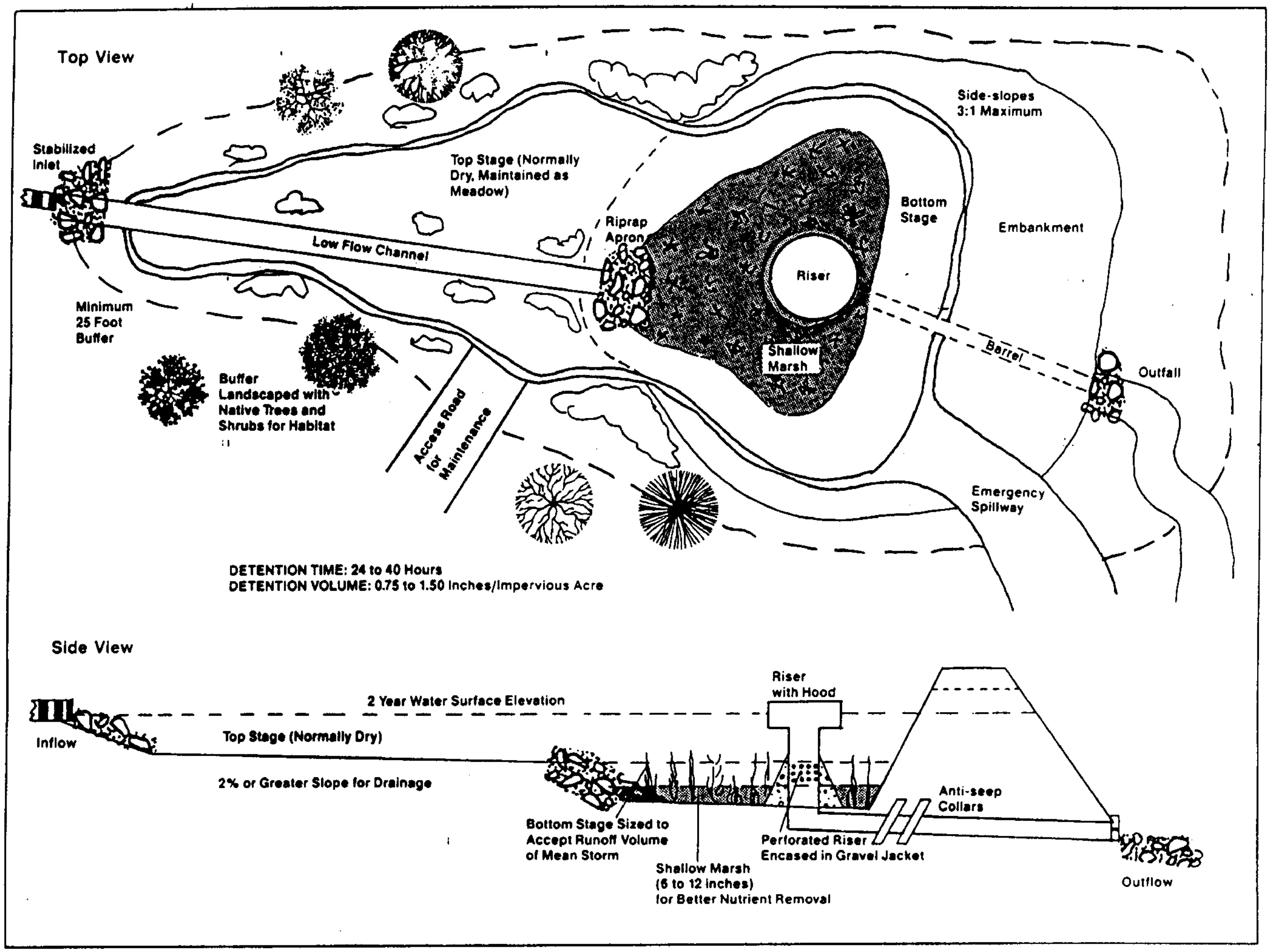
Extended detention ponds are less costly to construct for small watersheds that are wetlands. Using base information provided by Schueler (1987), and adjusting the coefficient for 1996 dollars, the estimated construction cost for a typical dry extended detention basin, as follows:

$$C = 16.5\ V_s^{0.69}$$

Where C is the estimated construction cost in dollars and V_s is the volume of pond storage in cubic feet. This cost does not include the cost of purchasing the land, which will vary significantly depending upon location. In addition to the above cost, it is recommended that an additional 25% be budgeted for engineering design, permitting, and construction management. For wet ponds, an additional $5,000 should also be budgeted for additional excavation and vegetative establishment.

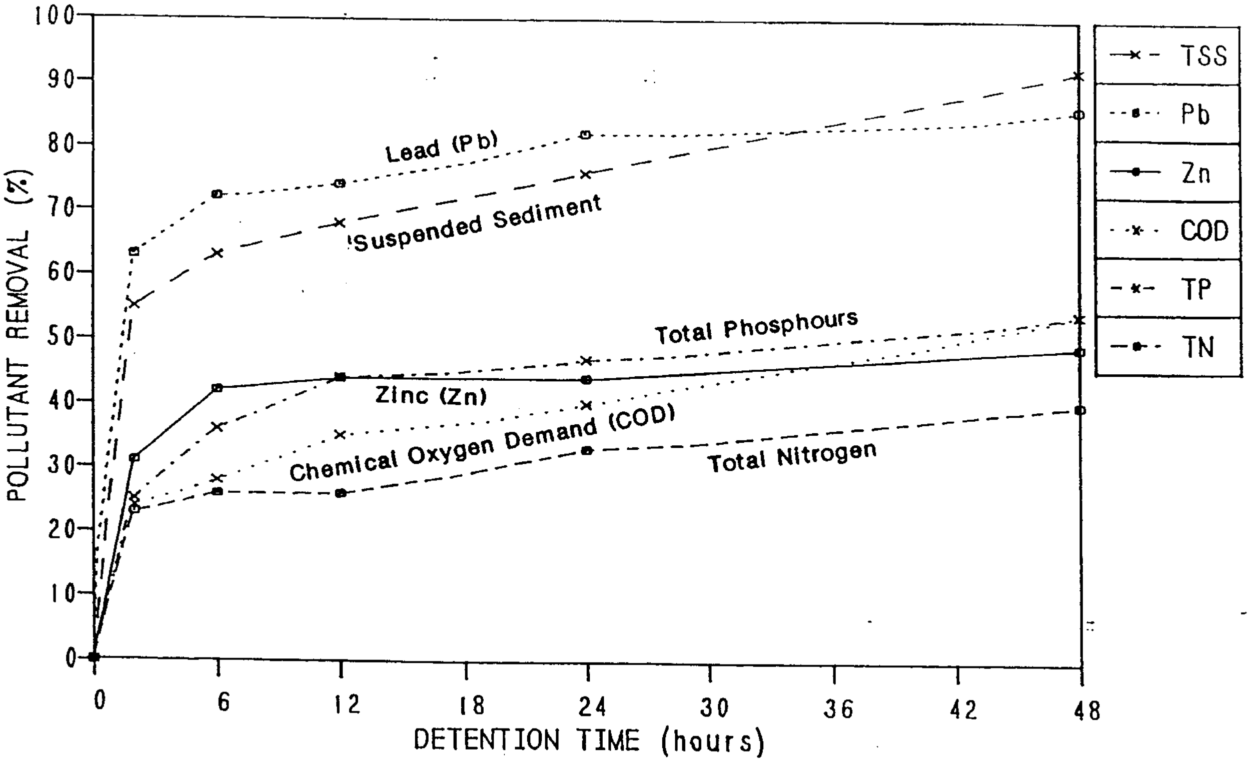
Limitations

- Require large land surface areas.
- Are limited to relatively flat topographic settings, and are not practical where shallo w bedrock is present.
- Odor, debris, weeds can be seen as public nuisances.
- Creation of permanent pools of water can provide additional habitat for insects. Although insect predators will be drawn to the area, and help balance levels, additional controls may be required. The use of pesticides should be limited to prevent degradation of the water quality.



Source: Figure 3.10, Schueler (1987)

Figure 10 - Schematic of Extended Detention



NOTE: Based on OWML (1983) settling column data. Average values for seven tests. Removal equivalent to 4 feet of settling.

Source: Figure 3.6, Schueler (1987)

Figure 11 - Removal Rate vs. Detention Time for Selected Pollutants

Media Filtration

Reference

County of Alameda Public Works Department, 1993.
Industrial/Commercial Best Management Practices TC6
Municipal Best Management Practices TC6
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).

General

Media filtration basins are defined as either open impoundments or buried structures which filter storm water runoff prior to discharge into an underdrain system. They are often used as pretreatment for large watersheds and other BMPs. In many instances, the filtering media used consists of sand, but may also consist of other types of filter mediums such as leaf compost filters, fiberglass, activated carbon, etc. An example of an off-line media filtration system is found on Figure 12 (page 62).

While effective at removing some pollutants (suspended solids and metals that may bind with sediments), sand filtration is not highly effective at removing nutrients, nor is it to be used in areas of heavy sedimentation. A summary of the estimated efficiency of media filtration for specified pollutants is as shown in Table 11 (**page 61**).

In an urban setting, media filtration basins are generally pl aced off-line from the primary drainage system and used to treat runoff from high frequency storms. The information presented below is a summary of the general criteria for utilization of infiltration basins.

- Sand filtration basins are generally placed off-line from the primary drainage system and are intended to treat only the high frequency storm events. Storm water is allowed to enter the filtration basin up to the design capacity. Flows in excess of the design are diverted back to the primary drainage system.
- Schueler (1984) recommends that infiltration basins be designed to serve 2 to 15 acres, and that infiltration trenches serve a maximum tributary area of 5 acres.
- Pretreatment is required for infiltration basins for the removal of sediment. Horner et. al. (1994) recommends an arbitrary removal criterion of 80%.
- The base of the infiltration basin/trench should be a minimum of 3-feet above the historic high water table
- For infiltration basins, the basin should be planted with native, drought tolerant grass. Side banks must be stabilized to prevent erosion into the device.
- Facilities should not be constructed in fill material or on a slopes greater than 15 percent.
- The maximum drawdown time shall be 24 hours or less.
- For infiltration trenches, the final sand depth should be 18-inches following consolidation.
- Flow onto the media filter should be spread uniformly across the bed using flow spreaders or multiple orifice openings.

Maintenance

Maintenance requirements include the removal of silt accumulation on top of the filter media, trash and debris on an as needed basis. Heavy sedimentation and dispersal of fines throughout the sand media may require replacement of the sand.

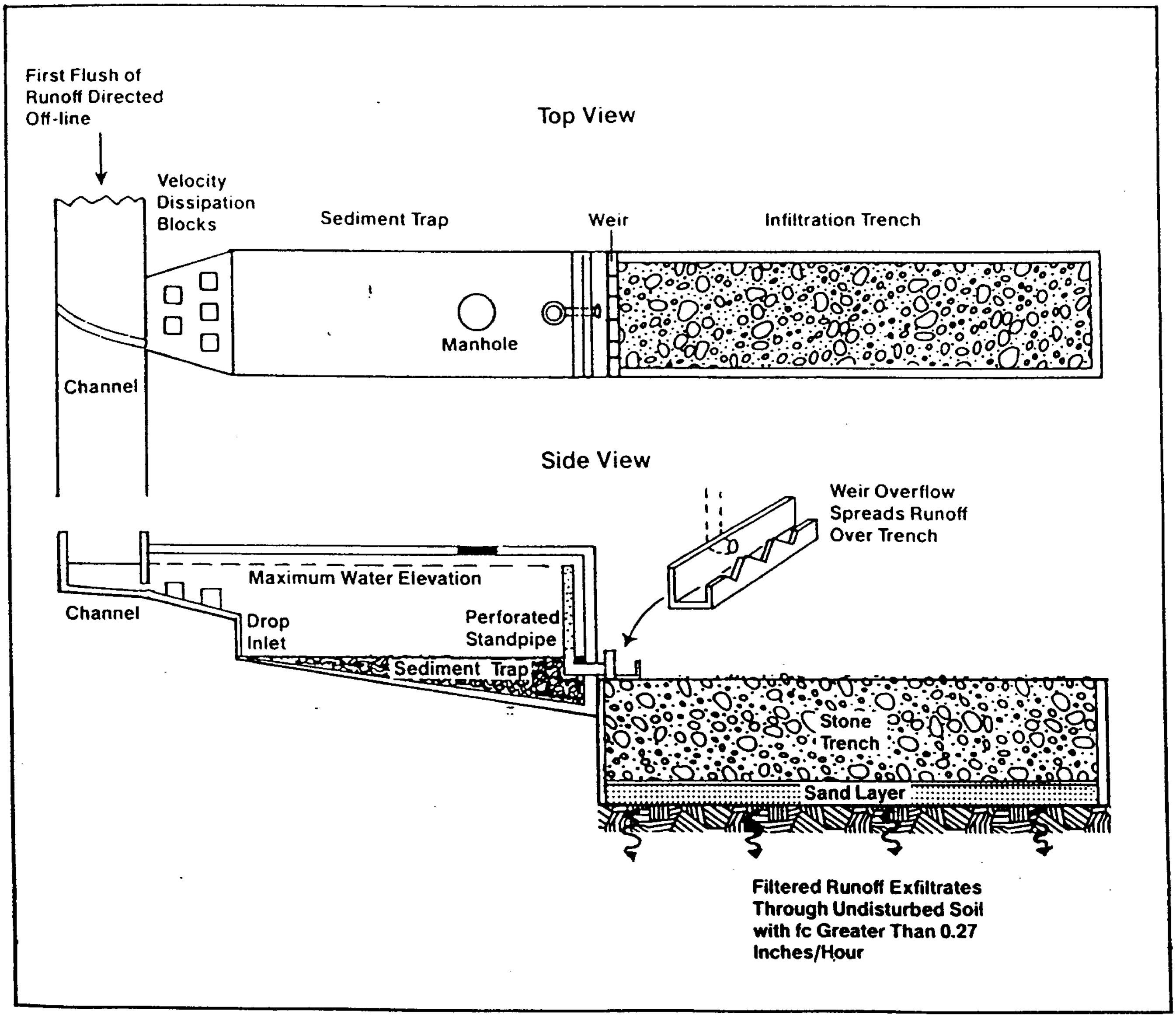
Limitations

- Filtration basins may require larg e land areas.
- Should not be used where the groundwater system is within 2-4 feet of the bottom of the structure.
- Media filters require pretreatment such as a presettling basin or biofilters.
- The maximum practical tributary area for sand filtration is 5 acres.

Table 12
Estimated Long-Term Pollutant Removal Rates for Media Filtration

POLLUTANT	PERCENT EFFICIENCY (%)		
	SAND FILTRATION	LEAF COMPOST FILTRATION	FIBERGLASS / CARBON ACTIVATED FILTRATION
Total Suspended solids	75 to 87	95	90
Total phosphorus	19 to 61	41	np
Total nitrogen	31 to 44	56	np
Ammonia-nitrogen	43 to 77	42	np
Lead	71 to 88	np	87
Zinc	49 to 82	88	77
Copper	33 to 60	67	86
COD	45 to 68	np	np
Fecal coliform	36 to 37	np	np
Total petroleum hydrocarbons	np	87	np

Source: Horner et. al. (1994)
np not published



Source: Figure 5.9, Schueler (1987)

Figure 12 - Off-Line Trench System Design

Oil/Water Separators (Water Quality Inlets)

Reference

County of Alameda Public Works Department, 1993.
*Industrial/Commercial Best Management Practices.*TC7
Municipal Best Management Practices. TC7
Washington State Department of Ecology. 1992.
Stormwater Management Manual for the Puget Sound Basin - (The Technical Manual).
Horner et. al. 1994.
Fundamentals of Urban Runoff Management - Technical and Institutional Issues
Schueler, 1987.
Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs
USEPA. 1993b
Urban Runoff Pollution Prevention and Control Planning

General

Oil/Water separators, also known as water quality inlets, are designed to remove sediment and petroleum based products from impervious surfaces before the runoff is conveyed into the storm water system or into an infiltration basin or trench. A schematic of a traditional oil/water separator is as shown on Figure13 (**page 65**). This type of oil/water separator has limited application to direct line storm water treatment. This is due in part to the fact that it is generally not designed for highly variable flow rates, turbulence, low oil concentration, or for high suspended solids concentrations. They are not highly effective at removing settleable pollutants due to their relatively short residence time. An alternative type of oil/water separators is as shown on Figure 14 (**page 66**). This particular separator is a Storm *ceptor*, as manufactured by Carder Concrete Products (1-303-791-1600). The advantage of this type oil/water separator design is that high flows are bypassed across the top of the separator, thereby reducing the potential for resuspension of trapped pollutants or scouring.

They are most effective where utilized primarily for spill control and spill mitigation. Examples of such being gas stations, maintenance and repair shops, vehicle storage yards, areas of high vehicle traffic, etc. Oil/Water separators are often sold as complete packages for installation at specific locations based upon predetermined quality parameters. The information presented below is a summary of the general criteria for utilization of oil/water separators.

- Oil/Water separators should be located off-line from the primary storm water conveyance system.
- The tributary drainage area should be an impervious surface (concrete is preferred), and the catchment area confined as much as practically possible. Surfaces which are not likely to contain oil based products should be diverted around the separator in order to reduce overall treatment costs.
- Runoff should be diverted away from the separator as failure to do so will increase the required size of the treatment.
- There are three basic types of separators, as follows:

1. **"T" Outlet -** This separator is simply an underground vault or manhole with an oil skimmer which restricts the entry of surface oils from discharge. "T" outlets are not capable of removing dispersed oil.
2. **API Separator -** The API separator is capable of removing dispersed oil, and is constructed as a long vault or basin with baffles which are designed to improve the hydraulic conditions for treatment. API separators are usually sized to remove oil droplets 150 micron in size and larger.
3. **CPS Separator -** The CPS separator consists of a series of fiberglass or polypropylene plates which are closely spaced together. The CPS separator is reported to be capable of equivalent removal characteristics of the API separator, with 1/5 to 1/2 the space requirement. CPS separators are usually sized to remove oil droplets 60 microns in size and larger.

- Oil/Water separators should precede all other treatment BMPs.
- Access covers must be provided to allow for maintenance, observation, and sampling.
- Waste oil and residuals must be disposed of in accordance with all applicable laws and regulations.

Cost

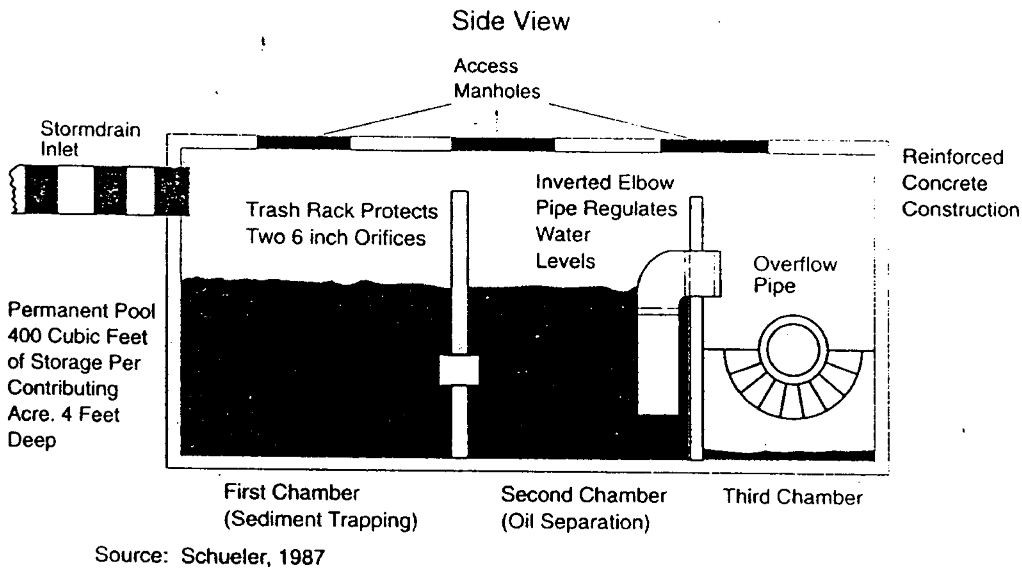
The cost of oil/water separators vary significantly with the size of the structure. Information provided by Schueler (1987) indicates the average cost of this type BMP to range between $8,000 and $23,000.

Maintenance

These BMPs can be moderately expensive. Oil/Water separators must be cleaned frequently to remove any captured oils from discharging into the storm water system, and the water level within the structure must be maintained to prevent oil transport through the outlet works.

Limitations

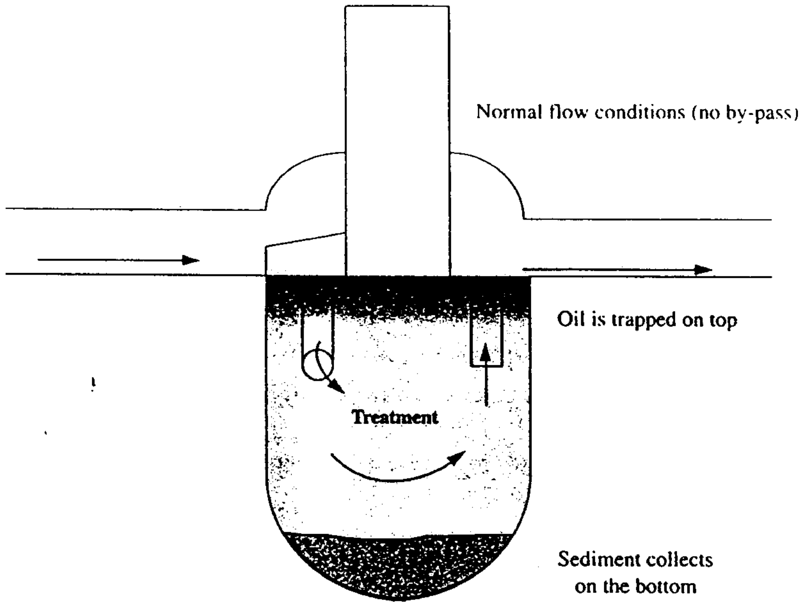
- There are few physical site limitations for use of oil/water separators and water quality inlets.
- Oil/Water separators have limited application to storm water treatment due to their inability to handle highly variable flow rates, turbulence, low oil concentration, or high suspended solids concentrations.
- Tributary areas should generally be less than 2 acres.



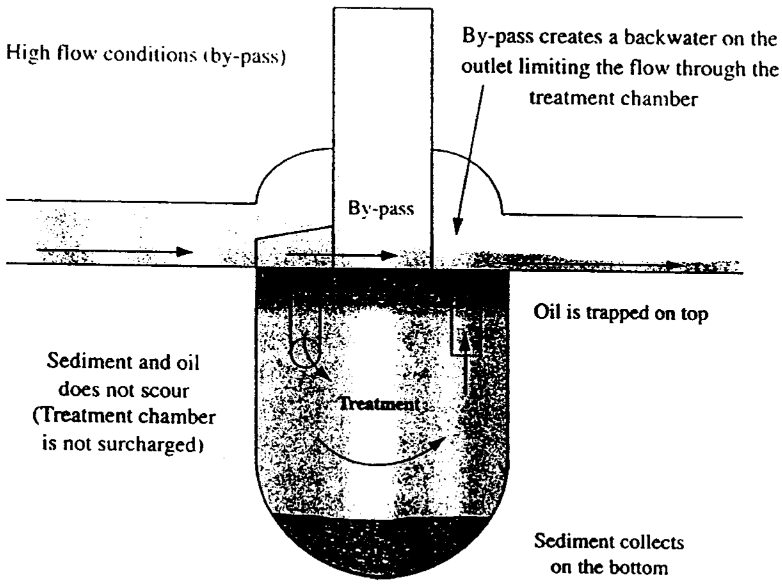
Source: Stormceptor Study Manual (1995)

Figure 13 - Schematic of an "API" type Oil/Water Separator

Stormceptor® Operation During Average Flow Conditions



Stormceptor® Operation During High Flow Conditions



Source: Stormceptor Study Manual (1995)

Figure 14 - Schematic of a "T" type Oil/Water Separator

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