SECTION IV

NONPOINT SOURCE POLLUTION CONTROL MEASURES - FACILITIES AND PRACTICES

SUMMARY OF SECTION IV

- Reviews types of NPS pollution problems and related control measures
- Describes nine groups of control measures
- Summarizes the effectiveness of various control measures in table form
- Presents questionnaire results concerning the effectiveness of various control measures
- Identifies additional sources of information
- Provides descriptions of over 40 individual control measures

INTRODUCTION

This section summarizes nonpoint source (NPS) pollution control measures that can be applied to various sources and activities within a watershed. It includes both facilities (for example, sedimentation ponds) and practices (for example, riparian protection). Some of the measures, such as pond/marsh facilities or erosion control, can be used to reduce the pollutant loads from several types of nonpoint sources. Others are specific to one type of source: for example, trapped catch basins in urban development or skyline logging for forest harvest activities.

The effectiveness of these control measures varies considerably, depending on the pollutants of concern; the source characteristics; the water bodies of interest; the watershed hydrology; and other watershed characteristics, such as soils, slopes, geology, type of cover, and the nature and extent of development. Effectiveness also depends on the planning and design criteria used. Many measures fail to meet expectations simply because they were not designed or applied correctly. This section discusses how and when the various control measures should be applied.

In keeping with the overview nature of the guidebook, **the descriptions are basic and do not present design/planning criteria**. Other sources, such as those listed later in this section or in the References section, present design criteria.

TYPES OF NPS POLLUTION PROBLEMS AND RELATED CONTROL MEASURES

Most NPS pollution results from disturbances, alterations, and uses of the land.

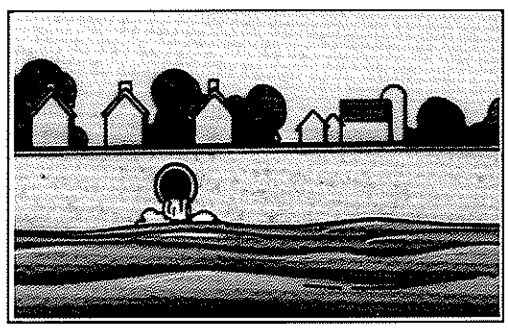
Disturbances include soil exposure that causes erosion and sedimentation in streams, lakes, or estuaries.

An example of an **alteration** is the replacement of natural vegetation with an asphalt parking lot. This increases runoff velocities and downstream channel erosion, and increases the load of pollutants (such as oil and particulates) discharged into a water body.

All types of **land uses** can create NPS pollution problems.

For the presentation of control measures in this section, NPS pollution problems are categorized into five basic types: residential, commercial, industrial, agricultural, and forest harvest.

RESIDENTIAL



Residential NPS pollution problems involve typical urban neighborhoods containing single-family or multifamily dwelling units. The problems originate from soil that has been eroded from lawns and gardens, or from impervious surfaces that increase water velocities and volumes and cause stream channel erosion. Various types of particulates on residential impervious surfaces (for example, "street dirt") can also be washed into streams and lakes, causing water quality problems involving sedimentation, metals, and various urban chemicals. Home-use chemicals such as fertilizers, herbicides/pesticides, paints, and solvents may also be transported into receiving waters. The most effective approaches to NPS control for developing areas are different from those for developed areas.

The most effective control measures involve:

- Public education
- Regional NPS control facilities, such as wetlands and vegetated swales (for developed areas)

- Various kinds of sediment traps in urban stormwater systems (for developed areas and new development)
- Landscape design and erosion control (for new development)
- Infiltration facilities
- Less use of chemicals
- Recycling and the proper disposal of chemicals
- Maintenance of on-site septic systems

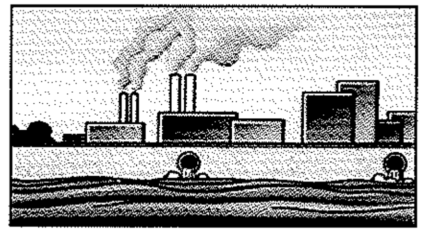
COMMERCIAL

Commercial NPS pollution problems originate in the relatively large areas of impervious surfaces associated with most commercial developments, such as office complexes, shopping centers, marinas, or downtown areas. The NPS mechanisms involved are primarily increased runoff velocities that cause channel erosion; the entrainment and transport of particulates from impervious surfaces; and spills or leaks of various chemicals, such as oil from cars or solvents from loading docks. As with residential development, the most effective NPS pollution controls vary from one area to another, depending in particular on the degree of current development.

The most effective control measures are:

- Hydrological site containment concepts included in the design of new commercial developments
- Landscaping measures to provide pollutant removal, such as ponds or vegetated swales
- Site manager training/education
- Spill response procedures for certain high risk sites
- Proper disposal of chemicals such as cleaners and print shop inks

INDUSTRIAL



Industrial developments that can cause NPS pollution problems include most, if not all, types of industrial activity. Examples in Oregon include recreational vehicle manufacturing, pulp and paper mills, plating factories, food processors, metal foundries and fabricators, shipyards, and paint or chemical manufacturers. To be consistent with the National Pollutant Discharge Elimination System (NPDES) permits for industrial stormwater discharges, land development of any type is defined as an industrial activity. The NPS mechanisms involved from industrial developments are primarily the entrainment and transport of industrial chemicals that have leaked or spilled on the site. Soil erosion is also a factor.

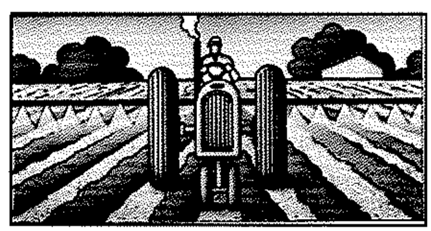
The most effective control measures for industrial plants are:

- Containment of site runoff from the site
- Plant employee training
- Spill response procedures

The best control measures for construction are:

- Erosion control
- Sediment traps (e.g., ponds)

AGRICULTURAL



For the purposes of this guidebook, agricultural activities include all types of row crops, orchards, nurseries, forage crops, feedlots, and grazing. Most agricultural NPS pollution problems originate either from erosion or the migration of agricultural chemicals into the receiving waters.

The most effective control measures are:

- Revised management practices for livestock, tillage, and bulk materials
- Riparian area protection
- Operator education

FOREST HARVEST

Forest harvest activities include access roads, skid trails, chemical applications, the yarding of logs, residue management, and cutting. The primary NPS pollution problems are soil erosion and chemical leaks or spills.

The most effective control measures are:

- Road and skid trail limits (density and exposed area) and design standards
- Logging/yarding criteria
- Erosion controls
- Operator education
- Chemical application controls
- Chemical containment

OTHER NPS POLLUTION PROBLEMS

Mining, marinas, and onsite wastewater facilities can also cause NPS pollution. Mining is not addressed in this section because the activities are usually concentrated enough to be regulated in a manner similar to point sources. Mining control measures are well defined and built into DEQ's regulatory process. NPS pollution activities at marinas and port areas generally fall within the industrial or commercial categories. On-site systems such as septic tanks discharge nitrate into the groundwater, and potentially into surface water, even when they are functioning well. Bacteria can be a problem when they malfunction. Because onsite wastewater facilities are currently regulated by local and state governments, additional control measure information in this guidebook is considered unnecessary. Construction and stream/lake/estuary alteration can occur in any of the five basic NPS pollution problem categories addressed in this section.

OVERVIEW OF CONTROL MEASURES

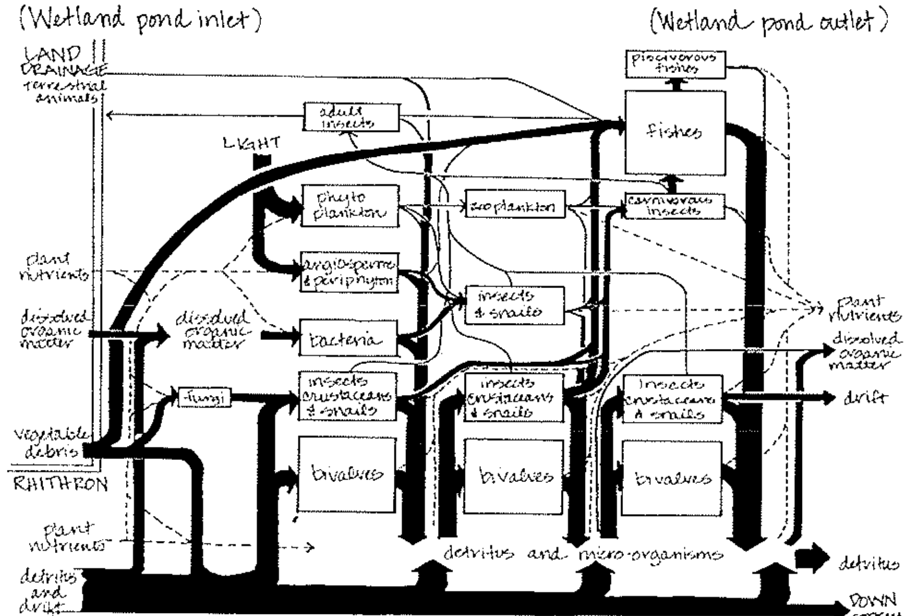
Control measures are presented under the nine groups described below. Some involve **facilities**, such as stormwater wetlands that reduce pollutants in surface water runoff. Others involve management **practices**, such as riparian area protection or agricultural tillage concepts. Monitoring of the control measures is also discussed.

Land use and surface water planning are considered to be management **processes** that can be used to specify and implement the control measures described in this section. These management processes are discussed primarily in Section III. Each of the individual control measures described later in this section includes a paragraph on "local implementation options," which identifies the management processes that best apply to that measure.

Public education is an important tool considered to be a prerequisite for all NPS pollution control programs. It is discussed in Section III.

PONDS AND MARSHES

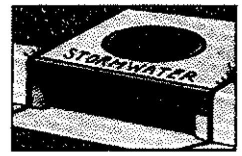
This category covers facilities that reduce the pollutant load in surface water, primarily through the settling of suspended particles (for example, eroded soil or "street dirt") and any chemicals attached to the particles (such as phosphorus and various metals). This particulate settling is the primary, and almost exclusive, pollutant removal process in the basic sediment trap facilities (such as sedimentation ponds and extended detention ponds) that pond water only infrequently. Wet ponds permanently pond water, and the pollutant removal mechanisms expand to include basic biological processes (such as nutrient removal by plants) and some physical filtering through vegetation. With ponded wetlands, the biological, physical, and chemical processes become much more complex and generally more effective.



Wetland & Polyculture Pond Ecosystem Schematic
from HBN Hynes; The Ecology of Running Waters; University of Toronto Press 1970; pg. 440

Pond and marsh facilities provide good to excellent pollutant removal for residential, commercial, agricultural, and forest harvest areas if they are adequately sized and shaped. They are most effective in removing suspended particles, nutrients, and metals attached to sediment. They are not effective for many industrial chemicals. They should be used very conservatively in industrial areas, and only if they include special design features (such as lining) and are part of a specially designed containment system.

STREET AND STORM SEWER SYSTEMS



Small pollutant removal facilities include trapped catch basins, sedimentation boxes or vaults, oil-water separators, and compost treatment units. They can be very effective if applied extensively in an area, primarily in urban street and storm sewer systems. The primary removal mechanism is particulate settling, where sediment, street dirt, metals attached to the sediment particles, and petroleum particles are removed.

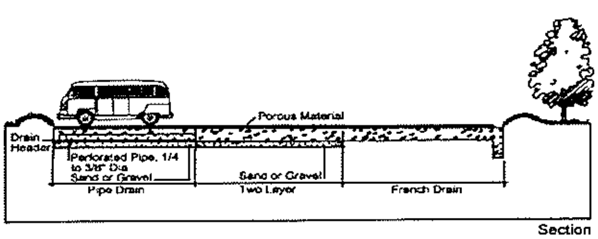
Adequate maintenance is a critical factor. It is an essential part of the pollutant removal process; if it is not done, the pollutants are transported into receiving waters. Materials disposal can require special disposal sites, particularly if industrial areas or spills are involved. Street sweeping, which is a maintenance activity, is included in this group; however, its effectiveness in the Northwest is questionable because of the frequency of natural washoff.

LANDSCAPE DESIGN

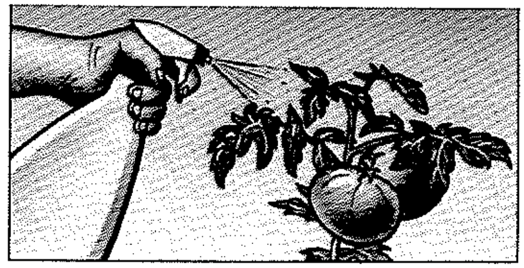
Landscape design includes features that can be included in any type of NPS pollution area, but is most easily integrated into developing urban areas. Included are vegetated swales, filter strips or riparian biofilters, contained drainage systems (particularly important for commercial and industrial areas), ponds, wetlands, and various types of erosion control during soil disturbance periods. These measures can be very effective if the design uses good hydrologic, hydraulic, and pollutant removal criteria, and if the system is adequately maintained. Erosion control for all types of NPS problem areas is the most important measure.

INFILTRATION FACILITIES

This group includes trenches, dry wells, porous pavement, ponds, wetlands, and roof drains that are designed to infiltrate surface water into the groundwater. In industrial areas, this approach is suitable only for roof drains; it is almost as limited for commercial and agricultural areas. It is portant to ensure that the areas within an industrial, commercial, or agricultural site that contain industrial chemicals are not drained into an infiltration facility. For areas where there is a low risk that industrial chemicals or high sediment loads will enter the runoff stream, infiltration can be very effective in reducing both peak flows and pollutant loads. The sorption of dissolved phosphorus onto the subsurface media is a particularly important pollutant removal function for infiltration.

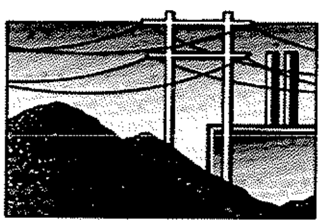


CHEMICAL APPLICATIONS



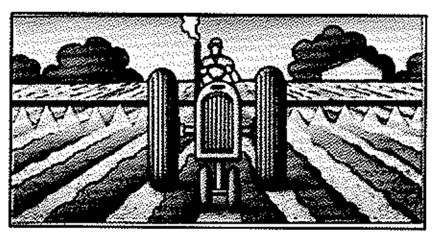
This group addresses herbicides, pesticides, and fertilizers. Detailed information is available from soil and water conservation districts and the product manufacturers. It is important to address chemical use in all urban, agricultural, and forest harvest areas. The important aspects include the method and amount, the timing of the application, storage, and equipment/container cleanup.

INDUSTRIAL AND COMMERCIAL SITES



Industrial and commercial areas often require special NPS pollution control measures because of the nature of the chemicals present. The most important measures are the elimination of non-stormwater, or illicit, connections to the surface water system; lining of surface water features to protect groundwater; preventative containment features included in the site design; monitoring; and maintenance. Even with such measures, emergency response procedures and capabilities will occasionally be required and are very important when such emergencies occur.

AGRICULTURAL AREAS

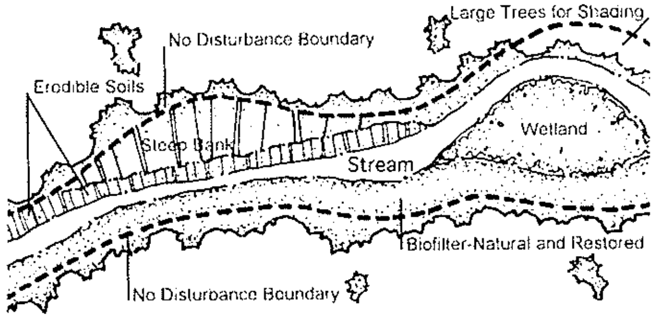


A number of NPS pollution control measures are unique to agricultural activities. Most of them involve modifications to farming practices. The measures include water quality-sensitive management of bulk materials, tillage, and container nurseries. Riparian area protection is important, particularly when livestock are involved. Pond/marsh facilities can also be effective.

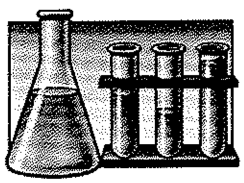
FOREST HARVEST AREAS

This group addresses activities associated with forest harvesting, including road and skid trail design, logging or yarding, forest residue management, and erosion control. Similar to agriculture, many of the forest harvest measures are unique to the activity and involve modifications to existing procedures.

STREAM, LAKE, AND RIPARIAN AREA PROTECTION



This group is an essential component of all NPS pollution control projects or programs. It involves equipment use limits, biofilter zones (preferably natural, but created if necessary), stream and riparian area restoration, and lake restoration.



MONITORING

Monitoring is also discussed as a control measure. Although it does not provide pollutant reduction, it is an essential program measure that documents the problems and tracks control measure performance.

EFFECTIVENESS OF CONTROL MEASURES

Table IV-1 summarizes the effectiveness of the control measure groups in relation to the types of NPS pollution problem.

Based on Montgomery Watson experience, Table IV-2 summarizes the removal efficiencies of the control measure groups.

Table IV-3 presents additional information for selected control measures. The information is adapted from the 1993 EPA document, *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*

Table IV-4 summarizes the advantages and disadvantages of selected NPS pollution control measures.

TABLE IV-1
CONTROL MEASURE EFFECTIVENESS FOR VARIOUS SOURCES

Control Measure Group	Type of Nonpoint Source Problem				
	Residential	Commercial	Industrial	Agricultural	Forest Har.
Ponds-Marshes	●	◑	○	◑	◑
Street/Storm Sewers	●	●	○	×	×
Landscape Design	●	●	○	○	×
Infiltration	●	◑	⊘	⊘	○
Chem. App.	◑	●	●	●	◑
Industrial/Commercial	×	●	●	◑	◑
Agricultural	○	×	×	●	×
Forest Harvest	○	×	×	×	●
Stream, Lk., Rip., Pr.	●	●	●	●	●

● Good Effectiveness
◑ Moderate Effectiveness
○ Low Effectiveness
× Not Applicable
⊘ Not Recommended

Table IV-2

Removal Efficiencies of Control Measure Groups
(Assuming adequate sizing, design and application)

Control Measure Group	Pollutant Removal Efficiency (percent)					
	TSS	Total P	N	Bacteria	Oil/Grease	Metals
Ponds-Marshes	**80**±15	**40**±20	**30**±15	**50**±20	⃠	**55**±10
Street/Storm Sewers	**30**±10	**15**±5	**10**±5	¥	¥	**15**±5
Landscape Design	**60**±10	**45**±20	**40**±20	¥	**70**±10	**45**±15
Infiltration	⃠	**75**±10	**40**±10	**85**±10	⃠	⃠
Chemical Applications	¥	Mod.	Mod.	¥	¥	¥
Commercial/Industrial	**70**±10	**40**±10	**30**±10	¥	**80**±10	**50**±10
Agricultural	**70**±10	**60**±20	**50**±20	¥	¥	¥
Forest Harvest	**70**±10	**60**±20	**50**±20	¥	**25**±10	¥
Stream, Lk., Rip., Protection	**60**±20	**50**±20	**45**±20	**30**±20	¥	¥

¥ Not applicable
⃠ Not recommended

TSS = Total suspended solids - All solid material suspended in the water, particularly soil/sediment particles if NPS pollution is involved

Total P = Total phosphorus - All of the phosphorus in the water, including the dissolved ortho component and the total particulate component (organic and inorganic)

N = Nitrogen - All nitrogen components combined, including nitrate, nitrite, organic, and ammonia

Bacteria = Fecal coliform bacteria as an indicator of waste from humans and animals

Oil/Grease = Petroleum products, generally associated with vehicles and industrial activities

Metals = All metals normally found in runoff from NPS areas, such as lead, copper, and zinc

TABLE IV-3
Effectiveness of Selected Control Measures

Control Measures	Removal Efficiency (%)						Factors	References
	TSS	TP	TN	COD	Metals	Oils/ Greases		
Wet Pond	50-80-95	50-65-90	10-55-90	10-40-90	10-40-95	⊘	• Storage volume • Pond shape • Detention time	Schueler et al., 1992; Portland - Lake Oswego- Clackamas County - USA Handbook, 1991
Marsh-Wetland	50-65-90	0-25-80	0-20-40	–	30-65-95	⊘	• Storage volume • Detention time • Pond shape • Wetland's biota • Seasonal variation	MWCOG, 1992; Portland - Lake Oswego- Clackamas County - USA Handbook, 1991
Extended Detention (Dry) Pond	45-70-90	10-25-60	20-30-60	30-30-40	20-50-60	⊘	• Storage volume • Detention time • Pond shape	Schueler and Helfrich, 1988; Portland - Lake Oswego- Clackamas County - USA Handbook, 1991
Trapped Catch Basins	10-20-30	5-10-20	5-10-20	¥	10-20-30	10-20-30	• Storage volume • Hydraulic loading • Cleaning	Portland - Lake Oswego- Clackamas County - USA Handbook, 1991
Water Quality Inlet	10-25-25	5-5-10	5-10-10	5-5-10	10-15-25	50-65-70	• Maintenance • Sedimentation storage volume	Schueler, 1987
Sedimentation Manhole	20-30-40	10-15-20	5-10-20	¥	20-30-40			Portland - Lake Oswego- Clackamas County - USA Handbook, 1991
Compost Treatment	60-80-90	0-50-80	20-35-90	–	40-60-80	40-60-80	• Hydraulic loading • Compost Mix	W.H. Pacific, Portland, OR, 1993
Swale	20-60-100	20-20-40	10-10-30	0-25-40	10-80-80	50-65-80	• Runoff volume • Slope • Soil infiltration rates • Vegetative cover • Swale length • Swale geometry	Washington State, 1988; Schueler, 1987; EPA, 1983; Seattle Metro, 1992
Filter Strip	40-65-90	30-40-80	20-40-60	0-40-80	30-45-80	50-65-80	• Runoff volume • Slope • Soil infiltration rates • Vegetative cover • Buffer length	Schueler, 1987; Seattle Metro, 1992
Infiltration Trench	50-75-100	50-60-100	50-55-100	50-65-100	50-65-100	⊘	• Soil percolation rates • Trench surface area • Storage volume	EPA, 1977; Schueler, 1987; EPA, 1983
Infiltration Pond	50-75-100	50-65-100	50-60-100	50-65-100	50-65-100	⊘	• Soil percolation rates • Basin surface area • Storage volume	EPA, 1977; Schueler, 1987; EPA, 1983

TABLE IV-4
ADVANTAGES AND DISADVANTAGES OF SELECTED CONTROL MEASURES

Control Measures	Advantages	Disadvantages
Wet Pond	• Can provide some peak flow control • Can serve large developments; most cost effective for larger, more intensively developed sites • Enhances aesthetics and provides recreational benefits • Permanent pool in wet ponds helps to prevent scour and resuspension of sediments • Provides moderate to high removal of both particulate and soluble urban stormwater pollutants	• Not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Potential exists for affecting groundwater
Marsh-Wetland	• Can serve large developments; most cost effective for larger, more intensively developed sites • Can provide peak flow control • Can enhance aesthetics and provide recreational benefits • The marsh fringe also protects shoreline from erosion • Permanent pool in ponded wetland helps to prevent scour and resuspension of sediments • Has high pollutant removal capability, including for dissolved constituents if designed properly	• Not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately designed and maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • With possible thermal discharge and oxygen depletion, may affect downstream aquatic life unless shading provided • May contribute to nutrient loadings during vegetation die-down periods • Regulatory constraints are important concerning existing wetlands and groundwater
Extended Detention (Dry) Pond	• Can provide some peak flow control • Possible to provide good particulate removal • Can serve large development • Requires less capital cost compared to wet pond • Does not generally release warm or anoxic water downstream • Provides excellent protection for downstream channel erosion • Can create valuable wetland and meadow habitat when properly landscaped	• Removal rates for soluble pollutants are quite low • Not economical for drainage area less than 10 acres • If not adequately maintained, can be an eyesore
Conjunctive Use Flood Detention Ponds	• Designed to also provide peak flow control • Can serve large developments; most cost effective for larger, more intensively developed sites • Enhances aesthetic and provides recreational benefits if landscaped well • Permanent pool in wet ponds helps prevent scour and resuspension of sediments	• Not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately designed or maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Off-stream types are complex and costly
Water Quality Inlet and Trapped Catch Basin	• Provide high degree of removal efficiencies for larger particles and debris as pretreatment • Require minimal land area • Flexibility to retrofit existing small drainage areas, and applicable to most urban areas	• Not feasible for drainage area greater than 1 acre • Marginal removal of small particles, heavy metals, and organic pollutants • Not effective as water quality control for intense storms • Minimal nutrient removal • Require frequent maintenance

TABLE IV-4
ADVANTAGES AND DISADVANTAGES OF SELECTED CONTROL MEASURES

Control Measures	Advantages	Disadvantages
Compost Treatment Unit	• Prefabricated compost units allow relatively inexpensive installation of unit within existing storm drainage systems • Underground units allow installation within existing street easements	• May require pretreatment (sedimentation) to prevent compost from prematurely clogging • Compost will have to be replaced and disposed of periodically • Compost mix design is complex and possibly proprietary technology • Promising, but developing technology
Swale	• Requires moderate land area • Can be used as part of the runoff conveyance system to provide pretreatment • Can provide sufficient runoff control to replace curb and gutter in single-family residential subdivisions and on highway medians • Economical	• Low pollutant removal rates for some pollutants • Leaching from swales that are integrated into fertilized lawns may increase nutrients
Filter Strip	• Can be used as part of the runoff conveyance system to provide pretreatment • Low maintenance requirements • Provides excellent urban wildlife habitat • Can effectively reduce particulate pollutant levels in areas where runoff velocity is low to moderate • Economical, particularly if the existing vegetation is preserved prior to development	• Limited feasibility in highly urbanized, developed areas where runoff velocities are high and flow is concentrated • Concentrated water flow significantly reduces effectiveness • Ability to remove soluble pollutants highly variable • Requires periodic repair, regrading, and sometimes sediment removal
Infiltration Trench	• Provides groundwater recharge • Can serve small drainage areas • Can fit into medians, perimeters, and other unused areas of a development site • Helps replicate predevelopment hydrology, increases dry weather baseflow, and reduces bankfull flooding frequency • Good pollutant removal	• Possible risk of contaminating groundwater if not properly sited and designed • Requires significant maintenance • Since not as visible as other measures, less likely to be maintained by residents • Only feasible where soil is permeable and there is sufficient depth to rock and water table
Infiltration Pond/Dry Well	• Provides groundwater recharge • Can serve large developments • High removal capability for particulate pollutants and moderate removal for soluble pollutants • When basin works, it can replicate predevelopment hydrology more closely than other options • Basins provide more habitat value than other infiltration systems	• Possible risk of contaminating groundwater if not properly sited and designed • Fairly high failure rate • Only feasible where soil is permeable and there is sufficient depth to rock and water table • If not adequately maintained, can be an eyesore • Regular maintenance activities cannot preven clogging of infiltration ponds and dry wells in some locations

EFFECTIVENESS QUESTIONNAIRE

The available NPS pollution control literature presents a wide range of information about the effectiveness of various control measures. To obtain additional information, a questionnaire was sent to 21 practitioners to ask about their experience concerning general performance. The practitioners are located as follows: 13 in Oregon, 6 in the State of Washington, 1 in California, and 1 in Washington, D.C. Some practitioners also passed the questionnaire on to colleagues. Twenty individual responses were received.

The practitioners were asked to rate the effectiveness of specific control measures. Table IV-5 summarizes the rating results for all of the control measure categories. Not all respondents rated every item on the list. The primary reason for not rating an item was unfamiliarity with it.

The respondents made some specific comments associated with the numerical rating of individual control measures. These comments affected how they rated some of the items and are presented in Table IV-5. Inclusion of a comment should not be interpreted to mean that DEQ or DLCD agrees with the comment.

The practitioners were also asked to respond to five questions about NPS pollution control measures. Appendix D summarizes the responses to those questions.

TABLE IV-5
RESULTS OF NONPOINT SOURCE CONTROL MEASURES EFFECTIVENESS RATING QUESTIONNAIRE

0	1	2	4	*Ponds and Marshes*
	2	8	6	Wet Ponds
		15	3	Sedimentation Ponds
	1	9	8	Marsh-Wetland Treatment
	4	9	3	Extended Detention Ponds
	3	4	6	Conjunctive Use Flood Detention Ponds

0	1	2	4	*Agricultural Areas*
		5	10	Livestock Management
		3	11	Bulk Materials Containment
		1	14	Riparian Area Protection
		7	7	Tillage Management
		5	5	Container Nursery Controls
		6	9	Fertilizer and Manure Management

0	1	2	4	*Street and Storm Sewer Systems*
1	7	3	1	Sedimentation Boxes
2	9	4	2	Trapped Catch Basins
2	9	5	1	Water Quality Inlets, Vaults and Tanks
1	8	3	2	Sedimentation Manholes
	4	4	4	Compost Treatment Units
3	5	6	3	Street Sweeping

0	1	2	4	*Silvicultural Areas*
	3	3	5	Road and Skidding System Design Standards
	1	5	4	Logging Method Requirements
	1	6	4	Forest Residue Management
	4	2	5	Surface/Mass Erosion Controls

0	1	2	4	*Landscape Design*
	2	10	7	Vegetated Swales
	5	7	7	Filter Strips
1	1	4	1	Contained Drainage Systems
	1	8	7	Ponds and Wetlands
	2	5	11	Erosion Control

0	1	2	4	*Stream, Lakes, and Riparian Area Protection*
	1	6	7	Equipment Use Limits
		3	12	Biofilter/Buffer Zones
	2	5	8	Stream and Riparian Area Restoration
	3	5		Lake Restoration (as per PL 92-500)

0	1	2	4	*Infiltration Facilities*
	5	10	2	Trenches
3	8	5	1	Dry Wells
5	4	6	2	Porous Pavement
	5	8	3	Infiltration Ponds/Wetlands
1	3	6	7	Roof Drain Infiltration

0	1	2	4	*Monitoring*
	2	5	4	For Complete Watersheds
	1	5	4	Water Quality-Basic (e.g. Nutrients, SS)
	1	5	3	Water Quality-Special (e.g. metals, industrial chems.)
		4	5	Aquatic Life (diversity, abundance, tissue)
	1	1	7	Sediments and Toxics

0	1	2	4	*Chemical Applications*
	1	6	8	Herbicide and Pesticide Controls
		4	11	Fertilizer Management

0	1	2	4	*Industrial and Commercial Sites*
	1		17	Eliminating Illicit Connections
		3	14	Containment of Contaminated Runoff
	1	2	14	Monitoring and Maintenance
	1	6	10	Emergency Response

Numbers in boxes indicate the number of respondents who assigned that rating

Description of Ratings
0 - not effective
1 - low effectiveness
2 - moderate effectiveness
4 - high/good effectiveness

NOTES:

- Marsh-Wetland Treatment: One comment indicated that the rating depends on the season.
- Compost Treatment Units: Several comments noted that a rating of 4 assumed that nutrient control was not an issue.
- Infiltration Facilities: Comments noted that the soil type and the level of maintenance provided would affect whether facilities such as trenches and infiltration ponds/wetlands would receive a rating of 2 or 4. It was also noted that roof drain infiltration is better for quantity than for quality.
- Landscape Design: Comments noted that dozens of erosion control measures exist; some are effective and some are not.
- Agricultural Areas: Concerns about agricultural areas were noted, specifically concerning container nursery controls and the fact that nurseries are still allowed to dump, or release the water from, ponds in the fall season.
- Lake Restoration: A comment noted that the technique used to restore the lake would affect the rating of this item. This particular respondent favored creating buffers to the lake and removing septic tanks in the drainage basin.
- Monitoring: The following comments were made:
  - Basic water quality monitoring is event based.
  - More in-depth water quality monitoring, which includes metals, chemicals, aquatic life, and toxics, is expensive, and testing should be selective.
  - One should have good reason to believe toxics are present before obligating funds.
  - Diversity and abundance are good indicators of system health, but are not related to specific best management practices and their performance.

Section IV

ADDITIONAL SOURCES OF INFORMATION

The References section lists information sources of interest to the reader, including the sources used to prepare this guidebook. The following publications comprise a good basic library that will take the reader a step beyond this guidebook in understanding NPS pollution problems, sources, and controls.

- American Society of Civil Engineers. Design of Urban Runoff Quality Controls. Proceedings of an Engineering Foundation Conference on Current Practice and Design Criteria, Potosi, Missouri, 1988. *(Information source 1, below)*
- King County Department of Public Works, Surface Water Management Division. Guidelines for Bank Stabilization Projects, In the Riverine Environments of King County. Seattle, Washington, 1993. *(Information source 2)*
- Municipality of Metropolitan Seattle, Water Pollution Control Department. Biofiltration Swale Performance, Recommendations, and Design Considerations. Seattle, Washington, 1992. *(Information source 3)*
- Portland, City of, Bureau of Environmental Services. Columbia Slough Planning Study Background Report. Portland, Oregon, 1989. *(Information source 4)*
- Portland, City of; City of Lake Oswego; Clackamas County; and Unified Sewerage Agency. Surface Water Quality Facilities Technical Guidance Handbook. 1991. *(Information source 4)*
- United States Department of Agriculture, Forest Service, Pacific Northwest Region. General Water Quality Best Management Practices (for forest harvest activities). 1988. *(Information source 5)*
- United States Environmental Protection Agency. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990. 1993. *(Information source 6)*
- United States Environmental Protection Agency. Rapid Bioassessment Protocols for Use in Streams and Rivers; Benthic Macroinvertebrates and Fish. 1989. *(Information source 7)*
- Washington Council of Governments, Metropolitan Department of Environmental Programs. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. 1987. *(Information source 8)*
- Ibid. A Current Assessment of Urban Best Management Practices. 1992. *(Information source 8)*
- Washington State Department of Ecology. Stormwater Management Manual for the Puget Sound Basin; The Technical Manual. 1992. *(Information source 9)*
- Water Environmental Federation and American Society of Civil Engineers. Design and Construction of Urban Stormwater Management Systems. 1988. *(Information source 1)*

The information listed above can be obtained by contacting the following sources.

1. American Society of Civil Engineers
   345 East 47th Street
   New York, NY 10017-2398

2. King County
   Surface Water Management Division
   Department of Public Works
   Yesler Building
   400 Yesler Way, Room 400
   Seattle, WA 98104-2637

3. Municipality of Metropolitan Seattle
   Water Pollution Control Department
   821 Second Avenue
   Seattle, WA 98104-1598

4. Portland Bureau of Environmental Services
   1120 SW Fifth
   Portland, OR 97204-1972

5. United States Department of Agriculture
   Forest Service
   Pacific Northwest Region
   P.O. Box 3623
   Portland, OR 97208
   333 SW First Avenue
   Portland, OR 97204

6. EPA-EPIC
   11029 Kenwood Road, Building 5
   Cincinnati, OH 45242
   (for CZARA Guidance document)

7. U.S. Environmental Protection Agency
   Assessment and Watershed Protection Division
   401 M Street, SW
   Washington, DC 20460

8. Information Center
   Metropolitan Washington Council of Governments
   777 North Capitol Street, NE, Suite 300
   Washington, DC 20002-4201

9. Washington Department of Ecology
   Mail Stop PV-11
   Olympia, WA 98504-8711

CONTROL MEASURES

The following sheets describe the basic NPS pollution control measures according to the following categories:

- Ponds and Marshes
- Street and Storm Sewer Systems
- Landscape Design
- Infiltration Facilities
- Chemical Applications
- Industrial and Commercial Sites
- Agricultural Areas
- Forest Harvest Areas
- Stream, Lake, and Riparian Area Protection

Monitoring techniques are also described following the description of control measures.

> Note: The facilities and measures described in the following section have been determined through experience to be suitable under certain conditions. However, due to state laws, rules, or policies, or local comprehensive plan policies relating to the protection of natural resource values, some of the facilities and measures may not be appropriate or permissible under certain circumstances.

PONDS AND MARSHES

WET PONDS

Description: Wet ponds appear as a depression which contains a permanent ponded pool, often behind an existing road fill or constructed embankment. Wet ponds are deeper on the average than a wetland and typically larger than a sedimentation pond. Treatment occurs through a variety of natural physical, chemical, and biological processes in the aquatic environment. Since embankments/road fills are usually utilized to establish the ponding, wet ponds are generally deeper at one end (near the embankment) than at the upstream end. They can be on-stream or off-stream with the on-stream type involving simpler, functional operation. They can be conceptualized as being in-between a wetland and a sedimentation pond. Pre-treatment is recommended.

Paramenters/Pollutants Potentially Addressed: Nitrogen, suspended sediments, metal, oil and grease (pre-treatment facilities are recommended to avoid oil and grease accumulations), BOD, bacteria and industrial chemicals in some cases (not generally recommended for industrial areas unless lining is provided).

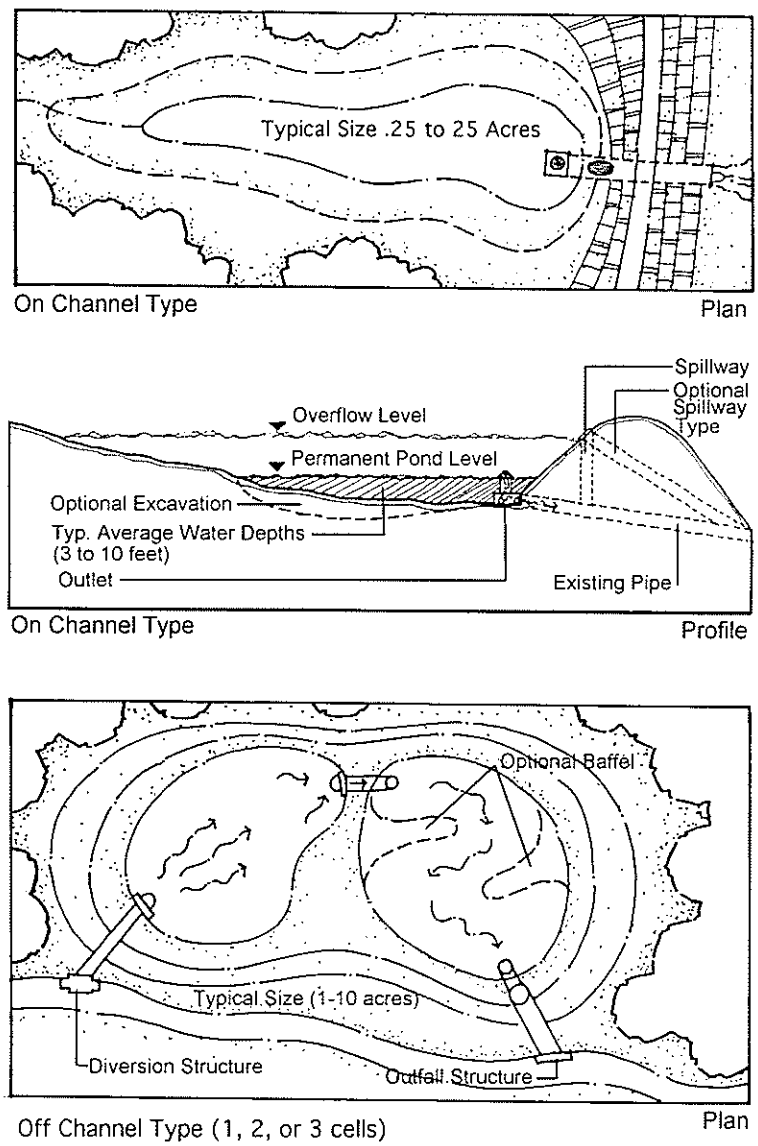
Advantages: Wet ponds are usually beneficial for wildlife and can benefit or hurt fish. They involve smaller land requirements than ponded wetlands and have relatively good water quality effectiveness if designed correctly and not overloaded. Generally wet ponds create multiple values involving habitat and passive recreation.

Disadvantages: If industrial chemicals are involved, wet ponds can affect groundwater adversely. Since ponding occurs fish passage is required if anadromous fish are involved and this can be costly, unsightly or impossible. Since ponded water is involved a risk of drowning exists but no greater than for any pond or pool. Relatively high maintenance requirements are involved and geotechnical questions must be addressed because ponded water behind an embankment could lead to slope failure. Wet ponds must be monitored to determine maintenance needs and to check on the functions and impacts.

Concept Variations: Ponded wetlands, sedimentation ponds, extended detention ponds and conjunctive use flood detention ponds are all variations of wet ponds. Extended detention ponds or other facilities which remain dry much of the time are the most noticeably different.

Maintenance Requirements: Wet pond maintenance includes periodic sediment removal; debris removal and cleaning particularly from trash racks; vegetation management around, and often within, the pond; periodic checks on hydraulic function; and periodic review of facility condition. During the first three years maintenance inspection should occur at least quarterly but can be less frequent after about three years.

Local Implementation Options: The implementation options include land use regulations which require wet ponds or one of the variations for new developments; regional facilities specified and sized in surface water management/master plans; capital improvement plans; and design-construction standards for both private and public developments. Operation and maintenance programs are required and should be defined during the design and construction process and adequately budgeted for. If a local jurisdiction has pond and marsh facilities, an integrated maintenance plan is highly recommended.



WET PONDS

SEDIMENTATION PONDS

Description: During normal dry periods a sedimentation pond is usually a dry depression behind a road fill or constructed berm. Some are designed to provide a permanent, or semi-permanent, pool of water and resemble a wet pond, though usually smaller. During storm periods, particularly intermediate level storms, a sedimentation pond is designed to provide a quiescent pool within which the settling of sediments can occur. During base flow periods, low intensity storms and the higher flood flows, sedimentation ponds are not designed to provide much settling. Sedimentation ponds can vary in size from one-fourth an acre up to twenty or more acres depending on the drainage area served. One of the most common applications is at construction sites during and immediately following construction to intercept soil particles disturbed by the construction. However, they can also serve urban, agricultural or silvicultural areas effectively. In most cases, particularly for industrial and commercial areas, a sedimentation pond should be preceded by a pre-treatment unit such as an oil-water separator and lining is usually needed. A sedimentation pond is similar to a wet pond but does not usually have a permanent pool. It is different from a sedimentation wetland or a ponded wetland because of an absence of, or less, wetland vegetation.

Paramenters/Pollutants Potentially Addressed: Sedimentation ponds can do an excellent job, if designed correctly, of removing suspended sediments and associated pollutants such as phosphorus and metals.

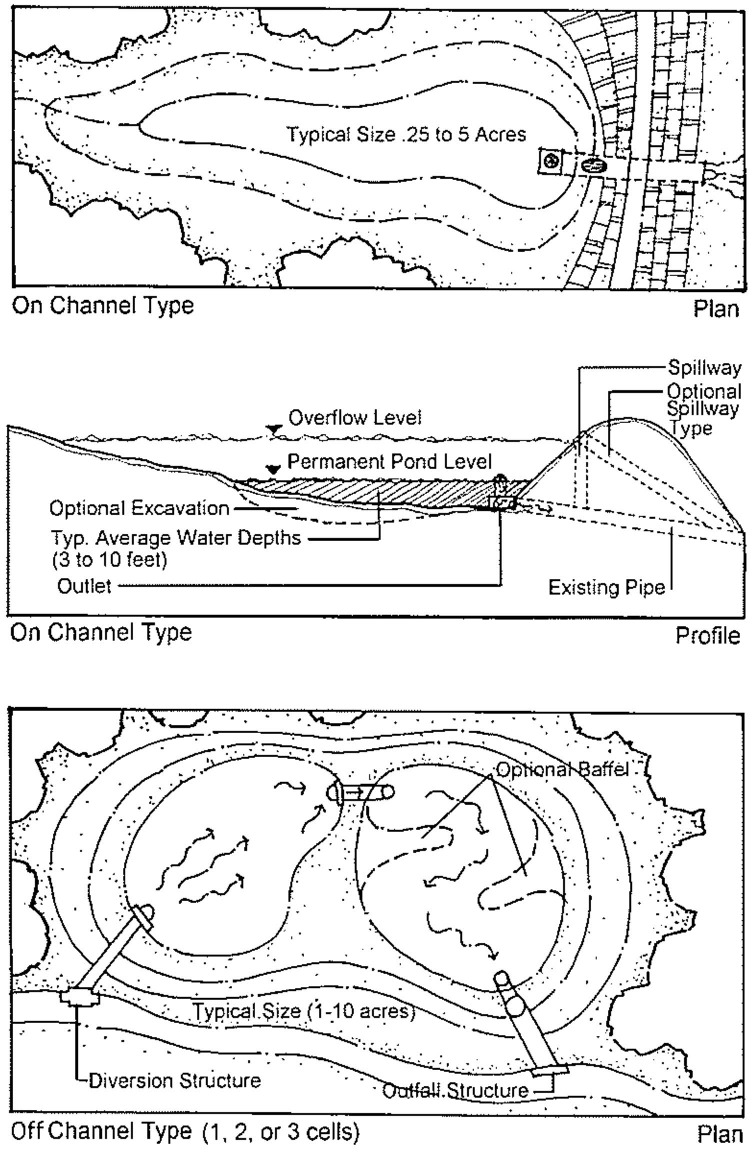
Advantages: The primary advantages involve less land required than for ponded wetlands, proven design standards and reduced safety problems due to the absence of a water surface during normal or low flow periods.

Disadvantages: The multiple use values of sedimentation ponds are less than for ponded wetlands or wet ponds due to the absence of a diverse aquatic habitat and fewer pollutants removed than with ponded wetlands and wet ponds.

Concept Variations: Extended detention ponds are very similar to sedimentation ponds but cover a considerably larger area because of the storage volume needed to reduce peak flood flows. Wet ponds are usually larger but very similar to wet sedimentation ponds. Sedimentation wetlands are wet sedimentation ponds with wetland vegetation to provide additional sediment removal functions.

Maintenance Requirements: Sedimentation ponds require frequent periodic sediment removal, the cleaning and removing of debris, and periodic checks regarding facility condition and hydraulic function. The periodic checks should occur at least twice annually, and quarterly is recommended. For new facilities, or the ones with high sediment loads, monthly inspections are advisable. Sedimentation ponds during the first few years of operation should be maintained two or three times per year and more often if construction areas are being served. After construction, or after the first two or three years some sedimentation ponds can be maintained on an annual basis and this should generally be done during the late spring or early fall depending on drainage area characteristics and runoff conditions.

Local Implementation Options: The primary local implementation options involve land use regulations, storm water management/master plans, capital improvement plans for public regional facilities and design-construction standards. An operation and maintenance program for each facility is needed if very many facilities are involved an integrated O&M plan should be developed.



SEDIMENTATION PONDS

CONSTRUCTED MARSH-WETLAND TREATMENT

Description: A marsh-wetland treatment facility, if well designed, should look very much like a natural wetland. A forebay or pretreatment unit is necessary to help protect the wetland from excessive sediment loads and other pollutants. The edges and much of the shallow area support wetland vegetation and the center area is typically open water during much of the year. The area involved may range from less than half an acre up to thirty or more acres. Such facilities are generally used as regional facilities to serve developed urban or commercial areas. Construction areas normally contribute excessive sediment loadings to wetlands, and industrial runoff may contaminate the wetland and present difficult maintenance and disposal problems. Marsh wetland facilities are usually larger and shallower than wet ponds that serve a similar-sized drainage area, and have a permanent or seasonal water surface in contrast to sedimentation ponds, which are dry.

Paramenters/Pollutants Potentially Addressed: Marsh-wetlands can remove several pollutants from stormwater, particularly those involving or attached to suspended sediments. Such facilities do a good job on nitrogen, metals, BOD, bacteria and, if infiltration or soil sorption is involved, phosphorus. Oil and grease can also be effectively removed but can contaminate the wetland. Thus such facilities should include a pre-treatment unit such as an oil-water separator. Industrial, agricultural and silvicultural chemicals can also be removed by wetlands, but wetland contamination, groundwater problems, and maintenance/disposal difficulties may result.

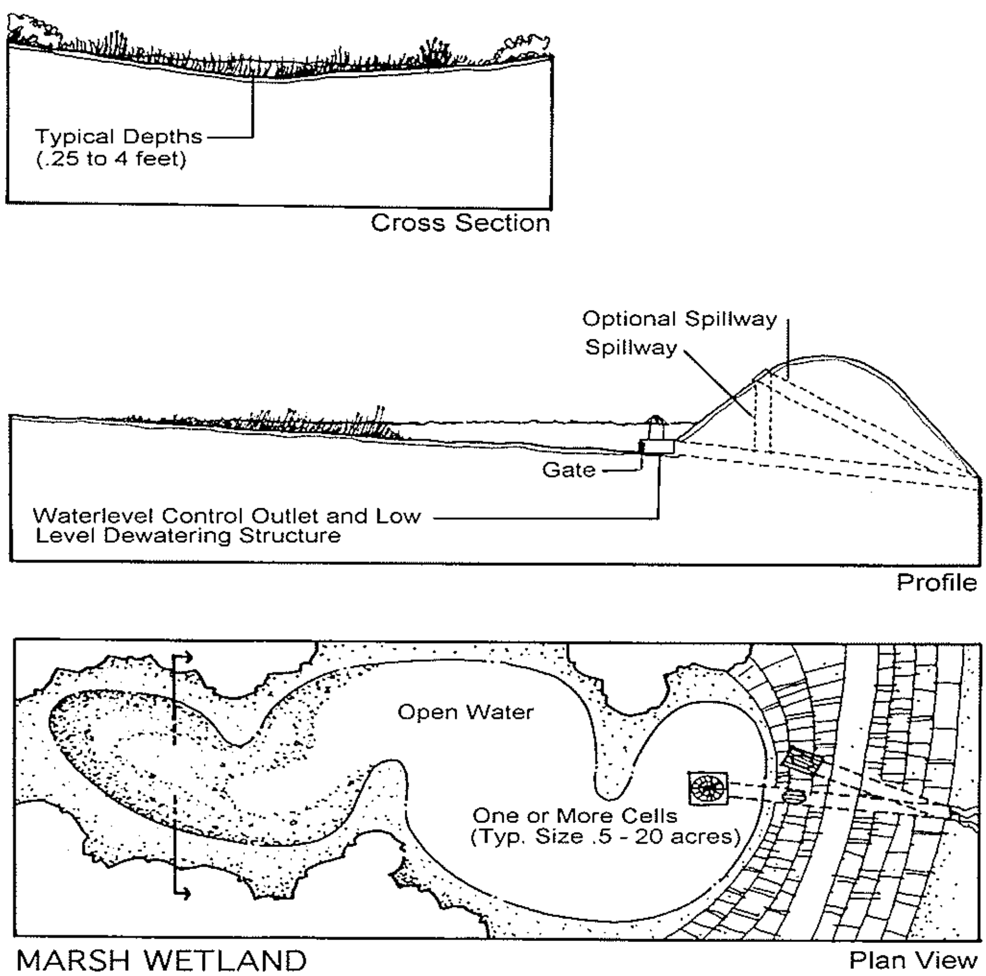
Advantages: Fish and wildlife benefits of marsh-wetland facilities are greater than for the others in this category. Other multiple use values such as education and passive recreation are also provided. The water quality effectiveness of wetlands can be considerable depending on the design.

Disadvantages: Since wetlands involve a permanent or seasonal water surface, groundwater recharge is likely to occur. Therefore, the groundwater impacts must be understood prior to constructing the marsh-wetland facilities. Since a pool is involved the geotechnical stability of the constructed berm or existing road fill to be used must be evaluated for piping, seepage, and failure by a qualified geotechnical engineer. Depending on the primary pollutant to be removed, the performance and design standards vary considerably, and design is often complex. Safety must be considered in the design for example to minimize the risk of drowning.

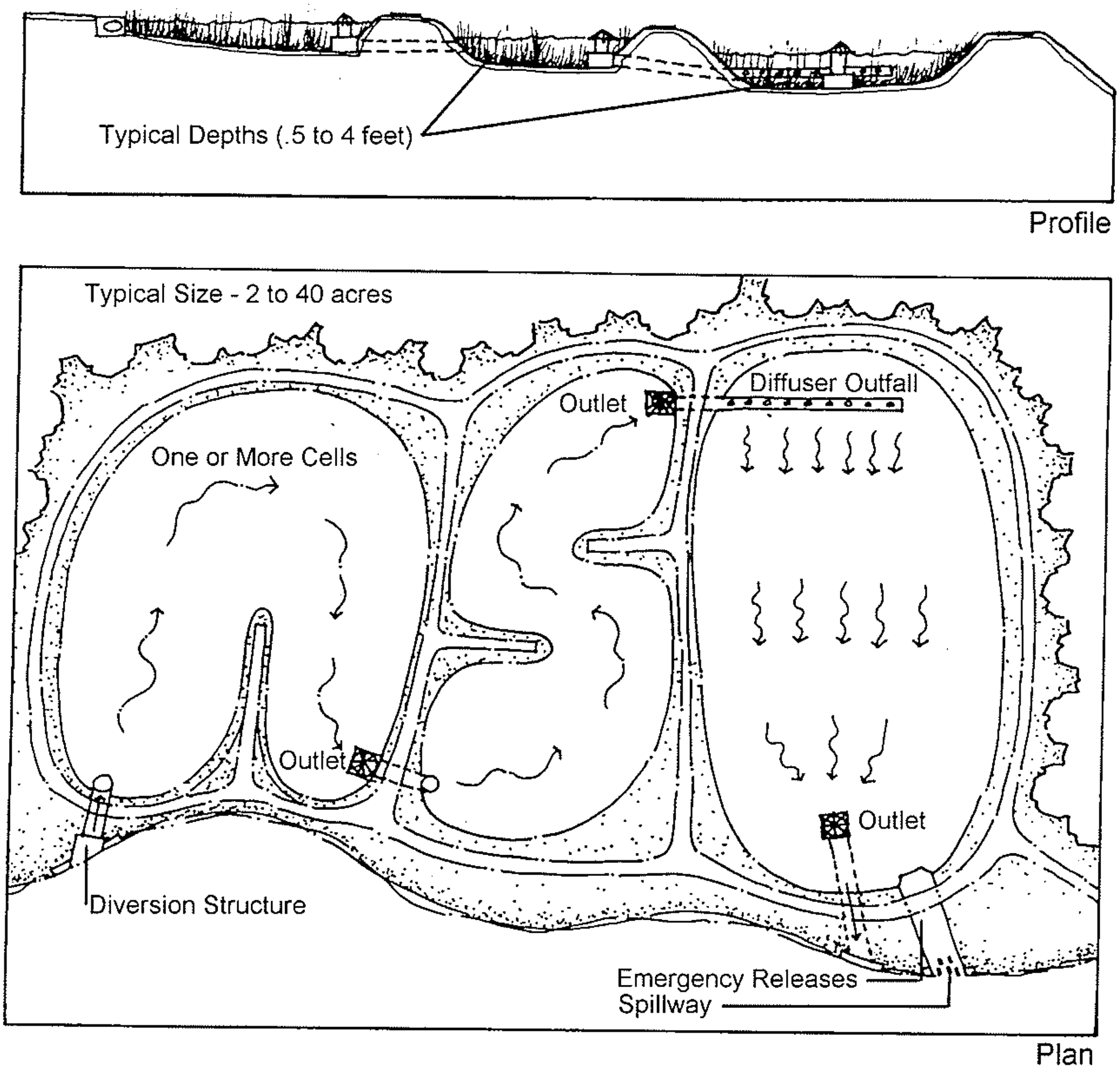
Concept Variations: Marsh-wetland facilities are very similar to wet ponds and can be integrated into conjunctive use flood detention ponds.

Maintenance Requirements: Maintenance requirements are relatively high and involve periodic sediment removal, debris removal and cleaning, management of aquatic, riparian and landscape vegetation, and periodic reviews of the hydraulic function and facility condition. During the first three years wetlands should be maintained quarterly with the frequency reduced after the first three years, if justified.

Local Implementation Options: Comprehensive plans can include regional wetland facilities and land use regulations can address the use of constucted wetlands in developing areas. A more detailed presentation of regional wetlands can be made in surface water management/ master plans. Such facilities should also be included in capital improvement plans. Design and construction standards and operation and maintenance programs are required because of the complexity of this type of control measure.



MARSH WETLAND
ENHANCED ON-CHANNEL WETLAND



MARSH-WETLAND
OFF-CHANNEL WETLAND

EXTENDED DETENTION PONDS

Description: Extended detention ponds look very much like sedimentation ponds with the most notable exception being size. Detention ponds are usually larger, in some cases much larger, due to the area required to detain the flood volume. The size of a detention pond is directly related to the magnitude of the design flood. During low intensity storm events, the lower part of an extended detention pond fills and provides for quiescent settling of sediments. During high flows a much larger area would be inundated. The ponds will reduce peak flows and provide flood damage reductions. Extended detention ponds are generally regional public facilities serving relatively large areas since the complex design and O&M requirements are usually more involved than that justified for private construction. However, large planned unit developments may include extended detention ponds. While dry, extended detention pond areas can be used for recreational purposes such as picnicking.

Paramenters/Pollutants Potentially Addressed: The primary parameter involved is suspended sediments and the attached pollutants such as phosphorus and metals.

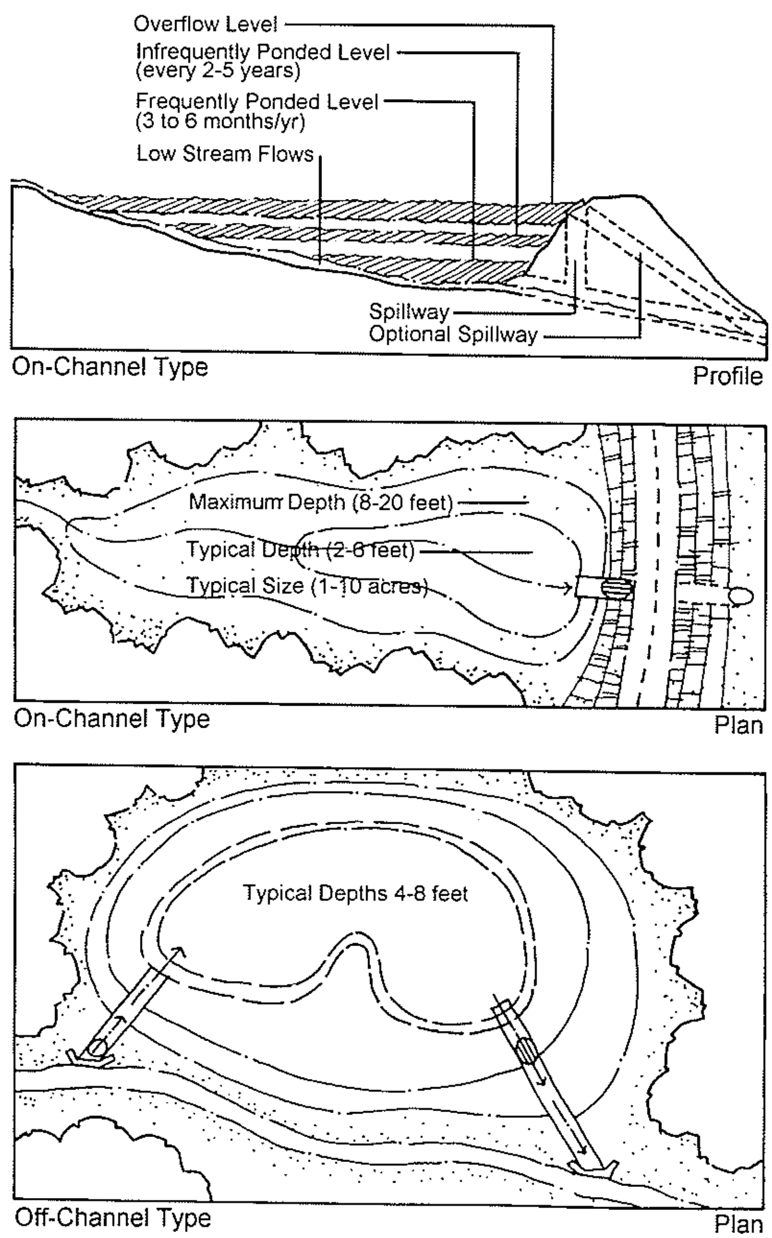
Advantages: Joint use recreational values and flood control benefits in addition to water quality improvement are the main advantages. Since aquatic and riparian vegetation are usually not involved, the fish and wildlife habitat value is usually less than for other types of facilities such as marshes and wetlands. Maintenance requirements are less than for wetlands but still relatively high. As such larger facilities offer advantages since the maintenance effort can be concentrated for large drainage areas. The land requirements are relatively large but much of the area required can be acquired through flood easements rather than fee-simple ownership.

Disadvantages: The primary disadvantage is the land required. Detention ponds are also moderately complex to design correctly.

Concept Variations: Extended detention ponds are very similar to sedimentation ponds.

Maintenance Requirements: Sediment removal, debris removal and cleaning, vegetation management and a periodic check of hydraulic function and facility condition are all required during maintenance. The frequency should be three or four annually during the first two years and adjusted according to experience thereafter. Most extended detention ponds will require at least an annual maintenance under even the best conditions.

Local Implementation Options: The primary implementation options are surface water management/master plans and capital improvements plans since most facilities are regional and public in nature. They should be designated in a community's comprehensive plan and considered for new developments where appropriate through land use regulations. Design-construction standards are required since the facilities are moderately complex and the facilities should be integrated into the O&M work program.



EXTENDED DETENTION PONDS

CONJUNCTIVE USE FLOOD DETENTION PONDS

Description: A conjunctive use flood detention pond is similar to an extended detention pond, but instead of a sedimentation pool for low intensity storms, a wetland treatment area is included in the lower portion of the site. It appears as a wetland behind a road fill or constructed berm with a relatively large normally dry area surrounding the wetland. It is the most complex type of runoff facility presented in this guide book and in most cases such facilities are public and regional in nature. If well designed, a conjunctive use flood detention pond will be the largest type of pond-marsh facility due to the combination of the area required for flood detention with permanent wetland functions. A pre-treatment unit is recommended.

Paramenters/Pollutants Potentially Addressed: Suspended sediments and the associated pollutants such as phosphorus and metals are addressed with conjunctive use flood detention ponds. If correctly designed some of the nitrogen can be removed and BOD and bacteria should be reduced. Oil and grease is addressed, but such loading should be minimized by pre-treatment through an oil-water separator.

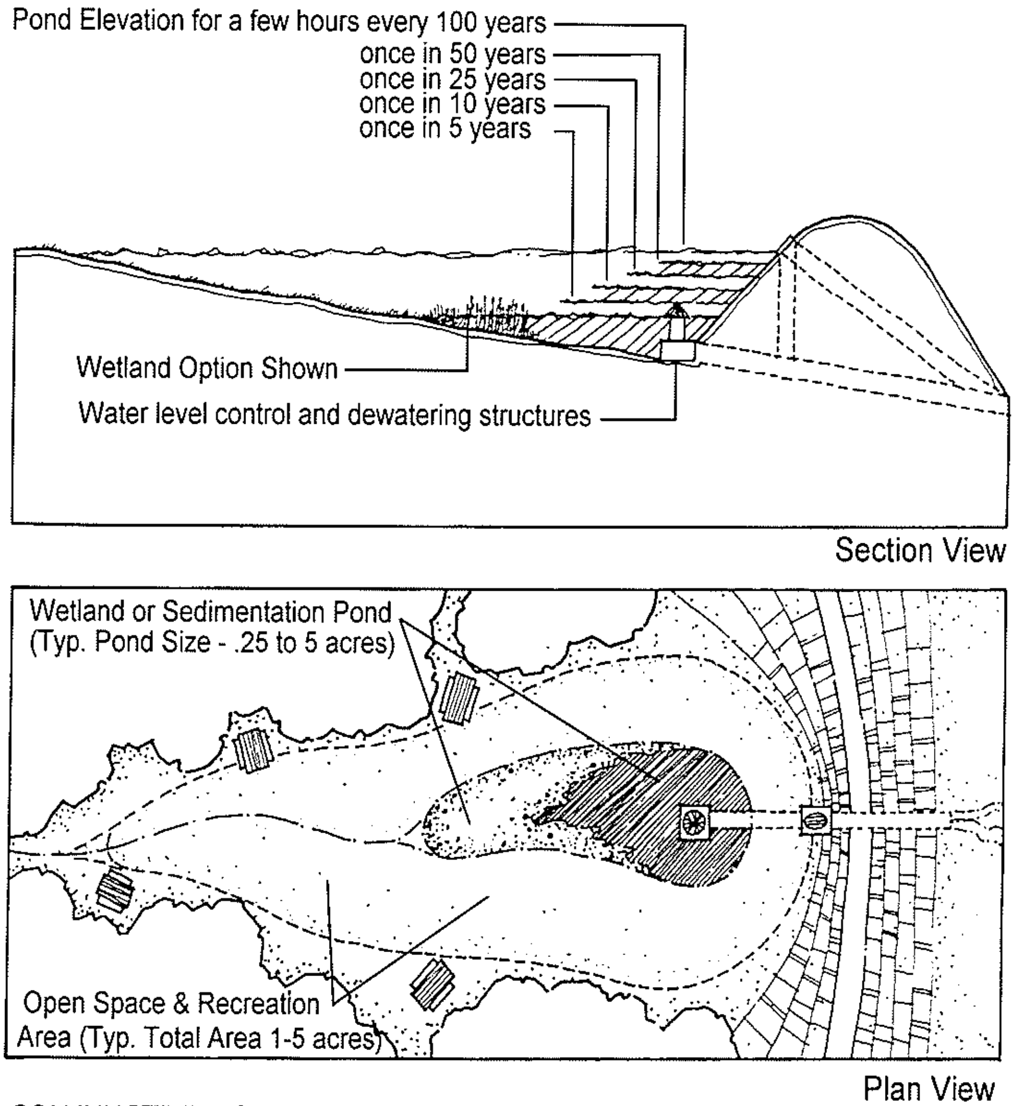
Advantages: The primary advantage involves good flood control benefits paired with good water quality benefits. In addition, such facilities can provide considerable fish and wildlife benefits, recreation, and educational uses, since a considerable dry land area is normally available in the flood detention pool. If designed correctly, such facilities can provide the same water quality benefits as wetlands, which means the values are maximized.

Disadvantages: Permitting conditions can be complex and maintenance requirements are relatively high. The land area required is large and geotechnical considerations must be evaluated thoroughly since fill instabilities during flood detention can result from improper design. Safety must be considered since a permanent pool is involved. Performance monitoring of various functions is justified, if not mandatory.

Concept Variations: An extended detention pond is similar but does not involve a wetland or permanent pool in the lower portion. The detention area will appear as a wetland, but will have a larger publicly owned area surrounding it to provide for the flood detention function.

Maintenance Requirements: These facilities require sediment and debris removal; cleaning; management of wetland, riparian, and landscape vegetation; and frequent checks on hydraulic function and facility condition. During the first three years, such facilities should be monitored; and it may be necessary to generally maintain them on a quarterly basis during this period. Maintenance frequency can be reduced after the first three years based on actual facility experience.

Local Implementation Options: Since these facilities are large and complex and usually constructed by public agencies they should be identified in the jurisdiction's comprehensive plan and originate in surface water management/master plans. Capital improvement plans and budgets are also necessary as well as design and construction standards. Of all the facilities discussed an integrated O&M plan and program are more important for this type of facility than any other.



CONJUNCTIVE USE FLOOD DETENTION POND
WITH A WETLAND OPTION

STREET AND STORM SEWER SYSTEMS

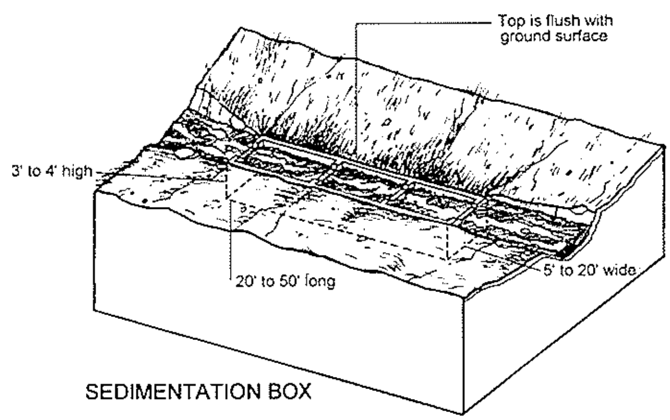
SEDIMENTATION BOXES

Description: Sedimentation boxes have recently been installed in Portland area streams and the success has been reported as good in removing suspended sediments and bed load. The facilities are rectangular concrete boxes recessed along a stream bed or ditch at an elevation which does not change the water surface profile. A number of chambers are provided which encourage bed load deposition and some settling out of sediments depending on particle size. Sizes can range from approximately 4' x 2' x 20' up to 15' x 4' x 50'. The functional concepts involved are similar to sedimentation ponds but have a completely constructed configuration and are generally smaller.

Paramenters/Pollutants Potentially Addressed: Primarily suspended solids and associated pollutants such as phosphorus and metals.

Advantages: Such facilities are relatively straightforward in design and construction and are easier to maintain than the more natural facilities such as wetlands or ponds.

Disadvantages: Permits may be required that are difficult to obtain. There may be some risk of drowning but this is expected to be minimal compared to the natural stream or ditch where construction occurs. The concept is relatively new; therefore, several variations may be necessary before the design and performance standards are established.



SEDIMENTATION BOX

Concept Variations: Water quality inlets, vaults, tanks and sedimentation manholes are very similar in function.

Maintenance Requirements: During the first two or three years such facilities should be inspected monthly and cleaned when necessary. During this period a maintenance protocol should be developed and less frequent maintenance may be appropriate after the first few years.

Local Implementation Options: The primary implementation approach involves surface water management/master plans, capital improvement plans, design-construction standards, and an integrated O&M program.

TRAPPED CATCH BASINS

Description: Trapped catch basins are simply stormwater inlets with a small recessed, sumped portion below the curb/field opening. They have a long history of use in urban areas throughout the nation but have been discontinued in favor of "self-cleaning" catch basins in the last few decades which are not effective for water quality purposes. They involve small traps or sumps below an inlet just before runoff enters a pipe (or open channel).

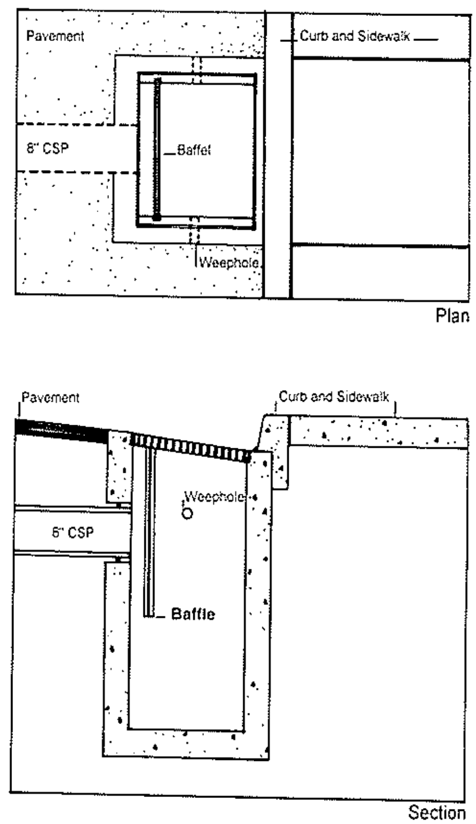
Paramenters/Pollutants Potentially Addressed: Suspended solids and associated pollutants such as phosphorus and metals.

Advantages: The primary advantages are the long history of use and well developed design standards for a wide range of facility types.

Disadvantages: Trapped catch basins do not operate effectively for water quality purposes unless maintained frequently. A wide range of water quality performance information exists, but it is generally agreed that catch basins must be frequently cleaned in order to remain effective.

Concept Variations: Trapped catch basins are very similar to water quality inlets except less complex.

Maintenance Requirements: Accumulated sediments should be removed at least twice a year. More frequent cleaning may be required where heavy sediment loads are involved. When installed below construction activities, they may need to be cleaned daily during some periods. They must be thoroughly cleaned before being accepted by a jurisdiction for maintenance responsibility. Leaves and litter must be removed from the inlet grating periodically to maintain flow capacity. *The water quality values of trapped catch basins cannot be achieved unless frequent cleaning occurs.*



TRAPPED CATCH BASINS

Local Implementation Options: The implementation approach primarily involves capital improvement plans and design-construction standards. In addition, an integrated operation and maintenance program is required and the use of trapped catch basins in appropriate areas should be included in surface water management/master planning.

WATER QUALITY INLETS, VAULTS AND TANKS

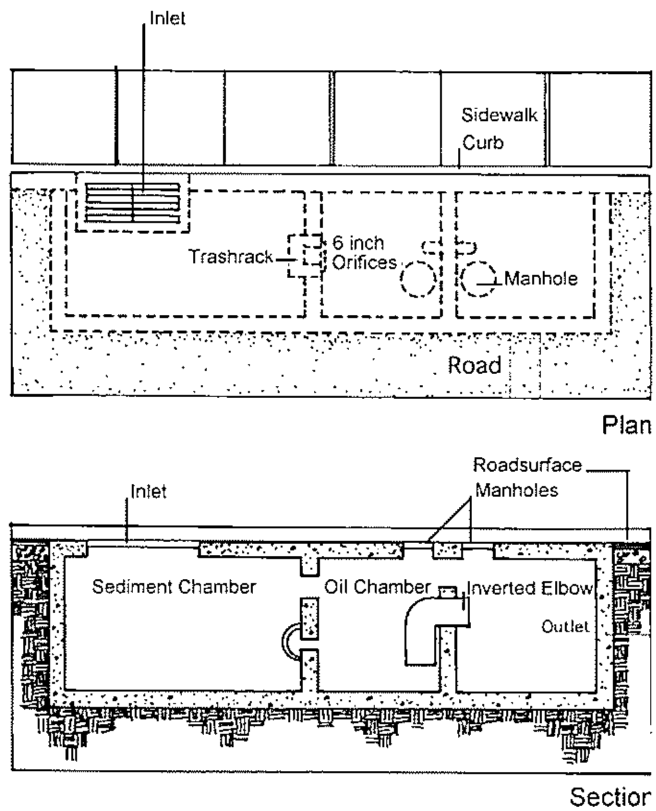
Description: Water quality inlets, vaults and tanks are underground storage facilities used to collect and store runoff, usually from urban, commercial, and industrial areas. However, they could be used in some agricultural areas such as below feed lots or manure storage areas. They are usually constructed from reinforced concrete or corrugated metal pipe. Some involve a permanent pool of water to allow for pollutant settling. Most are divided internally to control the water level, separate into removal chambers, and provide oil-water skimming.

Paramenters/Pollutants Potentially Addressed: Suspended solids and associated pollutants such as phosphorus and metals as well as oil and grease can be effectively removed by water quality inlets, vaults and tanks. Numerous design concepts exist including those which incorporate oil-water separation, so a range of pollutants can be addressed.

Advantages: The most important advantages are low land requirements, since the facilities are usually underground; the opportunity for prefabrication; and good information on performance and design.

Disadvantages: Compared to other street and storm sewer facilities, water quality inlets, vaults, and tanks require relatively high maintenance although less than that for a large wetland or marsh. In addition, the design of such facilities is often based on available hardware, rather than specific pollutant removal requirements.

Concept Variations: These facilities are very similar to sedimentation boxes and sedimentation manholes.



WATER QUALITY INLETS

Maintenance Requirements: Such facilities should be inspected at least twice a year. Maintenance may be required during both visits. The amount of accumulated material, and therefore the maintenance requirements, will vary according to annual precipitation-runoff patterns.

Local Implementation Options: The primary implementation approach involves capital improvement plans, design-construction standards, and an integrated operation and maintenance program. The facility should be evaluated and recommended if justified in jurisdictions stormwater management master plan.

SEDIMENTATION MANHOLES

Description: This facility is a concrete cylinder generally four to six feet in diameter and eight to twelve feet deep. It utilizes conventional concrete manhole structures designed and fabricated to trap sediments. They have been used extensively in the Portland area to intercept sediments prior to being discharged into a sump/dry-well. They are usually under the street or the adjoining right-of-way, and are not noticeable except for the manhole cover.

Paramenters/Pollutants Potentially Addressed: Suspended sediments and associated pollutants such as phosphorus and metals are reduced. In some cases oil and grease may also be intercepted.

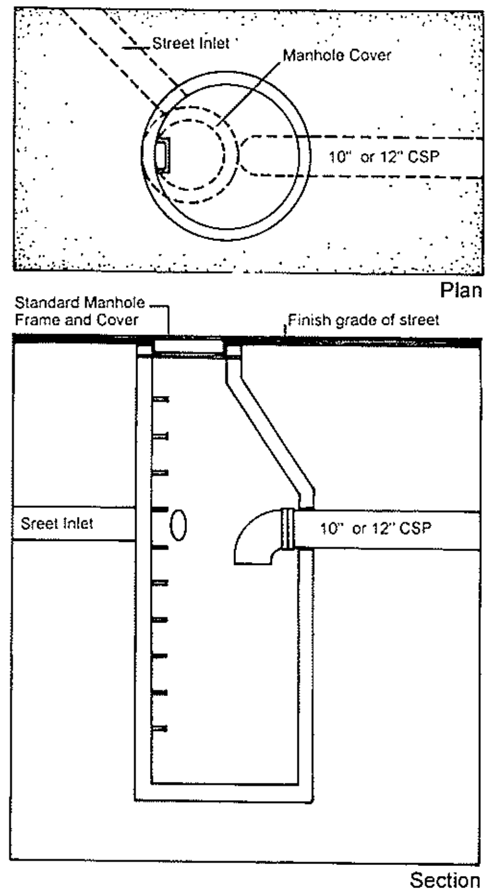
Advantages: Straightforward design, available technology and hardware, and low land requirements are advantages of sedimentation manholes.

Disadvantages: Sedimentation manholes require maintenance, although neither at the frequency of trapped catch basins nor to the degree of pond or marsh facilities. Although the design is relatively straightforward, opinions vary on water quality effectiveness.

Concept Variations: Sedimentation manholes provide the same type of function,— i.e., particle settling in quiescent water—as trapped catch basins, sedimentation boxes, and water quality inlets, vaults and tanks.

Maintenance Requirements: Twice annually as a general rule; more or less depending on pollutant loading.

Local Implementation Options: The use of sedimentation manholes should result from surface water management master planning. If included in the plan they should be included in the jurisdiction's capital improvement plans, design-construction standards, and operation and maintenance program.



SEDIMENTATION MANHOLE

COMPOST TREATMENT UNITS

Description: These facilities are rectangular, prefabricated boxes filled with leaf litter compost and intended to remove certain nutrients particularly phosphorus. Generally they are used to treat the runoff from street and highway sections or other large paved areas such as commercial parking lots.

Paramenters/Pollutants Potentially Addressed: Phosphorus, metals, and oil/grease can be effectively removed. Other parameters such as suspended sediments may be filtered out but this is not the intent of the facility and it may be counterproductive due to clogging of the compost.

Advantages: Good effectiveness for certain constituents if maintained regularly. The facilities can be installed in most highway right-of-ways.

Disadvantages: This is a relatively new and possibly proprietary technology. The maintenance requirements are uncertain. Clogging could be a problem if runoff with high suspended solids is involved.

Concept Variations: Several variations involve the type of compost and the size and layout of the facility. However, this is a relatively unique approach in NPS control involving biochemical activity to remove phosphorus and other nutrients.

Maintenance Requirements: Inspection should be made at least quarterly and maintenance operations performed when needed.

Local Implementation Options: The primary implementation option involves capital improvement plans coupled with design-construction standards and an O&M program. If such facilities are desirable in private developments, then the jurisdiction's comprehensive plan, land use regulations, and design standards would be involved.

STREET SWEEPING

Description: This street maintenance practice involves revising the schedule and type of street sweeping to remove particles from impervious surfaces. In some cases, the program may initiate street sweeping; but in most cases it involves a more frequent street sweeping schedule. The use of vacuum sweepers instead of conventional broom sweepers may also be needed. Street sweeping is generally used only in urban and suburban areas. The practice produces widely varying reductions of urban storm water pollutants.

Paramenters/Pollutants Potentially Addressed: Suspended solids is the main parameter removed. Attached phosphorus and heavy metals are also reduced.

Advantages: The primary advantages of the program is that it can be worked into existing maintenance operations and generally does not create significant adverse impacts on fish, wildlife or wetland resources.

Disadvantages: The primary disadvantages are the relatively high cost and uncertain effectiveness. Although improved stormwater quality has often been cited as the reason for more frequent street sweeping, data from various sources includes the EPA's National Urban Runoff Program do not indicate clear-cut improvements in water quality from more intensive street sweeping. This is particularly true in the Northwest, where washoff occurs frequently. However, the technique is being reconsidered and tried at certain northwest locations so new performance information specific to Oregon may be forthcoming.

Concept Variations: Street sweeping can be done with various kinds of equipment, generally involving broom sweepers, vacuum sweepers, and flush sweepers. The frequency of sweeping can also vary from two or three times per week to a few times per year. When water quality objectives are important, the range is generally form every two weeks to monthly, but this does not assure effectiveness.

Maintenance Requirements: Street sweeping is a component of urban street maintenance. More frequent sweeping for water quality objectives involves increased equipment maintenance.

Local Implementation Options: The primary implementation approach involves decisions during the surface water management planning process as to whether or not street sweeping should be emphasized. Implementation is through the jurisdiction's O&M program.

LANDSCAPE DESIGN

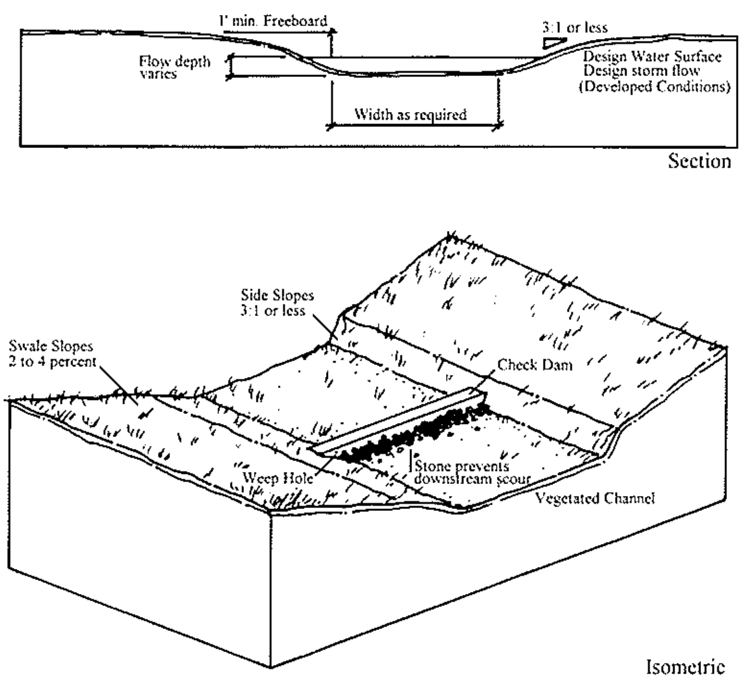
SWALES

Description: Vegetated or grassed swales are relatively flat vegetated ditches. The swale cross section is trapezoidal and the side slopes are usually at least three to one. The bottom width is at least three or four feet depending on design-runoff rates. The concept involves spreading runoff over a wide channel to provide biofiltering during low-to -medium-intensity storms. During higher flows the facility operates simply as a flood conveyance channel. Most facilities are at least 100 feet long and 15 to 20 feet wide at the top. Although they can be used to serve relatively large areas, and caused constructed as regional public facilities, they are most often used to serve private residential and commercial developments in urban areas. While they could also serve industrial, agricultural, and silvicultural areas, they are not generally used for such activities, since frequent maintenance and facility contamination could become problems.

Paramenters/Pollutants Potentially Addressed: Suspended solids and related pollutants such as phosphorus and metals are treated effectively with vegetated swales. Nitrogen can be removed. Oil and grease may be trapped, although a pre-treatment facility such as an oil-water separator is recommended if oil and grease loadings are expected to be high.

Advantages: This type of facility has been well researched in the Northwest. It is being extensively used, so the performance and design criteria are becoming well understood. The wildlife benefits can be good. In general, the water quality effectiveness is moderate to high.

Disadvantages: If an anadromous fish-bearing stream is involved, biofilters and swales can be problems due to the high width to depth ratio (shallow flow). In addition both land and maintenance requirements are relatively high.



VEGETATED SWALES

Concept Variations: The functions involved in swales or biofilters are similar to those of wetlands, but are not as complex. The same concepts are involved with filter strips.

Maintenance Requirements: Sediment should be removed whenever up to six inches accumulates at any location. Sediment must be removed in a manner to minimize damage to the vegetation. Swales should be inspected at least three or four times a year, particularly after heavy runoff, and mowed at least twice a year. In some cases, particularly during the establishment of the swale and during drought periods, watering may be worthwhile.

Local Implementation Options: Implementation should occur as the result of a surface water management/master plan and implemented through capital improvement plans, design-construction standards and O&M programs. If swales are desired in private developments, then the land use regulations of the jurisdictions should so indicate.

FILTER STRIPS

Description: Vegetated filter strips can be established along a stream, ditch, or other water body. However, their most effective and efficient implementation is to maintain buffer strips of natural vegetation. Either natural or constructed filter strips should incorporate riparian wildlife values and provide bank stabilization. Filter strips look like landscaped or natural vegetation along both sides of a waterway, lake, or wetland. Filter strips function similarly to vegetated swales, but primarily filter runoff entering the water body. Swales address the water flowing in the swale itself.

Paramenters/Pollutants Potentially Addressed: Suspended sediments are filtered out of runoff, and vegetation prevents bank erosion that would otherwise produce suspended sediments. When suspended sediments are removed, phosphorus, metals and other pollutants attached to the soil particles are removed. Oil and grease may also be removed, but if such pollutants are expected, pretreatment units such as oil-water separators should be installed above the filter. If temperature increases are possible, or if temperature reductions are needed in the watershed, filter strips should be integrated into riparian zone management, which includes an overstory to provide shading.

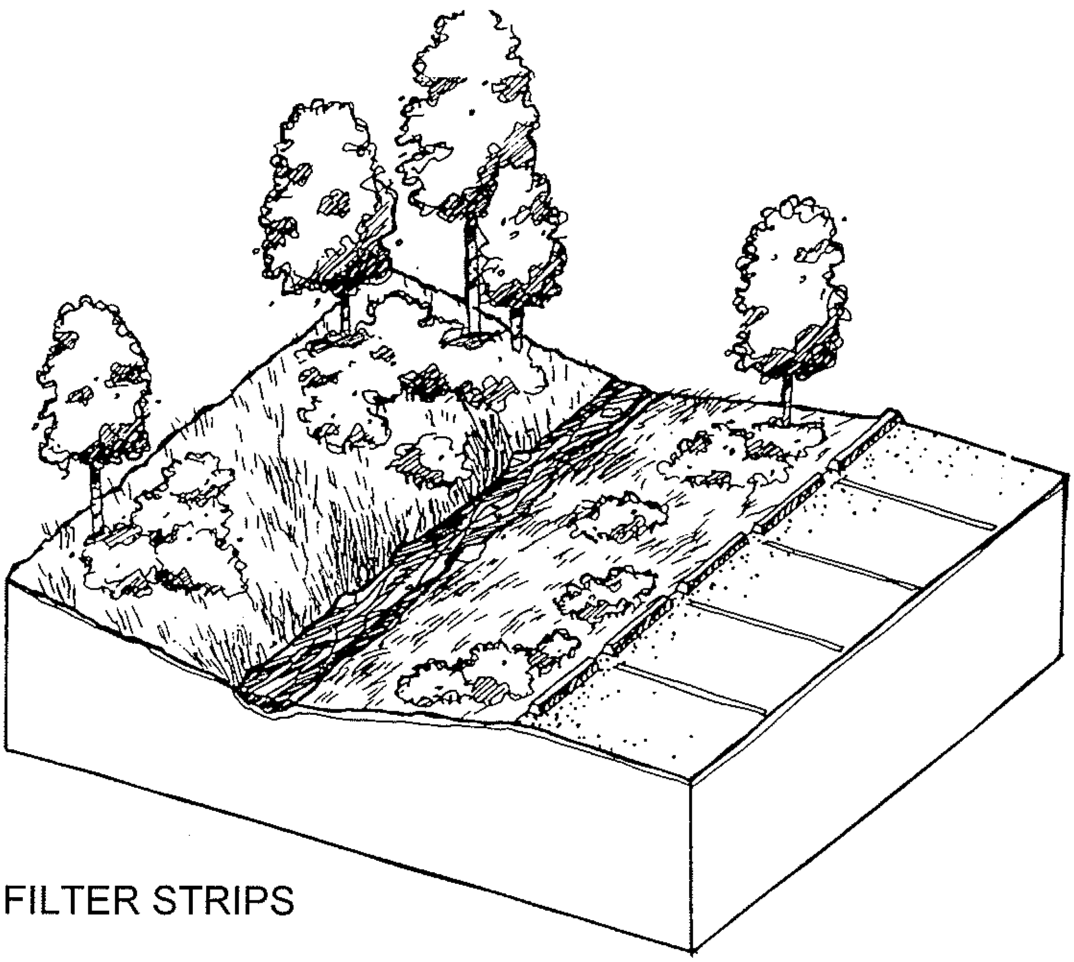
Advantages: Filter strips fit well into the landscape design of a community or site development. They can provide significant fish and wildlife benefits in addition to water quality improvement. Maintenance requirements vary but are generally low for natural filter strips. If large trees are included filter strips can also provide stream shading which helps to prevent temperature problems. Temperature is not addressed by most of the other control measures found in this guidebook. Filter strips can also be used in urban, agricultural, or silvicultural areas.

Disadvantages: Maintenance requirements can be complex and should be based on experience gained over a few years of observation. One of the most important disadvantages is disagreement concerning the ideal widths of filter strips. The necessary width varies according to the size and slope of the area draining into the filter strip and the land uses involved. In some cases the land requirements can be significant.

Concept Variations: Vegetated swales and bioengineered control measures that reduce bank erosion.

Maintenance Requirements: Filter strips in developed areas should be mowed at least twice in the summer to promote growth and pollutant uptake. The cuttings should be removed and properly disposed. For landscaped or developed filter strips, sediment accumulations exceeding six inches should be removed and curb cuts cleaned periodically to remove soil/vegetation blockages. Litter and debris should be removed. Inspections should occur quarterly. If the filter strip is natural, maintenance requirements should be minimal.

Local Implementation Options: An important local implementation option for protecting natural filter strips is the comprehensive plan and land use regulations. The requirements should be developed during surface water management/master planning. Retrofitting of waterways as required should be included in capital improvement plans and involve design-construction standards and O&M programs.



FILTER STRIPS

Section IV

CONTAINED DRAINAGE SYSTEMS

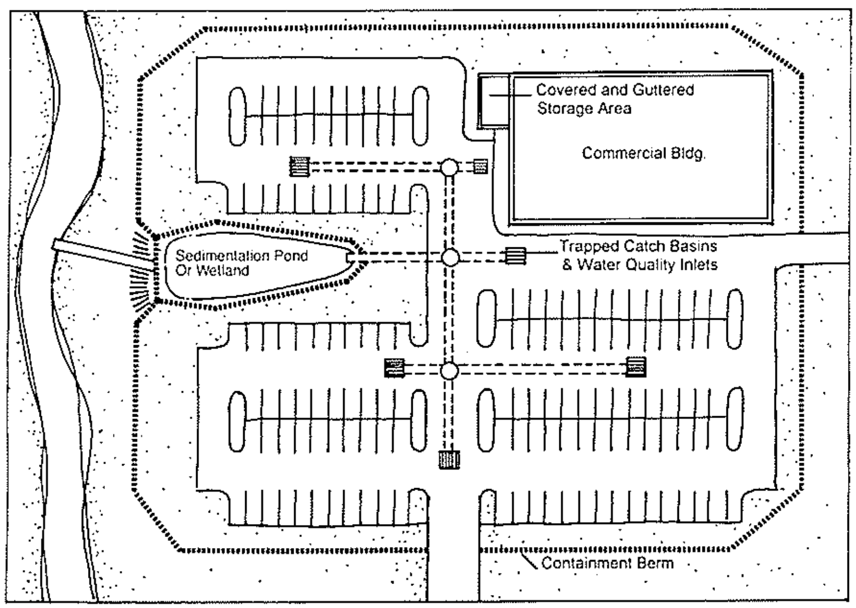
Description: In contrast to a facility concept, this is a system concept involving self containment of development site drainage. This can reduce the off-site impacts to natural or below natural conditions. Contained drainage systems can include facilities such as sedimentation ponds, marsh wetland treatment, infiltration facilities and vegetated swales to reduce the water quality and flooding impacts downstream. If infiltration is feasible, which depends on soil and geohydrologic conditions, the downstream impacts of the development can be reduced considerably.

Paramenters/Pollutants Potentially Addressed: Suspended solids and attached pollutants. Depending on the degree and type of containment, most pollutants can be reduced.

Advantages: Better planning and a system approach which can reduce the impact of a development of the watershed.

Disadvantages: Better and more costly planning and design is required. Maintenance must be done on a complete system basis, and this may cost more.

Concept Variations: Most of the facilities presented in this guidebook can be included in contained drainage systems.



CONTAINED DRAINAGE SYSTEM

Maintenance Requirements: Depends on the facilities involved. A system plan is required.

Local Implementation Options: The requirements and criteria for contained drainage systems should be included in comprehensive plans and land use regulations. The justification, recommendations, and specifics for such systems should be in the surface water management/ master plans for public systems. Capital improvement plans, design-construction standards and O&M programs are needed.

PONDS AND WETLANDS

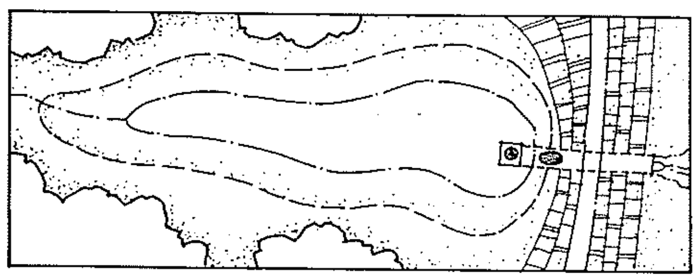
Description: These are small ponds or wetlands that have been included at the appropriate points in the design of a proposed development.

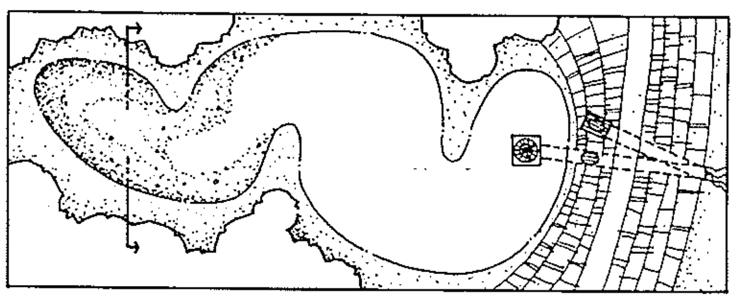
Paramenters/Pollutants Potentially Addressed: Suspended solids and associated pollutants such as phosphorus and metals.

Advantages: Such facilities can be incorporated into the landscape design as an amenity and the fish, wildlife and recreation values can be important.

Disadvantages: The disadvantages include the land requirements which on some sites can be significant, and the need for diligent periodic maintenance. Small ponds/wetlands can have disproportionately large maintenance requirements for the area served. Also, it is often tempting to design such facilities too small for private developments, and to ignore the geotechnical information requirements for design. Since ponds are involved safety considerations may also be a disadvantage for some locations.

Concept Variations: There are severa pond and wetland variations. They in volve on-stream versus off-stream loca tions, permanent or infrequent ponding the degree to which riparian or wetlanc vegetation is utilized, and the extent tc which multiple use values for fish, wild life, and recreation are achieved.





Maintenance Requirements: Such facilities will require cleaning and sedimen removal at least twice annually. Quarterly inspections should be made tc check the hydraulic function and general condition.

Local Implementation Options: The primary implementation approaches involve comprehensive plans, land use regulations, and a recommendation based on need identified in a surface water management/master plan.

EROSION CONTROL

Description: Erosion control involves preventive measures to reduce the delivery of sediments and other materials contributed to waterways as a result of surface erosion, mass erosion, stream bank erosion and debris torrents. In general the approach involves minimizing the size, season, and duration of soil disturbance and vegetation removal. Silt fences or straw bale perimeters are a common technique. Remedial measures such as sedimentation ponds below development areas may also be involved and the early re-establishment of vegetation and/or the use of a protective mulch is often required. The important concepts are to protect existing vegetative cover and natural slope stabilizing features such as plant roots. Considerable information is available on erosion control as practiced in Oregon and Appendix C presents additional information.

Paramenters/Pollutants Potentially Addressed: Suspended solids and associated pollutants such as phosphorus and metals.

Advantages: This is probably the most important approach to reducing the water pollution from all types of construction sites and agricultural/silvicultural areas. If erosion control is not practiced in an area then considerable investment would be needed in remedial measures such as sedimentation ponds and vegetated swales to realize the same values. If erosion control is not practiced the O&M requirements will be particularly high for most of the facility types presented in this guidebook.

Disadvantages: The primary disadvantage involves the cost at the front end of the development.

Concept Variations Erosion controls vary according to the type of stabilization emphasized, soils, slopes, the degree of emphasis on prevention as opposed to remediation, and whether they are based on performance standards or design standards are emphasized.

Maintenance Requirements: Any temporary filtering practice such as silt fences need to be inspected after storms. The maintenance required for most other control measures are reduced if erosion control is effective in the watershed above the measure. Erosion control requirements must be enforced and the performance monitored.

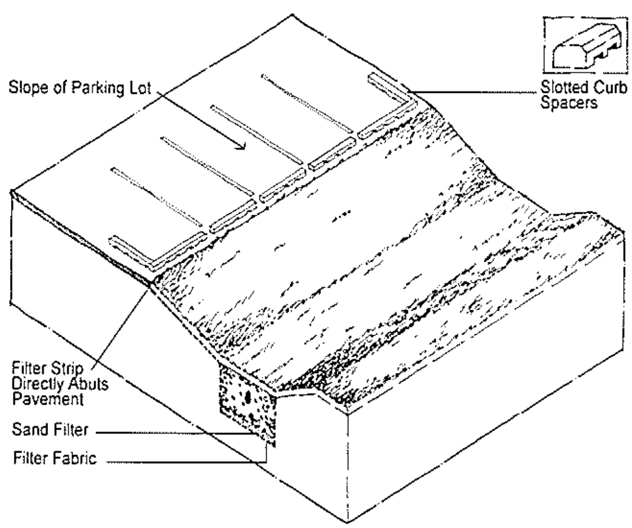
Local Implementation Options: The comprehensive plan, land use regulations, and surface water management/master plans are important for implementation. Special construction site erosion control ordinances and technical guidance handbooks are also needed.

INFILTRATION FACILITIES

INFILTRATION TRENCHES

Description: An infiltration trench involves a surface conveyance structure such as vegetated swale with a high infiltration capacity bottom. In some cases filtration is enhanced by installing a particular subsurface media. Most infiltration trenches are 5 to 20 feet wide and from 50 to 500 feet long, although any size is possible and should depend on the volume and nature of the runoff. Infiltration trenches can be used both in a regional stormwater conveyance system, and on residential lots. They can also be used effectively in commercial areas provided that the run-off is not expected to be contain hazardous or toxic materials. Infiltration trenches should not be used in industrial areas unless the trenches are completely protected from contaminated runoff. They are very similar in appearance to vegetated swales and function much the same as other infiltration facilities.

Paramenters/Pollutants Potentially Addressed: Infiltration facilities remove phosphorus and other pollutants which can be absorbed by the soil media. They will also remove suspended solids and attached pollutants such as heavy metals, but pre-treatment devices should be used to prevent suspended solids from plugging up the infiltration facility. Oil and grease can present similar problems, so oil-water separators should be used.



INFILTRATION TRENCH

Advantages: The primary advantage is good removal of pollutants such as phosphorus which are otherwise difficult to remove from stormwater. They are relatively straightforward to design but require good knowledge of subsurface conditions.

Disadvantages: The primary disadvantage is the potential effect on groundwater quality, which must be evaluated prior to design. Maintenance can also be high particularly if the runoff is fairly high in suspended solids, oil, or grease.

Concept Variations: Other infiltration facilities function very similar to infiltration trenches.

Section IV

Maintenance Requirements: The primary maintenance involves sediment removal, cleaning, debris removal, mowing, and a periodic check of the hydraulic function and facility condition. Maintenance inspections should be done monthly; most maintenance activities will be required once or twice annually.

Local Implementation Options: Infiltration trenches can be implemented through land use regulations that deal with site development, and through surface water management/master plans that specify publicly owned regional facilities. Public facilities must be implemented through capital improvement plans. Design and construction standards and O&M programs are necessary.

DRY WELLS

Description: A dry well is a vertical, perforated cylinder below the ground surface used to infiltrate water into the soil or lithic zones. They can vary in depth from four or five feet up to thirty feet, which is the depth commonly used in the Portland area. The diameters are generally from a few feet up to five or six feet. Standard manhole sections that have been perforated are commonly used. Dry wells are used in many locations but particularly in urban and suburban areas. For example, there are several thousand in the East Portland-mid-Multnomah County area. Dry wells function similarly to other infiltration facilities, but utilize depth rather than length on the ground.

Paramenters/Pollutants Potentially Addressed: Dry wells can do a good job of removing many pollutants, in particular dissolved phosphorus which is difficult to remove through other types of nonpoint source control facilities. They can also remove suspended solids and associated pollutants such as metals. However, pre-treatment facilities to remove suspended sediments and oil and grease should accompany all dry well installations. Commonly used for this pre-treatment in the Portland area are "sedimentation manholes" which are smaller concrete, vertical cylinders below the surface designed to provide a quiescent zone for settling out particles.

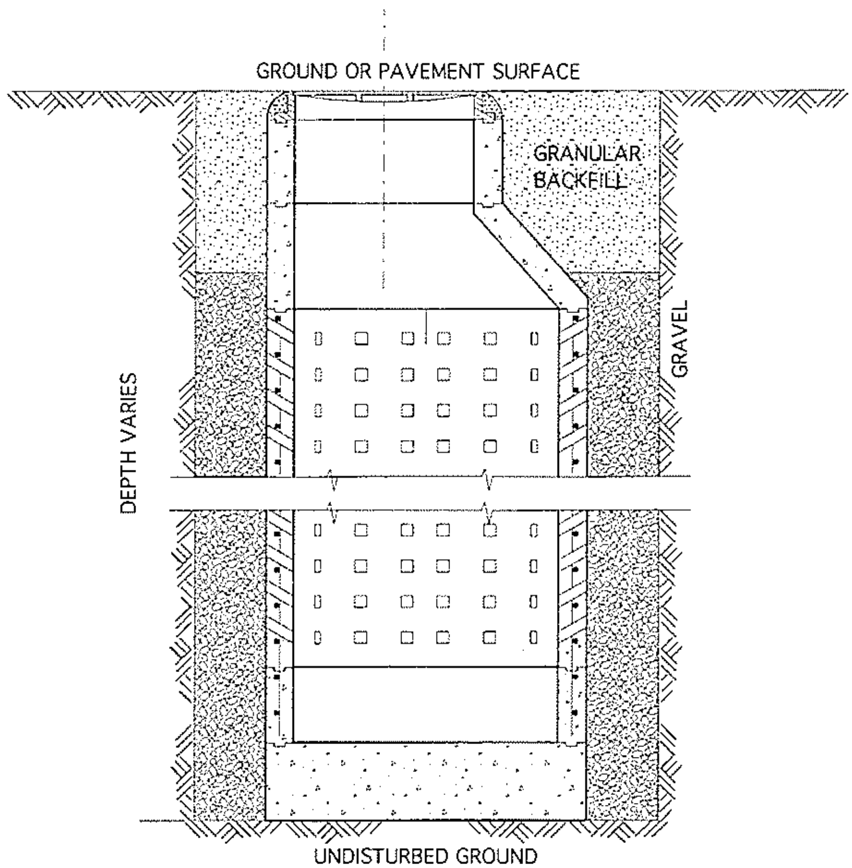
Advantages: Dry wells generally do not affect fish and wildlife. They are usually in the public right-of-way, so land requirements are often not high. They are relatively straightforward to design if the subsurface infiltration capacity is known. They can be very effective in removing dissolved phosphorus and other parameters.

Disadvantages: Potential groundwater contamination is the primary disadvantage of dry wells. They should not be used in industrial areas. They are appropriate for most residential areas and some commercial areas. Maintenance can also be a disadvantage although the structural nature of the facility allows relatively efficient maintenance. They should not be used if groundwater sources of drinking water will be adversely affected. Coordination with well head protection planning is important.

Concept Variations: All the infiltration facilities function in a manner similar to dry wells. Dry wells which are designed for peak flow management, i.e., ten year flood flows, must have a much higher infiltration capacity than those designed for water quality management. In general, water quality dry wells are designed for flows which are expected to be exceeded once or twice per year so the design flow level is considerably less than for flood peaks. Overflow conveyance systems are required if the dry well cannot accept the 10 year flow.

Maintenance Requirements: Maintenance requirements will vary depending on the nature of the drainage area served by the dry well. If the pre-treatment facility such as a sedimentation manhole is effective, dry wells may go years without needing to be cleaned. However, they must have a portal for maintenance access; during the first year or so, bi-monthly inspections are recommended with maintenance as required.

Local Implementation Options: The use of dry wells is a significant community issue in most locations and should be addressed in both the surface water management plan and the comprehensive plan for the area. Wellhead Protection programs of the local drinking water agencies should be considered before using dry wells or other infiltration facilities. Dry wells should be included in the capital improvement plans; density, number of installations, and the general locations should be noted. Design and construction standards are needed. A sound operation and maintenance program is required.



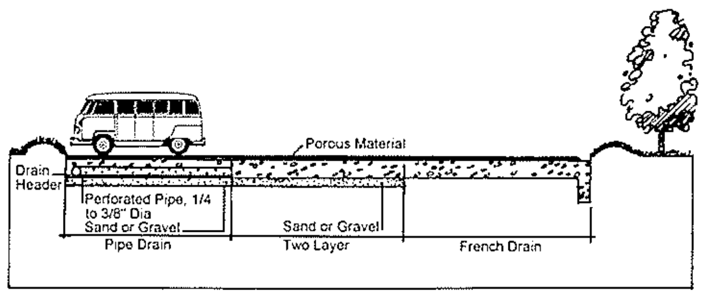
POROUS PAVEMENT

Description: Porous pavement appears the same as standard asphalt or gravel pavement but the material is designed to accept water much more readily than other similar surfaces. An infiltration gallery is usually constructed below the porous pavement to enhance the infiltration capabilities of the facility. Porous pavement is most appropriate for low-use portions of commercial parking lots, for driveways, and for low intensity use roadways. Compared to other infiltration facilities, porous pavement relies on a horizontal infiltration zone at or just below the ground surface as compared to dry wells which rely on infiltration from a vertical cylinder.

Paramenters/Pollutants Potentially Addressed: As with other infiltration facilities, porous pavement can do a good job in removing a wide range of pollutants particularly dissolved phosphorus. If much oil, grease or sediment is involved the porous pavement may plug up.

Advantages: The primary advantages are the effectiveness in removing certain pollutants such as dissolved phosphorus, and the relatively easy integration into normal urban development projects.

Disadvantages: Disadvantages include the effect on groundwater quality, the potential for clogging, and the associated maintenance requirements. Maintaining porous pavement can be particularly difficult if it serves a drainage area with a lot of disturbed soil surfaces.



Concept Variations: There are a number of types of porous pavement, primarily involving gravel or asphalt surfaces. All should have an infiltration chamber beneath the pavement surface.

Maintenance Requirements: The maintenance of porous pavement involves monthly inspections which focus on the amount of accumulated sediment and oil or grease. Resurfacing and patching are needed periodically. Accumulated sediments and oil/grease must be removed. Debris should be periodically cleaned. During storms the hydraulic function should be checked. The pavement condition should be reviewed annually.

Local Implementation Options: Porous pavement should be addressed in both surface water management/master plans and transportation plans for the jurisdiction involved. In addition, the wellhead protection plans of the local water purveyors should be considered and integrated into the planning. Where porous pavement use is designated, design-construction standards should be developed. The capital improvement plan is involved for public projects, and O&M programs are needed.

PONDS AND WETLANDS

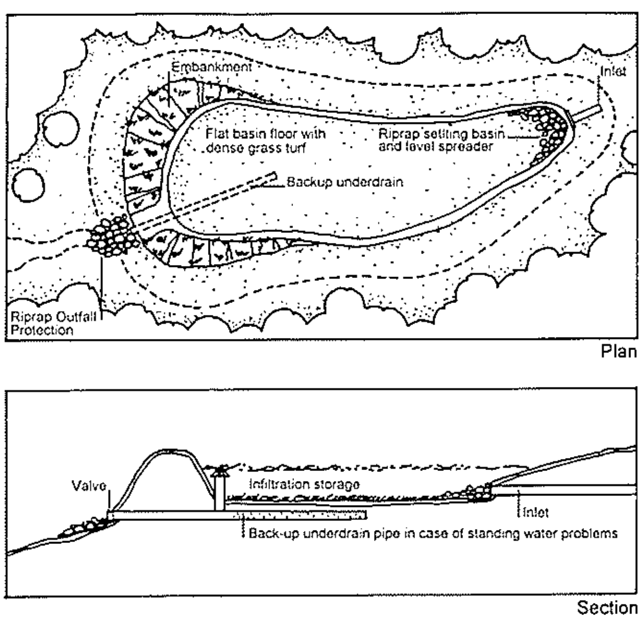
Description: Infiltration ponds and wetlands look exactly like their non-infiltrating counterparts, but they are designed to enhance infiltration into the subsurface. One difference is that they will probably be dry often. They can range from less than half an acre up to twenty or thirty acres and larger.

Paramenters/Pollutants Potentially Addressed: An infiltration pond or wetland will remove dissolved phosphorus, which is difficult to remove in conventional wetlands or ponds. Ponds or wetlands can have their water quality effectiveness enhanced considerably through infiltration, if the soil will allow adequate infiltration, and if no adverse groundwater impacts are anticipated.

Advantages: Comprehensive and effective pollutant removal is the main advantage of infiltration ponds and wetlands.

Disadvantages: The primary disadvantages are potential groundwater impact and the regulatory difficulty of getting all of the issues resolved. Maintenance requirements can also be considerable, especially if the drainage area produces a lot of sediment. Land requirements are also significant. Safety considerations must be evaluated.

Concept Variations: Infiltration ponds and wetlands are variations of wet ponds, sedimentation ponds, marsh-wetland treatment units, and other pond and marsh type facilities.



INFILTRATION POND

Maintenance Requirements: Maintenance requirements can be significant. They involve sediment removal; cleaning; debris removal; management of wetland, riparian, and landscape vegetation; and periodic checks of hydraulic function and facility condition.

Local Implementation Options: The primary implementation approaches involve surface water management/master plans and in some case comprehensive plans. To implement the planning, public facilities of this type must be included in the capital improvement plans. Design and construction standards and O&M programs are required.

ROOF DRAINS

Description: Roof drains are the smallest type of infiltration facility presented. They are small infiltration galleries at the end of a roof drain pipe. They are particularly appropriate for residential areas where infiltration capabilities are suitable. They can also be used in industrial and commercial areas, but runoff should be sampled to ensure that industrial pollutants do not create contamination problems.

Paramenters/Pollutants Potentially Addressed: Roof drains, if extensively used, can reduce runoff velocities and therefore reduce downstream channel erosion.

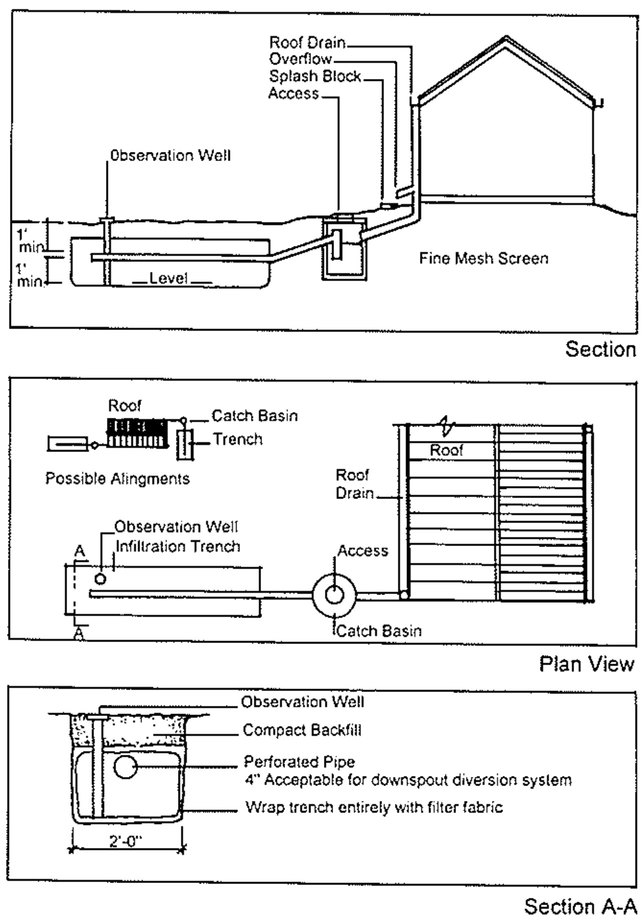
Advantages: If designed right infiltrating roof drains should have relatively low maintenance requirements and reduce the volume of runoff that downstream stormwater facilities will have to treat. They can also be relatively easily integrated into urban areas.

Disadvantages: The groundwater impacts must be anticipated. Local geohydrological evaluation is necessary.

Concept Variations: Infiltrating roof drains are a variety of infiltration facility and function in a manner similar to the rest.

Maintenance Requirements: The most unique maintenance requirement would be annual sampling of roof runoff quality from the larger commercial or industrial facilities. Inspection of the roof condition and occasional reconstruction of the infiltration media may be required.

Local Implementation Options: The primary local implementation option would be land use regulations and design-construction standards since most, if not all, of the opportunities would be in private developments.



ROOF DRAIN INFILTRATION SYSTEMS

CHEMICAL APPLICATIONS

HERBICIDES AND PESTICIDES

Description. Herbicides and pesticides are often used to control weeds, fungi, and insects. In many cases, herbicides and pesticides are mixed and applied with fertilizer. Overuse of pesticides can have a significant impact on water quality since many herbicides and pesticides are toxic to aquatic life.

Paramenters/Pollutants Potentially Addressed. The primary pollutants affected include potentially toxic chemicals, solids, and nutrients from fertilizers.

Advantages. Managed chemical applications save money, since the application rate and timing are calibrated to crop needs.

Disadvantages. Balancing crop requirements with application rates requires frequent crop monitoring.

Concept Variations. The primary methods include application rate controls, placement, and timing, and method of application. Application rate controls refer to balancing the crop requirements with the application rate. The method of application includes such activities as in-furrow applications or broadcasting followed immediately by soil incorporation. The principal idea is to incorporate the herbicide or pesticide into the soil immediately after application to prevent surface water contact and subsequent runoff from the exposed soils. This method has limited use since many chemicals are applied directly to the crop surface rather than incorporated into the soil. Timing of applications is important in maintaining the maximum time interval possible between chemical applications and runoff events. Timing according to the life stage of the pest can also preclude repeated applications. Integrated pest management (IPM) is an important approach to reducing the need for pesticide use.

Maintenance Requirements. The equipment must be maintained and calibrated after each use.

Local Implementation Options. Technical assistance is available through the local soil and water conservation district. Direct local requirements can be established for many source types. Instructions for pesticides are always on the container, and departure from the instructions may be illegal.

FERTILIZERS

Description. Overuse of fertilizers containing phosphorus and other nutrients can significantly increase the nutrient levels carried in surface water. Erosion of soils also contributes nutrients that were introduced to the soil by fertilizers. Phosphorus loading in surface water runoff and eroded soils increases with application rates and high phosphorus levels in the soil.

Paramenters/Pollutants Potentially Addressed. The primary constituents affected include nutrients, solids, and fecal coliform.

Advantages. The primary advantage of fertilizer management techniques is that balancing soil nutrient requirements with application rates presents a cost savings.

Disadvantages. Balancing soil requirements with application rates requires soil testing and monitoring to determine the soil condition.

Concept Variations. The primary methods available include application rate controls, placement and method of applications, and timing of application. Application rate controls refer to balancing the soil nutrient requirements with the application rate. The method of application includes such activities as in-furrow applications or broadcasting followed immediately by soil incorporation. The objective is to incorporate the fertilizer into the soil immediately following application to prevent storm water contact and subsequent runoff from the exposed soils. Timing is necessary to assure application at the time of maximum plant uptake.

Maintenance Requirements. The equipment must be maintained, calibrated, and replaced.

Local Implementation Options. Technical assistance is available through the local soil and water conservation district, and direct requirements can be established for many source types.

INDUSTRIAL AND COMMERCIAL SITES

ILLICIT CONNECTIONS

Description: Stormwater conveyance systems often receive discharges from industrial, commercial, and residential areas which carry pollutants at levels of concern. Examples include drainages from wash down areas, internal floor drains from plant complexes, sanitary sewer connections, and the infiltration of groundwater carrying pollutants from septic tanks, storage tanks, or leaky sewer systems. The EPA has concluded that illicit connections can have a significant effect on receiving water quality. EPA has targeted the elimination of such connections as one of the more important goals of the NPDES stormwater regulations. A program to eliminate illicit connections involves identification of such connections and local ordinances which require their diversion to other treatment/disposal systems. This involves water quality monitoring of the system, which can be complex and should include an inventory of industrial, commercial, and residential sources where such connections could originate. Community development records, industrial NPDES information, RCRA related permits/licenses, DEQ records, and analysis of aerial photographs can all be used as sources of such information.

Paramenters/Pollutants Potentially Addressed: Metals, oil and grease, BOD, bacteria, industrial and agricultural chemicals, nutrients, and suspended solids can all be involved. Priority pollutant scans as defined by the EPA may be appropriate if industrial/agricultural sources are suspected. In some cases, sediment sampling and/or fish tissue analysis may provide useful information to identify illicit connections.

Advantages: Eliminating illicit connections reduces pollutant loads at their source and places the remediation cost on the responsible parties. After agreement has been reached with the responsible parties, the cost to the public is minimal except for enforcement and program monitoring.

Disadvantages: The disadvantage of eliminating illicit connections is that the cost to identify connections can be high.

Concept Variations: The elimination of illicit connections is a unique aspect of nonpoint source management. A related concept is the containment of spills and runoff from industrial and commercial sites.
Maintenance Requirements: Once illicit connections have been eliminated the public agency requiring such elimination should monitor the water quality, and possibly sediments, below the former illicit connection and also periodically inspect the system to ensure that it remains "disconnected".

Local Implementation Options: Eliminating illicit connections should be part of a surface water management program. Special ordinances are generally required to establish source control programs and industrial and commercial site owners should be provided with guidance regarding the elimination of illicit connections. Work sessions with the various parties early in the process may eliminate some of the potential controversy. Inspections of the eliminated sources should be included as part of the organization's O&M program.

CONTAINMENT OF HIGH RISK AREAS

Description: The containment of contaminated, or potentially contaminated, runoff from commercial and industrial sites involves the use of containment gutters and sumps, berms, roofing of potential source areas, catchment vaults where spills can be stored and removed, emergency response programs, and storage/runoff-delay facilities. The concept involves diverting precipitation from any hazardous materials stored on a site by covering use and storage areas. In addition, the runoff from sites of concern is contained through the use of berms and runoff control facilities. The goal is to avoid contaminating runoff after fires, spills, or leakages with chemicals that would be of concern if permitted to enter the stormwater system surface or groundwater bodies. Potential contaminants are prevented from being exposed to precipitation and runoff. In case of a fire, the runoff is diverted and contained for at least a specified period such as three to six hours, or some assumed storm period or spill/release occurrence (i.e., a fire).

Paramenters/Pollutants Potentially Addressed: Nutrients, suspended solids, and industrial and agricultural priority pollutants involving categories such as solvents and fuels.

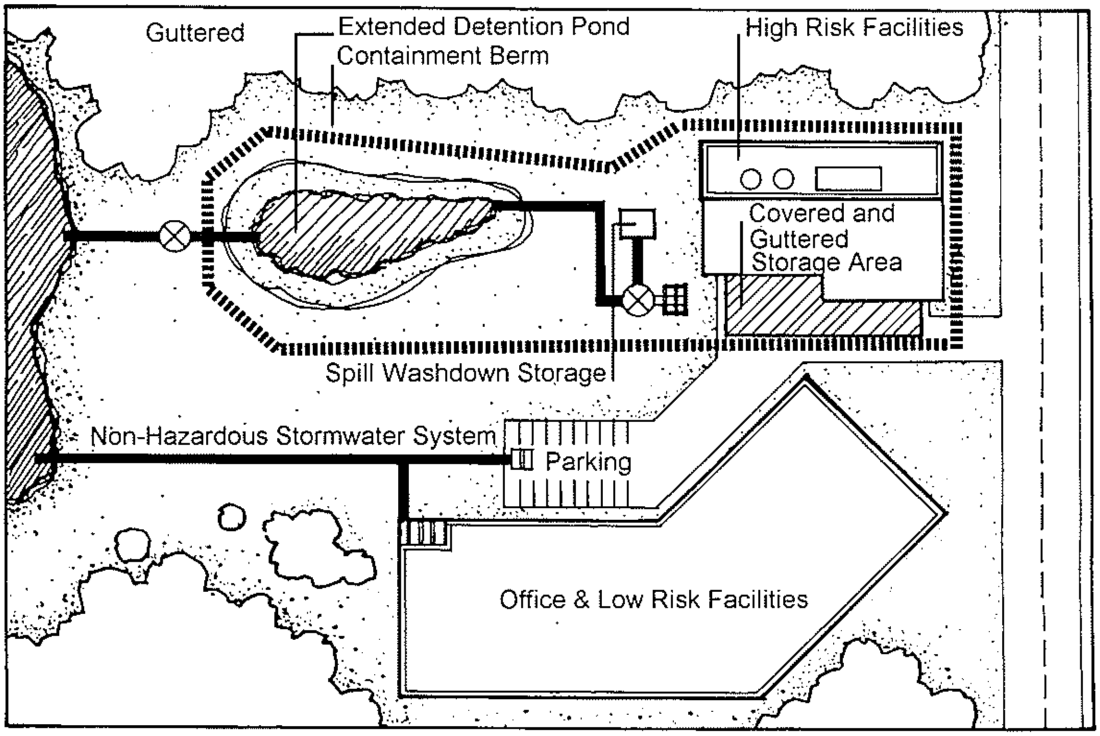
Advantages: The most important advantages of containing contaminated runoff through site planning and design are that potential problems are addressed at the source, and the responsibility for spills is placed on the owners/operators. Furthermore, difficult clean up problems associated with industrial sites such as groundwater contamination can be prevented.

Disadvantages: Containment of contaminated runoff is relatively easy if incorporated into the design of new industrial/commercial sites. The primary disadvantage is in retrofitting existing facilities since the cost associated with plant redesign and reconstruction may be high. The effect of the cost on small businesses may be significant.

Concept Variations: The main concept variation is eliminating illicit connections. However, the two concepts are not mutually exclusive; that is both are needed. Emergency response procedures are a necessary part of a containment program, but they should not be relied on exclusively. Good containment facilities can significantly reduce the risk of spills.

Maintenance Requirements: The maintenance requirements involve inspection of the site during and after construction or retrofitting, and then periodic monitoring. It is advisable to include sediment sampling in the watercourse immediately below the point of discharge of the containment site to determine if releases are occurring. Such monitoring should be done on an annual basis and after any emergency or cleanup occurrence at the site.

Local Implementation Options: Requiring the containment of contaminated runoff requires special ordinances but should also be designated in the comprehensive plan and various land use regulations/overlays that cover the area. These may include environmental zone overlays or industrial development overlays. The need for such programs should initially be identified in the surface water management/master plan and design-construction standards are needed. The jurisdictions O&M program should provide for periodic inspection and monitoring.



CONTAINMENT OF HIGH RISK AREAS

MONITORING AND MAINTENANCE

Description: All of the local programs which address nonpoint sources associated with commercial and industrial sites should include monitoring and maintenance as high priority budget items. The recommended monitoring should include priority pollutant scans, monitoring for the chemicals which may be present within and below each specific site, and tissue and sediment sampling below the site. The monitoring program should include both system-wide surface water and groundwater components and grab sample sites above and down gradient from each facility location. Sediment samples can indicate whether occasional release have occurred which would not be detected in system-wide water quality monitoring, and fish tissue sampling can provide the same type of information.

Paramenters/Pollutants Potentially Addressed: The monitoring should include nutrients and suspended solids but the more important parameters are priority pollutants, metals, oil and grease and the chemicals expected at the specific industrial site.

Advantages: Monitoring is critical to making industrial and commercial site programs work and that is its key advantage.

Disadvantages: The disadvantage of monitoring and maintenance related to industrial and commercial sites by public agencies is that the cost is continual and such programs are often the target of budget cutbacks.

Concept Variations: The primary variation to public monitoring and maintenance is to legally require the site owners to provide for monitoring and maintenance on their site, and possibly for the water systems potentially impacted by their site.

Maintenance Requirements: Monitoring equipment must be periodically updated and replaced.

Local Implementation Options: An operation and maintenance program must be defined and funded by the jurisdiction. Periodic maintenance of facilities, generally by the site owner, is essential and this can sometimes be provided by a public agency under contract.

EMERGENCY RESPONSE

Description: Emergency response involves specialized equipment and a team of specialists who are experienced with hazardous materials and responding to releases of contaminants. Such release might occur due to fires, spills, leaks, train or truck accidents, and illegal release. Emergency response may be the responsibility of the police department, the fire department, or special units of the jurisdiction. It might be provided for by an industrial park or commercial area, and for very large industrial sites by the owner/operator of the facility. The response procedures involved are too complex to present in this guidebook. They involve a notification system, a certified trained response crew, periodic recertification, transportation and material transport vehicles, cleanup procedures, personnel protection gear, special equipment/materials, the removal of contaminated materials, and safe disposal.

Paramenters/Pollutants Potentially Addressed: Primarily priority pollutants.

Advantages: Emergency response presents numerous advantages for site management. It is also a necessity for all industrial and transportation areas where chemicals are involved and for most commercial areas. The concept involves remedial action after a problem has occurred but such programs are essential.

Disadvantages: Cost is the primary disadvantage to an emergency response program. Cleanup costs are high and some of the contamination will be missed because of timing or detection constraints.

Concept Variations: The primary concept variations involve who pays the cost of such programs and provides the crews and equipment. Local jurisdictions should have at least a basic emergency response plan with designated personnel and the minimum equipment required. But much of the burden can be placed on the owners and private companies which specialize in emergency response.

Maintenance Requirements: The maintenance requirements involve periodic personnel training, equipment replacement and maintenance.

Local Implementation Options: Special local ordinances are usually required to initiate emergency response programs and performance standards are important.

AGRICULTURAL AREAS

LIVESTOCK MANAGEMENT

Description. Livestock holding areas such as barnyards, corrals, and pastures can contribute significant levels of nutrients to receiving waters. The magnitude of the effect of these sources depends on the size of the area, number and type of animal, and the location of the area with respect to receiving waters. Management practices emphasize minimizing stormwater contact, containing contaminated stormwater, runoff treatment systems, reduced livestock densities, and eliminating access to sensitive areas.

Paramenters/Pollutants Potentially Addressed. Livestock management practices are designed to control nutrients, solids, and fecal coliform.

Advantages. The primary advantages involve the simplicity of the relatively non-structural measures which can be achieved through changes in management techniques.

Disadvantages. The success of livestock practices depends on local landowner commitment. Limits on livestock densities or containment/treatment facilities, will be controversial.

Concept Variations. Variations of livestock management include minimizing storm water contact with livestock wastes, containing contaminated storm water, and treatment practices. Minimizing storm water contact can be achieved with covered manure storage areas, piped drainage systems around barnyards, and piped roof drains. Containment of contaminated storm water focuses on detaining contaminated water until it can be treated and discharged. Treatment practices include fencing, water reuse, sedimentation facilities, biofilter strips adjacent to water courses, and underground storage with land application of manure. Limits of livestock densities may also be effective in controlling overgrazing and subsequent erosion.

Maintenance Requirements. Livestock management systems require varying levels of maintenance activities. Activities could include fence repair, periodic cleaning of the storage tanks and treatment systems, and sediment removal from drainage facilities.

Local Implementation Options. The primary local role in addressing agricultural NPS involves land use regulations to protect stream corridors and local ordinances regarding management activities and livestock densities.

BULK MATERIALS MANAGEMENT

Description. Bulk materials management refers to the management of manure and other bulk materials such as silage commonly found within agricultural areas. The principal activities associated with bulk materials management are containment and land application

Paramenters/Pollutants Potentially Addressed. The pollutants controlled through these systems include solids, nutrients, and fecal coliform.

Advantages. Containing wastes to prevent storm water contact is effective in preventing pollutants from being carried into the receiving water body.

Disadvantages. The main disadvantage of bulk materials storage is that a relatively significant capital investment is usually required to install containment and land application facilities.

Concept Variations. Variations include waste management facilities such as tanks, pits, settling basins, and adequately covered storage to prevent discharges of waste to surface waters. Nutrient application practices are necessary to prevent "over-fertilization."

Maintenance Requirements. Maintenance requirements include periodic inspection and repair of pumps, piping, and storage facilities.

Local Implementation Options. Guidelines and specifications for the planning, construction, and siting of manure storage facilities are contained in the Oregon Animal Waste Installation Guidebook. Technical assistance is available through Soil and Water Conservation Districts. Local requirements could be adopted.

RIPARIAN AREA PROTECTION

Description. This involves protecting stream banks and a vegetated riparian buffer associated with surface water bodies. Riparian areas provide a natural bio-filtration system along stream banks, wetlands, and other water bodies. These areas dissipate energy, reduce erosion, and enhance sediment deposition. Riparian buffers in developed areas are established and maintained through local development ordinances. Preservation of undeveloped corridors can be achieved through land use regulations and greenspace programs.

Paramenters/Pollutants Potentially Addressed. Riparian areas remove suspended solids and associated pollutants such as phosphorus. Shade provided by riparian vegetation also improves temperature conditions within the stream.

Advantages. The primary advantages of riparian area management involves water quality, fish, wildlife and the restoration/preservation of stream side corridors.

Disadvantages. Protection of riparian areas sometimes requires removing land from agricultural use.

Concept Variations. Filter strips and vegetated swales are similar.

Maintenance Requirements. Trash and debris may need to be removed.

Local Implementation Options. The primary local implementation options involves education, land use regulation, surface water management/master plans. Local programs might also involve riparian area land purchases and green spaces programs.

TILLAGE MANAGEMENT

Description. In some areas, cultivation or tillage is the major cause of agricultural soil erosion. Tillage practices can increase soil losses through storm runoff and wind erosion. Tillage management refers to techniques used to reduce the erosive effect of water on exposed soils.

Paramenters/Pollutants Potentially Addressed. Tillage management is designed to control soil erosion and sediment which deposit in receiving waters. Pollutants which attach to soil particles including fertilizers, herbicides, and pesticides are also controlled.

Advantages. Tillage management reflects a change in farming techniques which in the long run will benefit the local farmer rather than a structural modification .

Disadvantages. Changes in tillage practices are difficult to achieve through education alone.

Concept Variations. Several variations of tillage methods are currently in use throughout the western states. Conservation tillage, which leaves some or all of the previous year's crop residue on the soil surface, is effective in controlling soil erosion. The degree of control is closely related to the percentage of the soil surface covered with residue. Contour farming, where crops are alternated with cultivated strips is also effective in capturing eroded soil particles. Several variations are available, including strip cropping, block farming, wind strip cropping, and buffer strip contouring.

Maintenance Requirements. Not applicable

Local Implementation Options. The primary implementation options involve education, land use regulations and local soil and water conservation district involvement. A tillage management plan which outlines tillage methods and practices may be designed to aid farmers in the implementation of the most effective tillage for their particular topographic and crop features.

CONTAINER NURSERY MANAGEMENT

Description. Runoff from container nurseries often contains high levels of nutrients from the application of chemical fertilizers. Water quality management techniques for these operations emphasize containment of the growing and storage areas, water reuse, and water conservation.

Paramenters/Pollutants Potentially Addressed. Nutrients, herbicides, insecticides, and suspended solids.

Advantages. The activities presented within this section may represent cost savings for the nursery operator through a more cost efficient operation.

Disadvantages. Many of the management systems require a relatively large capital investment to install.

Concept Variations. The variations used in container nurseries emphasize three concepts: containment, water use control, and water reuse. Containment is designed to separate contaminated stormwater and irrigation water from "clean" water, thereby reducing the volume of stormwater requiring treatment. Clean water diversions are achieved by installing facilities to intercept and divert water from rooftops, roadways, and upslope areas. Water use control focuses on minimizing the amount of water used for irrigation, thereby reducing the volume requiring treatment. Typical practices include increasing the frequency while reducing the volume of irrigation water applied in a single application; installing drip or microjet irrigation systems; and the use of timers and sensors to control application timing. Water reuse practices are designed to reduce water use by reusing irrigation water and contaminated stormwater. A wastewater recovery system can be installed to collect and redistribute irrigation water.

Maintenance Requirements. Container nursery management methods require varying levels of maintenance depending on the type of system. Containment and treatment facilities require periodic cleaning and inspections.

Local Implementation Options. Guidelines and specifications for the planning, construction, and siting of nursery facilities are available through the local Soil and Water Conservation District. The activity can be addressed in surface water management and water quality plans, and through water quality ordinances.

FOREST HARVEST

ROAD AND SKID TRAIL SYSTEM STANDARDS

Description: For this discussion road and skid trails for tracked or rubber tired skidders are considered to have the same types of impacts and involve the same types of controls. The road and constructed skid trails generally exert the greatest impact associated with forest harvest activities on water quality due to the soil exposure and erosion-sedimentation that results.

Forest harvest requires development of a primary and secondary road system, and the density and configuration depend on the logging method to be used. Some methods such as jammer-logging require a very dense road system while other methods such as skyline logging minimize the road density. Road and skid trail system requirements can be generally categorized as follows:

- Minimizing , and possible limits on the density of roads per square mile (e.g., feet per square mile).
- Constraints regarding the soil types and slope steepness on which roads can be constructed.
- Filter-zone strips, and in some cases no disturbance zones, along each stream (refer to the Stream, Lake and Riparian Area Protection section).
- Design and layout of skid trails to reduce the water quality impacts, and in some cases limits on the skid trail density.
- Water quality design constraints for, or prohibition of, stream crossings.
- Abandonment of forest roads and skid trails after logging is completed that are not needed for critical management purposes..
- Limits on the total width of the road prism (including the fill slope, roadway surface and cut slope).
- Road use and maintenance limitations to reduce the re-establishment of fine surface materials available for erosion, and water quality sensitive road maintenance.
- Low volume overflow sections for road fills at high risk culverts to minimize problems associated with fill blowout during major runoff events.
- Guidelines or requirements for water control structures such as cross drains, culverts, water bars, driveable dips or diversion ditches to minimize erosion on the road bed, cut bank and fill slope.
- Soil stabilization and re-vegetation for cut and fill slopes.
- Design standards which address items such as soil compaction, moisture conditions, haul/side casts, waste disposal, subgrade design and water control structures.
- Limits on landing area coverage and design:
- Limits on road surface treatment of oils and other chemicals.

Most forest harvesting operations address these considerations to one degree or another but the level of constraint and enforcement of the requirements are important to water quality success.

Paramenters/Pollutants Potentially Addressed: The parameters primarily involved in road and skid trail sources are suspended solids (eroded soil) and associated chemicals such as phosphorus or metals. Due to equipment use, maintenance oil and grease and other industrial chemicals could be involved, as well as the full range of silvicultural chemicals.

Advantages: The primary advantage is control over the major source of erosion-sedimentation from forest harvest activities. There are associated benefits such as for wildlife due to less road density and harassment potential, and the availability of riparian cover. Since water quality and stream structure benefit, fish habitat is also protected.

Disadvantages: The disadvantages include the difficulty of applying and enforcing road and skid trail constraints and the increased cost associated with such systems. This is offset if the non-market cost associated with the erosion-sedimentation, water quality and fish impacts are included in the estimate of cost.

Concept Variations: There are a number of variations to each of the items discussed above so an almost endless number of combinations are possible. In some cases more control of one type can result in less need for control of another type.

Maintenance Requirements: The primary maintenance need is to continually update the system to relax requirements which are not productive and tighten requirements when needed.

Local Implementation Options: Local governments can impact federal timber harvesting operations including road and skid trail design on U.S. Forest Service or Bureau of Land Management lands though local "water quality requirements" as provided for in Section 313 of PL 92-500. To affect state and private timber operations local jurisdictions will have to negotiate with the Oregon Department of Forestry regarding forest practices, and the Oregon Department of Environmental Quality regarding the TMDL requirements placed on state and private forestry operations. The underlying foundation for such local water quality requirements and negotiations should be included in a water quality plan and ordinance provisions, a component of a surface water management/master plan and/or the jurisdiction's comprehensive land use plan.

LOGGING METHOD REQUIREMENTS

Description: There are three major categories and five subcategories of logging systems as follows:

- Tractor Logging
  - Crawler
  - Wheel (rubber-tired)

- Cable Logging
  - Skyline (at least four variations)
  - High lead (at least two to three variations including jammer)

- Aerial (helicopter)

The differences in water quality impact of the methods above relate to the degree of suspension or conversely soil contact of a log being skidded; the degree of direct site disturbance by heavy equipment; the road system required; and the site re-entry requirements for regeneration purposes. Crawler tractor and rubber-tired skidders generally result in the greatest adverse water quality impact. Tractor and jammer logging require a high road density which can cause significant adverse water quality effects. The cable logging method with the least water quality impact is the running skyline which allows long yarding distances and therefore minimizes the road density and site damage. Helicopter logging is the least site disturbing method but is costly and subject to meteorological conditions more than the other methods, as is balloon logging. In particularly sensitive watersheds where timber harvesting is to be done but water quality is a primary concern, a preference or requirement can be placed on the logging method to be used.

Paramenters/Pollutants Potentially Addressed: A number of pollutants are affected by the logging method selected, with particular emphasis on suspended solids (sediments) and attached constituents such as phosphorus, metals or forest/road chemicals.

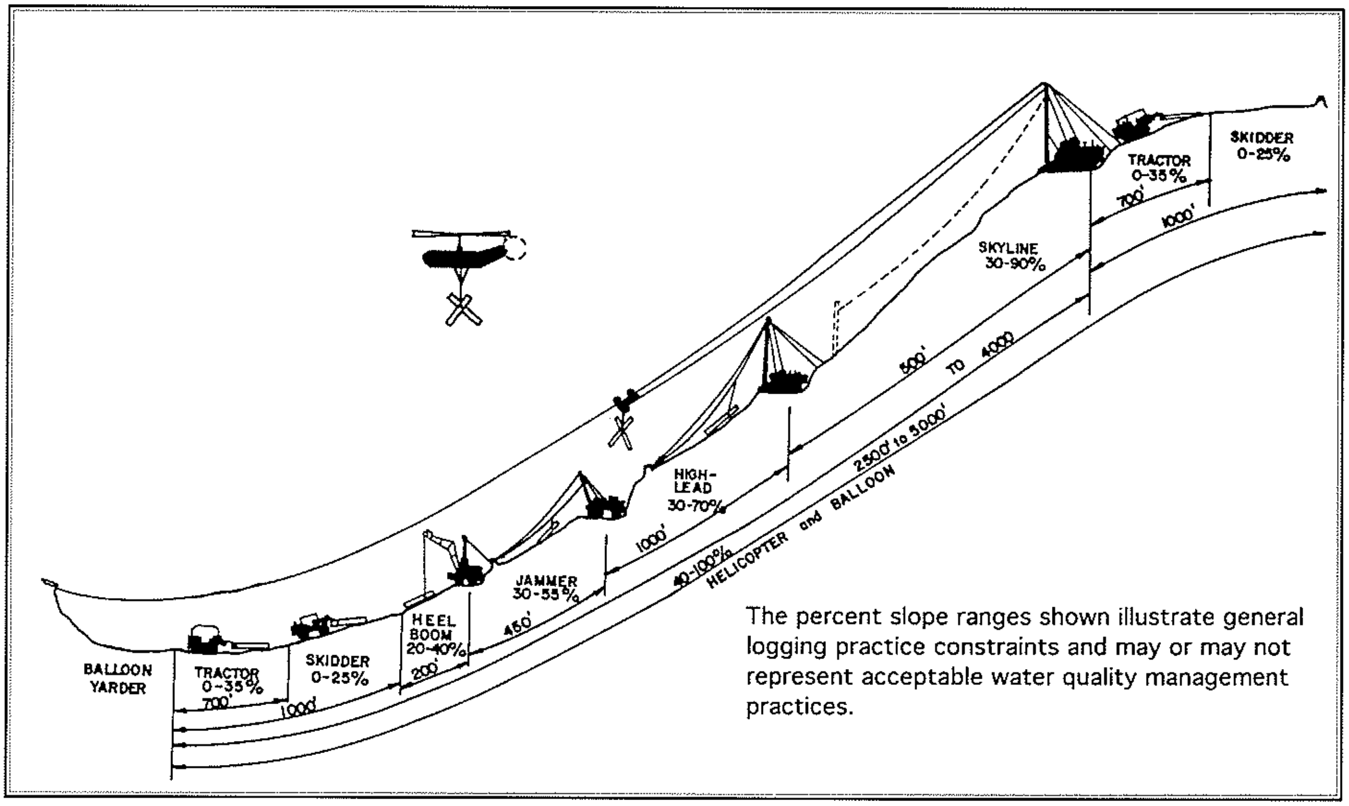
Advantages: The less impactive logging methods also result in a lower road density which benefits wildlife and can complement riparian and fish protection measures.

Disadvantages: Although the total cost of logging operations is complex to determine, in general the systems which have the least water quality impact cost more and, in some cases, such as helicopter or balloon logging, the cost can be prohibitive.

Concept Variations: There are numerous logging methods which can be substituted for the high impact skidder methods such as four variations of skyline and two to three variations of high lead. Balloon and helicopter logging can be used in particularly sensitive areas.

Maintenance Requirements: The primary maintenance requirement for a system of constraining logging methods is to maintain awareness of advances in technology that might shift the preferred system one way or the other.

Local Implementation Options: Local governments can impact federal timber harvesting operations including logging methods on U.S. Forest Service or Bureau of Land Management lands though local water quality "requirements" as provided for in Section 313 of PL 92-500. To affect state and private timber operations, local jurisdictions will have to negotiate with the Oregon Department of Forestry regarding forest practices and with the Oregon Department of Environmental Quality regarding the application of water quality standards and TMDL requirements placed on state and private forestry operations. The underlying foundation for such local water quality requirements and negotiations should be included in a water quality plan and ordinance provisions, a component of a surface water management/master plan and/or the jurisdiction's comprehensive land use plan.



The percent slope ranges shown illustrate general logging practice constraints and may or may not represent acceptable water quality management practices.

FOREST RESIDUE MANAGEMENT

Description: Forest harvesting results in a large amount of residue, primarily woody debris and understory vegetation. The manner in which the residue is managed can have positive or negative effects on water quality. It is sometimes best to leave slash after logging without further disturbing the site to reduce surface erosion. The slash material can also be utilized to form skid trail barriers and retard surface erosion. Chipped residues can be distributed over landings and along right-of-ways to reduce soil erosion. The four general categories of residue management are: no treatment, rearranging or mechanically treating and leaving, removal and disposal, and burning. In general, the most water quality beneficial method is to rearrange/mechanically treat, i.e., chop or break into smaller pieces and leave in a planned pattern to reduce erosion.

Paramenters/Pollutants Potentially Addressed: If forest residue is managed to reduce erosion, suspended sediments will be reduced in the water bodies affected. In some cases, complex chemicals may leach out of the woody/vegetation debris but this is not usually a problem.

Advantages: The advantages of managing the forest residues involve erosion protection, the placement of residues so that the material isn't brought down in debris torrents or with eroded material, better conditions for growth once trees are established, better nutrient cycling, and better soil-biologic conditions.

Disadvantages: The primary disadvantage is cost to the owner/operator but this is offset by the reduction in public cost of improper residue management. The disadvantages include potential increases in revegetation costs and fine hazard.

Concept Variations: There are four basic approaches to managing residue as described above, each with a number of variations.

Maintenance Requirements: The system of controlling residue management should be continually updated as new information emerges.

Local Implementation Options: Local governments can impact federal timber harvesting operations including forest residue management road and skid trail design on U.S. Forest Service or Bureau of Land Management lands though local water quality "requirements" as provided for in Section 313 of PL 92-500. To affect state and private timber operations local jurisdictions will have to negotiate with the Oregon Department of Forestry regarding forest practices, and the Oregon Department of Environmental Quality regarding the TMDL requirements placed on state and private forestry operations. The underlying foundation for such local water quality requirements and negotiations should be included in a water quality plan and ordinance provisions, a component of a surface water management/master plan and/or the jurisdiction's comprehensive land use plan.

SURFACE AND MASS EROSION CONTROLS

Description: Surface erosion is the result of rain or flowing water detaching an exposed soil particle and then transporting the detached particle by surface flow to some downstream deposition point. The four basic physiographic factors which affect surface erosion are: soil characteristics, rainfall characteristics, topography and plant litter/cover. The primary means of protecting against surface erosion are: re-establishing vegetation or a mulch protective cover on all soils immediately after exposure; minimizing the area, duration and season of soil exposure; using logging equipment that will reduce soil disturbance; and minimizing the road density.

Mass erosion is a large failure of an entire slope or area. The types of failures include: debris movements; creep, slumps and earth flows; and dry ravel. The main methods of controlling mass surface erosion involve limits on the slopes where harvesting or road/skid trail construction can occur; protection of natural stabilization mechanisms such as large root systems; and avoidance of certain problem soils.

Paramenters/Pollutants Potentially Addressed: Suspended sediments and bed load and the attached pollutants such as phosphorus and metals are the main constituents involved.

Advantages: The primary advantages of erosion control are for water quality but major damages can occur from mass and surface erosion because of drainage way blockages, flooding and direct property damage.

Disadvantages: Avoiding problem soils and slopes can reduce the volume of wood available, and erosion controls are sometimes expensive.

Concept Variations: The type of controls appropriate for a certain area vary considerably from one region to the next. A qualified soil scientist or geotechnical engineer should recommend site-specific measures.

Maintenance Requirements: The approach to controlling surface and mass erosion should be updated periodically based on new information, particularly actual experience with various soils and slopes within the region.

Local Implementation Options: Local governments can impact federal timber harvesting operations including erosion controls on U.S. Forest Service or Bureau of Land Management lands though local water quality "requirements" as provided for in Section 313 of PL 92-500. To affect state and private timber operations local jurisdictions will have to negotiate with the Oregon Department of Forestry regarding forest practices, and the Oregon Department of Environmental Quality regarding the TMDL requirements placed on state and private forestry operations.

The underlying foundation for such local water quality requirements and negotiations should be included in a water quality plan and ordinance provisions, a component of a surface water management/master plan and/or the jurisdiction's comprehensive land use plan.

STREAM, LAKE, AND RIPARIAN AREA PROTECTION

EQUIPMENT USE LIMITS

Description: Equipment use limits involve specifying areas where equipment cannot be used, particularly during construction. Such limits can be site-specific or associated with certain environmental areas. Important areas to protect for water quality purposes are: riparian areas, steep slopes, certain soils, water zones and wetlands.

Paramenters/Pollutants Potentially Addressed: Suspended sediments and associated metals and phosphorus are the primary parameters that can be reduced through equipment use limitations.

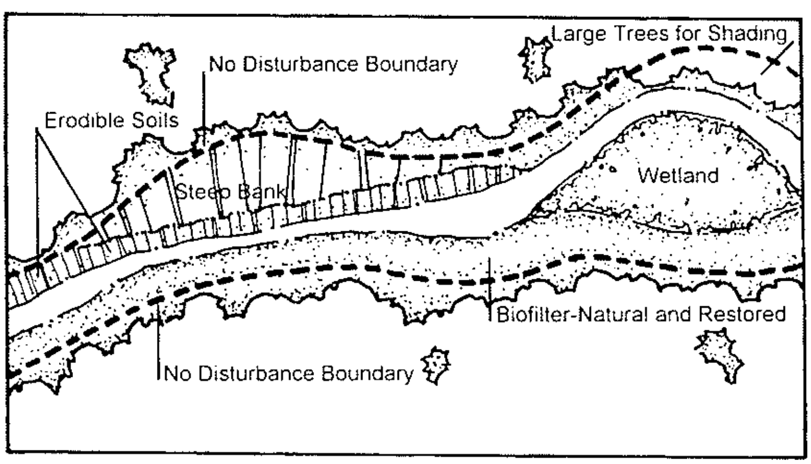
Advantages: In addition to water quality benefits, flood damages can be reduced because the potential for mass soil failures and channel erosion is reduced. Fish, wildlife, and wetland habitat also benefit from restrictions on equipment operation.

Disadvantages: The primary disadvantage is that equipment limitations can make the private development cost for the operator/owner more expensive, but this may be offset by a reduction of public resource impact costs.

Concept Variations: The primary variations are presented in the "description" above. Levels of control can range from encouragement to absolute limitations.

Maintenance Requirements: No direct maintenance requirements.

Local Implementation Options: The implementation options available to local governments depend on the type of land use/development activity involved. The most comprehensive approach involves inclusion in surface water/water quality management plans, the jurisdiction's comprehensive land use plan, and special water quality ordinances.



BIOFILTER ZONES

Description: Biofilter zones can be artificially created after construction or development activities have occurred, but are the most cost efficient if existing natural biofilters are maintained. For small ephemeral streams or drainage ways the biofilter zones can vary from 25 to 50 feet on each side. Perennial streams or lakes require a width of 50 to 200 feet. For wetlands, 75 to 200 feet is the norm. Widths vary according to the potential for channel erosion, the side slopes adjoining the buffer, and the level of protection desired.

Paramenters/Pollutants Potentially Addressed: Suspended sediments and associated phosphorus and metals.

Advantages: Fish, wildlife, wetlands, and water quality benefit from biofilter/buffer zones. Natural systems require very little maintenance and the water quality effectiveness is generally high due to filtering of runoff entering the waterway and the reduction of bank erosion due to equipment disturbances. Biofilter/buffer zones often add a valuable amenity for most site designs.

Disadvantages: The primary disadvantage is the resistance of some land owners to commit to the land needed for an effective biofilter. The completely landscaped types can require intensive maintenance.

Concept Variations: Biofilter zones can vary in width, the use of existing or landscaped vegetation, and the level of maintenance or upkeep needed. There is an infinite variation due to the different vegetation and soils involved from region to region.

Maintenance Requirements: Natural systems are generally better if low maintenance is applied. Artificial or landscaped systems may require mowing, pruning, and periodic vegetation replacement.

Local Implementation Options: The local implementation options include a surface water or water quality management/master plan, the comprehensive plan, and land use regulations. Such zones should also be addressed in the jurisdiction's Operation and Maintenance program and the budget.

STREAM AND RIPARIAN AREA RESTORATION

Description: Stream restoration can improve water quality, and the methods include constructed pool, transition zone, and riffle sections; stop log or weir structures; created meanders; and an artificially placed substrate to enhance habitat values. Riparian restoration involves various forms of "bioengineering" , rock protection, or integrated methods. Vegetation plantings of species such as willows that will establish an extensive root mass quickly are effective. In association with wetland creation and stream restoration, low lying riparian areas can be designed that will maintain saturated soil (i.e., wetland) conditions for much or all of the year. This requires a careful design of the stream hydraulic system.

Paramenters/Pollutants Potentially Addressed: Suspended sediments are reduced through the reduction of bank erosion. Riparian zone protection or establishment can provide for temperature protection if vegetation is large enough to provide shade.

Advantages: In addition to water quality, fish, wildlife, and wetland values are enhanced through the protection or re-establishment of stream and riparian vegetation. The aesthetics and recreational values are also enhanced.

Disadvantages: Requires permits. The appropriate plant species can sometimes be difficult to obtain. The construction of good stream/riparian restoration projects is complex but the small size can be misleading for designers and contractors. In some cases, the costs are high. Some projects have failed because of inadequate consideration of hydraulics, hydrology, or stream geomorphology.

Concept Variations: A number of stream and riparian area restoration types are described above, and these lead to numerous alternatives.

Maintenance Requirements: Maintenance requirements may be high for some types of stream restorations, particularly if pools are involved and upstream erosion is high. This may result in frequent need to remove sediments from the stream structure. For many stream and riparian systems, though, once good restoration has been designed the maintenance requirements should be generally low, primarily involving periodic inspections. In some cases, volunteer maintenance projects may be used.

Local Implementation Options: The local implementation options include the surface water and water quality management/master plans, the comprehensive plans, design-construction standards and inclusion in an O&M program. Public expenditures must also be cited in a capital improvements plan.

LAKE RESTORATION

Description: Lakes are much less resistant to NPS pollutant effects than streams. This is because they trap pollutants such as sediment, most have periods of inadequate flushing, and the result is less assimilative capacity. Lakes can be restored through all of the nonpoint source control presented in this Guidebook.
In addition the following practices have been used:

- diversion of surface waters or discharges containing high pollutant levels
- replacement or repair of nutrient sources such as on-site wastewater systems
- phosphorus precipitation/inactivation
- aeration
- sediment removal
- dilution and flushing
- artificial circulation
- hypolimnetic withdrawal/aeration
- sediment oxidation
- food web manipulation
- algaecides/herbicides
- water level manipulation
- shading and sediment covers
- biological control (fish/insects)
- vegetation harvesting
- chemical additions (e.g., limestone)
- groundwater pumping-diversion
- special construction controls

Discussion of these measures, which are specifically for lake restoration, goes beyond the scope of this Guidebook. For those interested in more information, refer to "The Lake and Reservoir Restoration Guidance Manual" (1990) published by EPA.

Paramenters/Pollutants Potentially Addressed: All NPS pollutants.

Advantages: Fish, wildlife and wetland benefits occur, in addition to water quality. Since lakes act as pollutant traps/sinks they may act as a nonpoint source control measure, per se, and restoration may serve as an O&M program. Lake systems are extremely complex, and a solution to one problem is likely to result in another.

Disadvantages: The cost of lake restoration can be high. Little, if any, federal grant money is presently available for such work. Complex diagnostic work is usually required.

Concept Variations: The variations are many and depend on the lake and watershed characteristics, particularly the pollutant sources within the watershed.

Maintenance Requirements: High maintenance is generally required, in some cases involving the periodic removal of sediments or vegetation from a lake.

Local Implementation Options: The primary approach to implementation is inclusion in a water quality management plan and the jurisdiction's comprehensive plan. Design and construction programs will be necessary so the work must be included in a capital improvement plan. After lake restoration occurs an O&M program must be designed.

MONITORING

WATERSHED MONITORING

Description: Watershed monitoring documents the success of NPS control measures and provides the basis for modifying and improving them. Such monitoring can include a number of watershed characteristics. Two of the most important baseline conditions to evaluate are the soil and geologic types within the watershed. For soils, both the engineering classifications/characteristics and the SCS classification should be evaluated. The SCS characteristics are necessary if issues like erodibility, and septic tank suitability are important. If water control structures are to be constructed within the watershed the engineering classifications are essential. The vegetation conditions and soil disturbances can be recorded every few years through aerial photography. The pollution sources should be identified and monitored on a continuing basis; for example construction sites, commercial or industrial developments, areas where septic tanks are present, or stored chemical locations.

Stream and lake conditions should also be monitored. For streams this should include flow during water quality sampling and preferably on a continuous basis. Water quality parameters such as suspended solids, conductivity, total dissolved solids, phosphorus, nitrogen, and various metals should be tested for periodically. In addition, the stream bedload, or sediment which moves slowly along the substrate (the interface between the water and the bottom of the stream), may be of interest.

Sediment sampling should be done for baseline conditions and the laboratory tests should include metals, industrial chemicals and toxicity tests. Monitoring the aquatic life conditions for species abundance and diversity can be very useful in understanding the stream's health. Baseline condition tissue sampling and toxicity testing should be performed and if toxics are present the sampling should be continued. The instream finite increment method (IFIM) is important for baseline monitoring if low or high flow conditions are significant for fish. The fish passage barriers, stream structure, and riparian cover should also be identified and monitored. Lakes involve similar water quality monitoring. Lake morphology and depth-temperature-water chemistry relationships are particularly important.

A useful tool in understanding a watershed and its lake/stream health is aerial photography. This can involve the analysis of videotape to isolate various bands in the video spectrum that show beta carotene and chlorophyll A, which is useful in understanding lake eutrophication problems. Thirty-five millimeter photography involving both color slides and infrared slides are very useful in understanding the location and impact of pollutant sources and explaining those impacts to the public.

Paramenters/Pollutants Potentially Addressed: Monitoring needs will vary from one watershed to the next. The basic water quality parameters to evaluate are discussed next, followed by special water quality parameters. Watershed characteristics in addition to water quality that can be evaluated and monitored on a periodic basis are:

- Vegetation types and extent.
- Soil types (engineering and SCS).
- Disturbed soil areas.
- Pollutant sources.
- IFIM. barrier analysis, geomorphologic structure, and riparian cover for streams.
- Depth-temperature-water chemistry relationships for lakes.
- Aerial photography involving video and 35-mm (standard and infrared).

Advantages: The main advantage of watershed monitoring is to have a complete picture of stream and lake health, and the factors which are affecting that health. In addition to water quality, fish, wildlife and wetland values can benefit.

Disadvantages: The primary disadvantages involve cost and the diligence required to continue a sound watershed monitoring program.

Concept Variations: Since there are a number of aspects that can be included in watershed monitoring there are an almost infinite variety of specific monitoring programs ranging from basic water quality to aquatic life.

Maintenance Requirements: Watershed monitoring is basically a maintenance program. In order to be successful, watershed monitoring must first establish the baseline conditions and then periodically evaluate the trends. Some conditions such as vegetation cover and soil disturbance should be monitored annually, but in many cases the periodic updates can occur every three to five years depending on the rate of watershed change.

Local Implementation Options: Since comprehensive watershed monitoring involves a major commitment it should be identified in the jurisdiction's surface water management/master plan and the comprehensive plan. The program should be budgeted for, including equipment or contracts needed, and the work should be included in the agency's operation and maintenance program. Whenever possible, cost-sharing among various jurisdictions within a watershed should be a program objective.

WATER QUALITY-BASIC

Description: Basic water quality monitoring can involve grab sampling, periodic sampling and storm event sampling performed at instream stations or at outfall/mixing zone locations. Grab sampling is done at pre-established stations on an as-needed basis. Periodic monitoring is done at pre-established stations on a regularly scheduled basis (weekly, monthly, quarterly or annually). The parameters may change from one sampling event to another. Storm event monitoring occurs on the rising and falling stages of the hydrograph and the time to sample is often very difficult to determine. Flow should be measured at all sampling events and where frequent, periodic or storm event monitoring is to be performed automated equipment may be justified.

Paramenters/Pollutants Potentially Addressed: Basic water quality monitoring that focuses on the impacts of nonpoint sources involves the following:

- Flow.
- Temperature.
- pH.
- Conductivity.
- Total suspended solids/sediments (TSS).
- Total Phosphorus.
- Nitrogen.
- Biochemical Oxygen Demand (BOD).
- Bacteria.
- Oil and Grease.
- Various metals of concern, such as copper, lead and mercury.

Advantages: The advantage of basic water quality monitoring is that it helps determine the degree to which problems exist. The monitoring may be infrequent and involve a limited set of water quality parameters, but even such basic monitoring is more valuable than no data. In addition to establishing the need for nonpoint source control measures, basic water quality monitoring can measure the performance of the control measures and periodically check the trends and water quality health of the watershed.

Disadvantages: The cost for equipment, sampling, laboratory tests and data evaluation.

Concept Variations: The variables involving the number of parameters, the frequency of sampling, the quality or sophistication of the laboratory tests and the degree and type of analysis result in a large variety of monitoring program alternatives.

Maintenance Requirements: Monitoring can be considered a maintenance program *per se* but it also requires equipment maintenance and updated employee training.

Local Implementation Options: The need and specifics regarding monitoring programs should be identified in the surface water management/master plans, the capital improvements plans for equipment, and the operation and maintenance budgets.

WATER QUALITY-SPECIAL

Description: Various special types of water quality monitoring can be performed including the following:

- Bedload which measures the sediment movement along the stream substrate.
- Sediment toxicity monitoring including various risk analyses.
- Mixing zone analysis which evaluates the transitional impacts of discharges into a water body.
- Extending or expanding upon the monitoring performed can be accomplished through various 1-, 2-, and 3-dimensional water quality models (in effect the creation of an artificial database).

Paramenters/Pollutants Potentially Addressed: Presented in Appendix B.

Advantages: Special monitoring is advantageous when watersheds or water bodies have unique characteristics or problems which can only be understood through monitoring beyond the basic level.

Disadvantages: The disadvantages include the difficulty in determining the appropriate special monitoring elements, and the cost.

Concept Variations: The variations are limitless and depend on the type of monitoring, the parameters targeted, sampling frequencies, station locations and the use of automated equipment.

Maintenance Requirements: Special monitoring generally involves sophisticated equipment which must be periodically maintained and replaced and this includes both field and laboratory equipment.

Local Implementation Options: The types of special monitoring justified should be identified in a surface water/stormwater/water quality management plan and then presented in detail in a monitoring plan that becomes part of the organization's operation and maintenance program. Equipment purchasing needs should be identified in the capital improvements plan.

AQUATIC LIFE

Description: The most basic types of aquatic life monitoring involve abundance and diversity surveys of fish species and macroinvertebrates. EPA has identified a number of "Rapid Bioassessment Protocols for use in Streams and Rivers" (1989). The laboratory testing of fish tissue is also important, particularly if industrial, agricultural or silvicultural chemicals are suspected. Toxicity tests, including both acute and chronic bioassays, are important if specific discharges or stream conditions are suspected of having significantly adverse effects on the aquatic life in a stream or a lake. If fish in the stream are important then the instream finite increment method (IFIM) evaluation of high and low flow impacts may be useful. Analyzing fish passage barriers may also be needed. The stream structure and riparian conditions identified through fieldwork and aerial photography may be worthwhile.

Paramenters/Pollutants Potentially Addressed: Aquatic life monitoring can potentially address all of the parameters suspected of causing problems in a watershed or a water body.

Advantages: Monitoring aquatic life as opposed to water quality addresses to what degree aquatic resources are being affected by the various point and nonpoint sources in a watershed.

Disadvantages: Aquatic life monitoring is more labor intensive, requires more highly trained specialists in the field, and consequently costs more than other types of monitoring.

Concept Variations: There are a number of potential variations which depend on the type of monitoring to be performed, the station locations, the frequencies and the level to which systematic evaluation methods are used.

Maintenance Requirements: Aquatic life monitoring can be included as part of a maintenance program *per se*. Since aquatic life monitoring is often labor intensive rather than equipment intensive the maintenance costs for the program is usually not excessive.

Local Implementation Options: The need and type of aquatic life monitoring to be performed should be identified in a surface water/stormwater/water quality management plan and included in the organization's action programs such as an operation and maintenance program.

SEDIMENTS AND TOXICS

Description: Many types of nonpoint source contaminants are discharged into a water body on an instantaneous or short-term basis and are settled out or passed quickly through the system, so basic and many special water quality monitoring approaches may not detect problems. However, many contaminants, particularly metals and industrial/agricultural/silvicultural chemicals are partially released to the sediments. Sampling at the top, and at various depths, of the sediments can indicate problems that would otherwise be missed. Toxics are important because they can cause aquatic life and human health problems at very low concentrations. Toxics should be monitored in the water column, the sediments and fish tissue.

Parameters/Pollutants Potentially Addressed: Sediment quality is usually measured using the parameters presented in Appendix B. Toxics involve complex laboratory procedures and a wide variety of parameters that are presented in Appendix B.

Advantages: The primary advantage is the identification of problem discharges which pass through the water system undetected. The other advantage is that problems related to the aquatic food chain often originate in sediments or because of toxics.

Disadvantages: The primary disadvantage is cost.

Concept Variations: An infinite number of alternative sediment or toxic monitoring programs are possible.

Maintenance Requirements: Equipment must be maintained and replaced.

Local Implementation Options: The need and type of sediment and toxics monitoring to be performed should be identified in a surface water/stormwater/water quality management plan and included in the organization's action programs such as an operation and maintenance program.