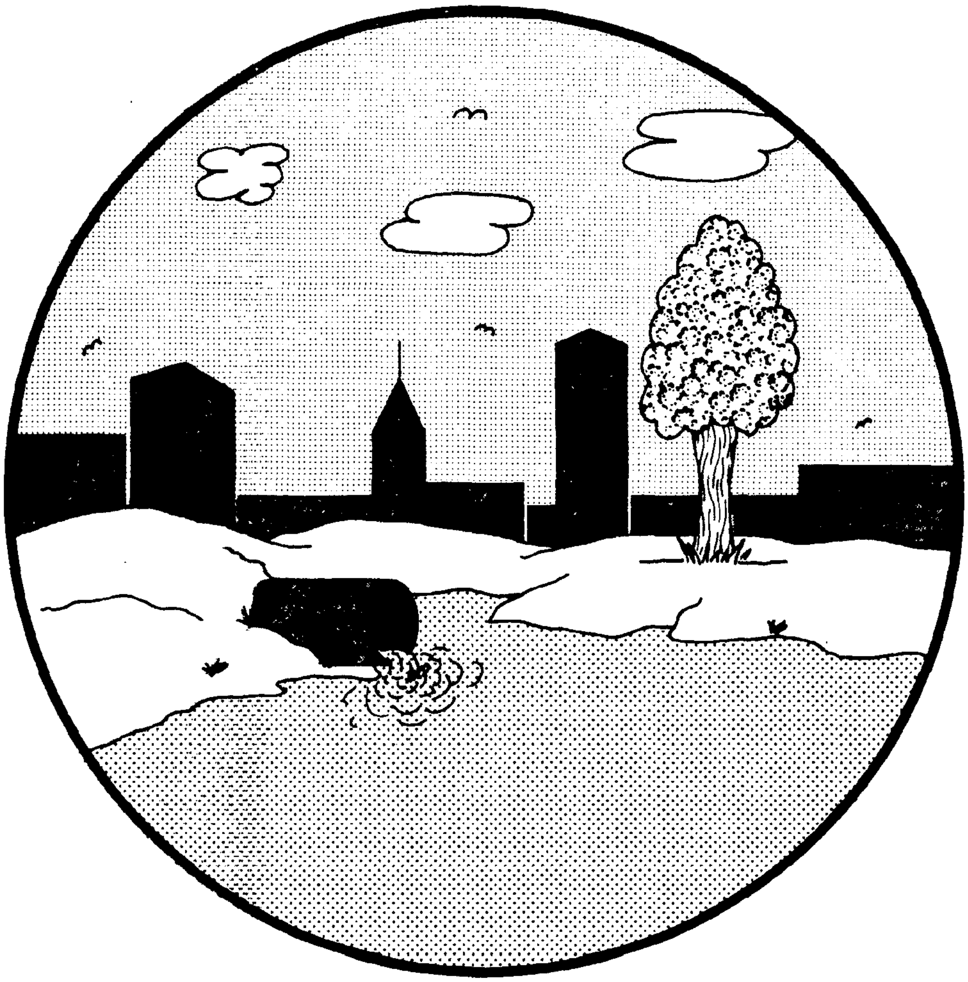
RETROFIT PLANNING FOR URBAN STORMWATER RUNOFF



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RETROFIT PLANNING FOR URBAN STORMWATER RUNOFF

Prepared for

Regional Planning Council
2225 North Charles Street
Baltimore, Maryland 21045

Project Manager

Lawrence Leasner

Prepared by

The Environmental Center
Anne Arundel Community College
Arnold, Maryland 21012

Principal Author

Samuel R. Martin
Consultant

Editor

Joelle Lofton

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Send Inquiries to: Coastal Zone Coordinator
Regional Planning Council
2225 North Charles Street
Baltimore, MD 21218

ABSTRACT

The State of Maryland, with rapidly urbanizing watersheds draining to the Chesapeake Bay, has made significant strides in managing urbanizing area stormwater runoff quantity and quality during the last decade. Existing urban areas are subject to the same environmental laws but have not been given the same management attention. This guide is designed for those planners, engineers, and others in local, state, or Federal governments who manage watersheds or make decisions regarding water quality in existing urban areas.

The term "retrofit" refers to improving the quality of urban stormwater runoff to whatever degree is achievable considering water quality problems, technology limits, and budget constraints. The improvements can include the modification of existing or addition of new management practices. Improvements also may include changes in activities or land uses. Users will be helped to: (1) assess pollutant runoff from existing urban development, (2) select cost-effective controls, and (3) develop and implement retrofit strategies. assessing the pollution potential of stormwater runoff from existing urban land and designing control strategies to reduce the pollution.

In using this method, the user completes a six method. Step 1 divides the jurisdiction into watersheds and ranks them by priority. Steps 2 through 5 focus on smaller drainage areas called "analysis areas" in a single priority watershed. These steps define the analysis area characteristics, pollution potential, initial rank by order of concern, site conditions and opportunities, and retrofit management strategies. The management practices are divided into three general control categories - source, erosion, and stormwater runoff. Step 6 assembles and implements a retrofit plan for each priority watershed in the jurisdiction. With a properly devised retrofit plan, the stormwater pollution, runoff velocity, and/or runoff volume can be reduced.

After working through this guide, users of the Urban Retrofit Planning Method will be able to integrate the control of runoff pollution from urban areas into water quality management programs of the local, state, and Federal governments. Users also can apply the method (as one of the tools) to develop local Chesapeake Bay Critical Area plans and programs and investigate the quality of stormwater runoff in urban areas. Finally, users can apply the retrofit method as part of a comprehensive watershed management process.

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PREFACE

Water quality management has reached new horizons during the last two decades. Add to the long-term study of and success in controlling point sources of pollution the more recent concern for nonpoint pollution and its management. The result: the reason for this guide.

The Baltimore region is a major source of urban stormwater runoff. The potential for urban lands to generate a wide range of physical, chemical, and bacteriological pollutants was demonstrated in the 1983 U.S. Environmental Protection Agency's Nationwide Urban Runoff Program. Typical pollutants found in Baltimore's urban runoff include: sediment, nutrients (both nitrogen and phosphorus), oxygen demanding substances, heavy metals, and other toxic chemicals. The urban lands drain into watershed streams and lakes and the Chesapeake Bay. Studies of these receiving waters indicate that urban runoff and other pollutant sources have caused such problems as sedimentation, algal blooms, eutrophication, contamination and death of fishery resources, and damage to the aquatic habitat.

In 1984, the Maryland General Assembly recognized the role of urbanization in the degradation of the Chesapeake Bay, and approved a set of "Chesapeake Bay Initiatives." Included in the initiatives are two programs that address the control of pollutants from urban areas: Critical Area Protection and Stormwater Pollution Control Cost-Share Programs. This document contains guidance for assessing the pollution potential of stormwater runoff from existing urban land and designing control strategies to reduce the pollution.

This guide is designed for those in local, state, or Federal governments who manage watersheds or make decisions regarding water quality in urban areas. Users--ideally an experienced team of planners, engineers, landscape architects, biologists, ecologists, and informed citizens--will be helped to

* assess pollutant runoff from existing urban development,
* select cost-effective controls, and
* develop and implement retrofit strategies.

After working through this guide, users of the Urban Retrofit Planning Method will be able to integrate the control of runoff pollution from urban areas into water quality management programs of the local, state, and Federal governments. Users also can apply the method (as one of the tools) to develop local

Chesapeake Bay Critical Area plans and programs and investigate the quality of stormwater runoff in urban areas. Finally, users can apply the retrofit method as part of a comprehensive watershed management process.

Users must note: First, this guide will not provide all of the information required to develop retrofit management strategies for all situations. Users should consult the References and Resource Directory sections as well as other information sources. Second, The Urban Retrofit Planning Method only addresses stormwater runoff from existing urban land in an appropriate drainage area. The method neither replaces required site specific investigations and engineering design nor provides a uniform solution for all instances.

Part I

The Urban Retrofit Planning Method

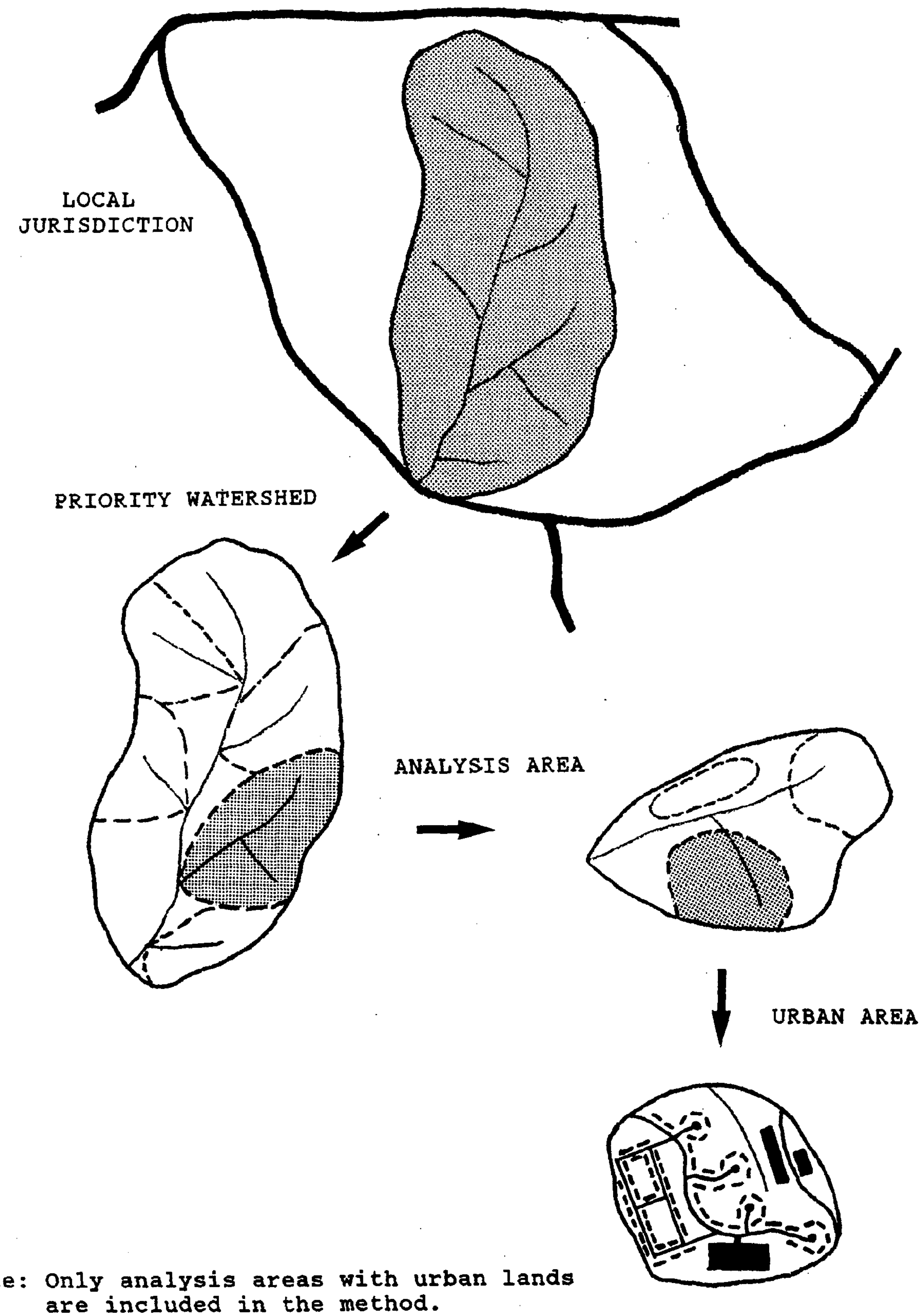
INTRODUCTION

The purpose of the Urban Stormwater Retrofit Planning Method is to identify and rank drainage areas with existing urban lands in order of concern; assess methods for reducing pollution from the stormwater runoff of existing areas; and develop appropriate retrofit strategies for implementation.

In this guide, "retrofit" refers to improving the quality of urban stormwater runoff to whatever degree is achievable considering water quality problems, technology limits, and budget constraints. The improvements can include the modification of existing or addition of new management practices. Improvements also may include changes in activities or land uses.

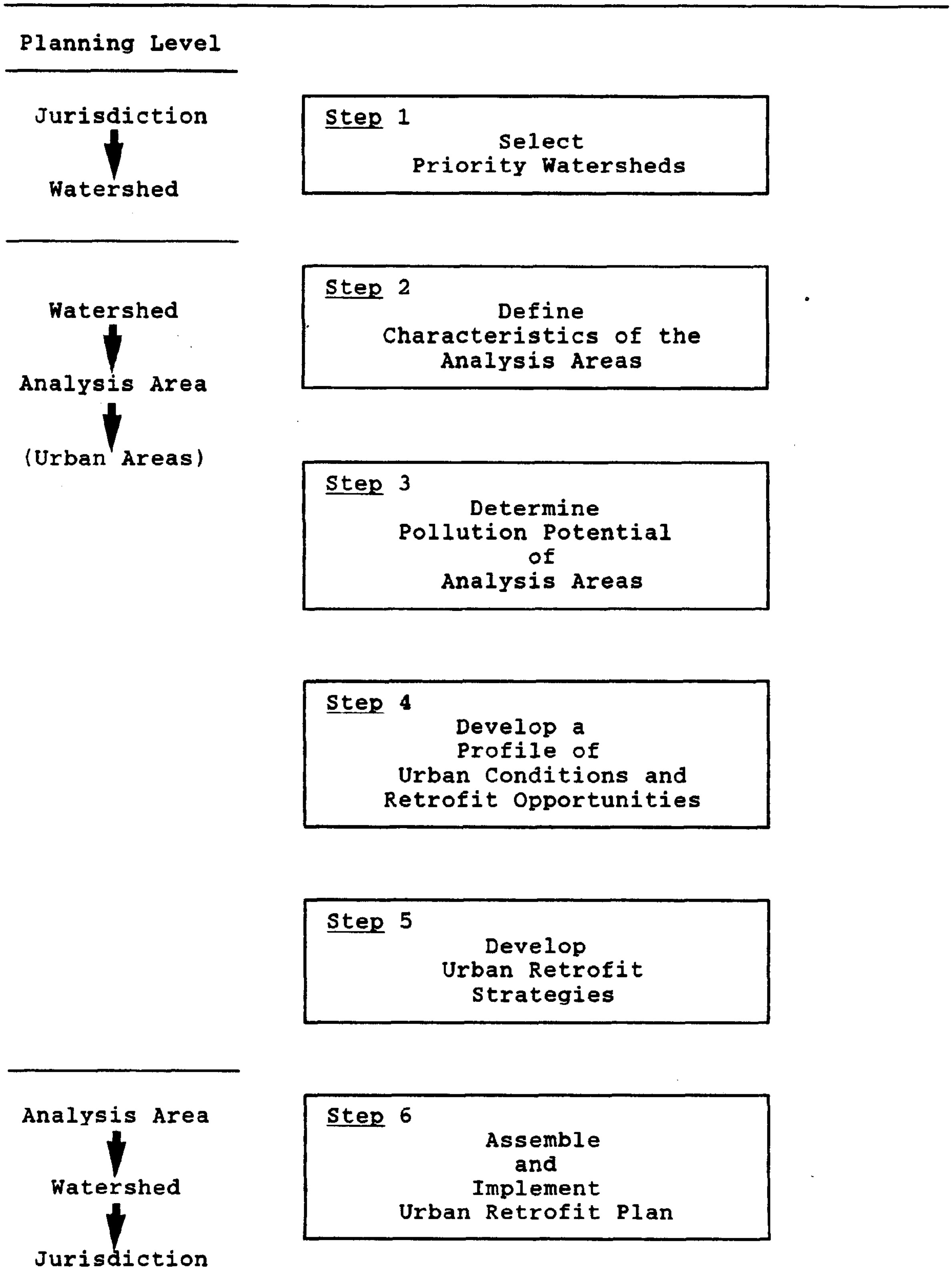
In using this method, the user focuses on three levels, decreasing in size and increasing in level of detail: (1) the watershed; (2) analysis (drainage) areas; and (3) urban areas. (See Figure 1.1) The user completes a six-step process (Figure 1.2). Step 1 divides the jurisdiction into watersheds and ranks them by priority. Steps 2 - 5 focuses on smaller drainage areas called "analysis areas" in a single priority watershed. These steps define the analysis area characteristics, pollution potential, initial rank by order of concern, site conditions and opportunities, and retrofit management strategies. Step 6 assembles and implements a retrofit plan for each priority watershed in the jurisdiction. With a properly devised retrofit plan, the stormwater pollution, runoff velocity, and/or runoff volume can be reduced.

Figure 1.1. Levels of Focus in the Urban Retrofit Planning Method.



Note: Only analysis areas with urban lands are included in the method.

Figure 1.2. Six Urban Retrofit Planning Steps.



SIX STEPS TO URBAN RETROFITTING

Step 1 -- A Synopsis
Select Priority Watersheds

A. Map the Jurisdiction and Divide into Watersheds.

OR

B. Tabulate Evaluation Factors, Values, & Scores for Each Watershed.	B. Allow Concensus Judgment of Technical Staff.
↓	↓
C. Rank Watersheds & Select Priority Watersheds.	C. Select Priority Watersheds.

Note: The user may bypass Step 1 if

... the local government has already selected one or more priority watersheds for developing urban retrofit plans,

... the municipality is a local government located within one watershed.

See discussion on concensus judgment in Step 3.

Select Priority Watersheds

A. Map the local jurisdiction and divide into watersheds.

Define the boundaries of all watersheds on a map that includes the entire jurisdiction. A map scale of 1 inch = 1 mile or larger is adequate for counties, while smaller municipalities could require 1 inch = 1000 feet or larger scale maps.

Designate all sub-basins and segments according to the Maryland classification system and define them as watersheds.

The Maryland Classification System.

The State of Maryland uses a classification system to define the boundaries of major drainage areas. The first (major) is classified as a basin; the next level is the subbasin; and the last level is the segment. All drainage areas in the Baltimore region are located in the North Atlantic Slope Basin. The seven subbasins located in the Baltimore region are listed in the following chart.

Basin: North Atlantic Slope
Number: 02

Subbasin Classification No.	Subbasin Name
12-02	Lower Susquehanna River
13-07	Bush River
13-08	Gunpowder River
13-09	Patapsco River
13-10	West Chesapeake Rivers
13-11	Patuxent River
14-03	Middle Potomac River

Each of the subbasins comprises smaller drainage areas (segments). The segments for the Baltimore region are listed in Appendix A. (See State Office of Environmental Programs' Maryland Water Quality Inventory (1986) for maps and an additional discussion.)

B. Tabulate evaluation factors, values, and scores for each watershed.

To select a priority watershed, the user must develop values and scores for certain physical, water quality, and socioeconomic factors. Enter the results in Worksheet 1.1 Watershed Comparison and Ranking Worksheet (see page 9).

__Watershed Name__ - Enter the Maryland subbasin, segment, or other name for each watershed in column (1).

__Watershed Area__ - Use a planimeter or alternate method to calculate the total watershed land area in acres. Measure the drainage boundaries on a 1 inch = 1 mile or larger scale map. Enter the results in column (2).

__Urban Area__ - Outline the total urban area on a 1 inch = 1 mile or larger scale map. Calculate the area in acres. Enter the results in column (3). The urban area is defined as the combination of all residential (greater or equal to 1 dwelling unit per acre), commercial, industrial, developed institutional, and transportation-related lands.

__Percentage Urban Land__ - Calculate the percentage of urban land in each watershed.

$$\text{Percentage Urban Land} = \frac{\text{Urban Area}}{\text{Watershed Area}} \times 100 \quad \text{[Eqn. 1]}$$

$$\text{Column 4} = \frac{\text{Column (3)}}{\text{Column (2)}} \times 100$$

Enter the results for each watershed in column (4).

__Current Watershed Population__ - Estimate the current population for each watershed. Overlay watershed boundary maps on local geographic areas where current populations have been determined and prorate the populations. Geographic areas where populations may have been calculated include sanitary sewersheds, transportation planning zones, or census tracts. Enter the results in column (5).

Worksheet 1.1 Watershed Comparison and Ranks.

Jurisdiction Name:

Date:
I.D.:

Wtrshd. Name (1)	Wtrshd. Area (Acres) (2)	Urban Area (Acres) (3)	Urban Land (%) (4)	Wtrshd. Population (5)	Population Density (6)	Wtr. Qual. Evaluation Score (7)	Wtrshd. Priority Score (8)	Urban Land Score (9)	Density Score (10)	Total Score (11)
Totals										

Watershed Population Density - Calculate the current population density of the total watershed land area.

$$\text{Population Density} = \frac{\text{Watershed Population}}{\text{Watershed Area}} \times 100 \qquad \text{[Eqn. 2]}$$

$$\text{Column 6} = \frac{\text{Column 5}}{\text{Column 2}} \times 100$$

Enter the results for each watershed in column (6), page 9.

Water Quality Evaluation Score - From Appendix B, find the receiving water quality evaluation value for the appropriate subbasin or segment. Obtain numerical scores from the following chart and enter the score in column (7) for each watershed.

Water Quality Description	Value	Score
Excellent	E	1
Good	G	2
Fair	F	3
Poor	P	4

Watershed Priority Score - From Appendix C, determine whether or not each watershed is on the 1986 Maryland Watershed Priority List.

If the watershed is on the List, enter 1 in column (8).

If the watershed is not on the List, enter 0 in column (8).

Urban Land Score - For each watershed, use the percentage of urban land in column (4) to obtain the appropriate score from the following chart, and enter scores in column (9).

Urban Land Percentage	Score
0 - 9	0
10 - 19	1
20 - 29	2
30 - 39	3
40 - 49	4
50 - 59	5
60 - 69	6
70 - 79	7
80 - 89	8
90 - 99	9
100	10

Density Score - For each watershed, use the population density (gross people per acre) in column (6), page 9, to obtain the appropriate score from the following chart, and enter scores in column (10).

Population Density	Score
<= 1.0	0
>1.0 - 2.0	1
>2.0 - 3.0	2
>3.0 - 4.0	3
>4.0 - 5.0	4
>5.0 - 6.0	5
>6.0 - 7.0	6
>7.0 - 8.0	7
>8.0 - 9.0	8
>9.0 - 10.0	9
>10.0	10

Total Score - Add the scores for each watershed. Enter the results in column (11), page 9.

Total Score	=	Water Quality Evaluation Score	+	Watershed Priority Score	+	Urban Land Score	+	Density Score

[Eqn.3]

Column (11)	=	col.(7)	+	col.(8)	+	col.(9)	+	col.(10)

Other factors may be important in the user's selection of a priority watershed. Three categories of possible evaluation factors follow. The user can quantify the factors with values for each watershed, expand the worksheet with any necessary column, and insert the approximate values.

Urban Area Characteristics.

- o Urban land use classes such as residential densities, commercial, industrial (Standard Industrial Class Codes), and institutional, as well as transportation-related characteristics.

- o Estimated population density of the urban area.

- o Calculations of estimated pollutant loadings in stormwater runoff from the urban area. If adequate information is available, the urban runoff loads can be compared to estimated loads from activities such as agriculture, construction, and sanitary sewage pumping station overflows. (Techniques for estimating urban runoff pollutant loads are described in USEPA (May 1979), Martin (1985), and MWCOG (July 1987). Contact the Maryland Department of Environment for information on estimating other pollutant loads.)

- o Portion of the urban area located within a specific distance of receiving water bodies. The more distant the source of stormwater runoff from streams, lakes, or estuaries, there will be less influence on the water quality. For example, the portion of the total urban area located within one-quarter of a mile from a stream or an estuary.

Receiving Water Characteristics.

- o Types and beneficial use classifications of water bodies receiving runoff from a watershed's urban lands.

- o Historical receiving water quality data. The data could be compared to Federal and state water quality criteria for frequency of violations or exceedance of a threshold level. (See the 208 Areawide Water Quality Management Plans and Maryland Water Quality Inventories for discussions of historical data.)

- o Impairment or denial of one or more beneficial uses. (See USEPA, Dec. 1983 for a definition.)

Other Characteristics.

- o The level of resident public concern about the water resources in a watershed.

- o The level of local governmental concern (from both the technical staff and elected decisionmakers) about the water resources in a watershed.

  These characteristics are not quantified easily but can be expressed as relative weights assigned to each watershed. For example, the watershed with the highest score in the worksheet may not be selected as the priority watershed if the residents in a lower ranked watershed have shown a significant level of interest in the water quality, are willing to perform some retrofitting on private lands, and the local government considers the lower ranked watershed to be feasible for retrofitting.

C. Rank watersheds and select a priority watershed.

Rank the watersheds in order of highest to lowest values based on the Total Score for each watershed in column (11) of Worksheet 1.1 (page 9). Select a watershed for retrofitting by combining the watershed rank and any other appropriate factors.

Results of Step 1

1. A watershed selected by the user for retrofitting.
2. A ranked list of other watersheds and their characteristics. These watersheds may be selected in the future for retrofitting.

Step 2 -- A Synopsis
Define the Characteristics of the Analysis Areas

A. Evaluate the Watershed and Select Scale of Analysis Area.

↓

B. Define Boundaries and Name Analysis Areas.

↓

C. Define Physical Characteristics of Each Analysis Area.

↓

D. Disregard Analysis Areas with <u>no</u> Urban Lands.

Note: If a comprehensive watershed study was performed on the watershed, the information and procedures of Step 2 may already be available. If the watershed was the subject of a flood or other stormwater management study involving computer modeling (SCS TR -20 or other model), information on land use, drainage area delineations, maps, and storm drain system catchments may be available.

Define the Characteristics of the Analysis Areas

A. Evaluate the watershed and select scale of analysis areas.

The scale is the level of detail used to define a drainage system. To evaluate the watershed and select a scale for the analysis areas, users must combine certain physical characteristics of the watershed with a set of simple evaluation criteria. The process is described in the following four actions.

1. Select a Watershed Base Map and Scale. A reasonable base map and scale should be selected to record the information gathered in this step. The map scale will vary with the size of the watershed but for most watersheds in the Baltimore region, a scale of 1 inch = 1 mile is acceptable, but a scale of 1 inch = 2000 feet is better.

2. Gather Information about the Watershed. The following information should be collected for use in this evaluation:

   - o Land use/cover inventories
   - o Topographic maps (for defining drainage area boundaries and showing stream systems)
   - o Water/sanitary sewer service areas (a supplement to land use information)

   Map this information if it not in a form compatible with the base map. Although the map scales may be different, the user can reduce or enlarge the data photographically. A digital geographic information system, (if the information has been changed to x and y coordinates for the priority watershed), will simplify the tasks of gathering and analyzing information.

3. Overlay Information on Base Map. Overlay mapped information on the base map of the watershed. Make sure levels of drainage areas within the watershed also are defined. These areas will be referred to as analysis areas. (See Test Case, Figure 2.2, page .)

4. Select Analysis Area Scale. Before selecting the analysis area scale, the user should consider the watershed size, urban area distribution, and available labor.

   - o Compare the prospective analysis area size to the watershed size. A reasonable analysis area size for a medium-level urban retrofit assessment ranges from a few hundred acres to 10 or 20 square miles.

   - o Look at the distribution of urban areas within the analysis area. Is the urban land generally distributed in clusters or is it spread over larger areas? Clustering may require a smaller analysis area.

- Compare the available resources for the urban retrofit assessment project with the estimated amount of work required to define characteristics in the prospective analysis area.

- A procedure to help define the scale of analysis area is to perform the requirements of Step 1 for one or more example analysis areas. The results can be examined for the time and resources required.

B. Define boundaries and name the analysis areas.

Having selected the analysis area scale, use the topographic maps to define the boundaries. For clarity during later steps in the investigation, name and number each analysis area. (See Test Case in Part II of the guide for an example.)

C. Define physical characteristics of each analysis area.

Overlay the analysis area boundary map on the priority watershed information to define the following physical parameters and enter each parameter in Worksheet 1.2 - Analysis Area Information (page 17).

Total Watershed Area - The land area does not include the tidal embayment area. An initial estimate of total area is listed in Worksheet 1.1, column (2), page 9. This may be adequate if the scale of map used in Step 1 is as large as the topographic map in Step 2. If not, revise based on the new information. Enter the revised value in the Analysis Area Information Worksheet (page 17).

Subwatershed Name - Enter the name of the Level II drainage area in column (1), page 17. (It may be the analysis area. See Figure 2.2 in the Test Case, page .)

Analysis Area Number and Name - Enter the appropriate information in columns (2) and (3), page 17.

Land Area of Analysis Area - Use a planimeter or alternate method to obtain the land area of the analysis area. Record the value for each analysis area in column (4), page 17.

Urban Land Area in Analysis Area - Measure the urban areas in each analysis area on the map. Record the values in column (5), page 17. The total should be compared to the initial estimate recorded in Worksheet 1.1, column (3), page 9.

Worksheet 1.2 Analysis Area Information.

Priority Watershed: ____________________

Total Watershed Area: ____________________ Acres

Page ___ of ___
Date ________
I.D. ________

Sub-wtrshd. Name	Analysis Area		Land Area of Analysis Area (Acres)	Urban Area (Acres)	Urban Land Areas by Use										Type and Class of Receiving Water Body			
	No.	Name			RES[a] (lot size in acres)						COM[b]	IND[c]	INS[d]	OTH[e]				
					2	1	1/2	1/3	1/4	<=1/8					Pri. Type	Pri. Class	Sec. Type	Sec. Class
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Total																		

[a] RES = Residential
[b] COM = Commercial
[c] IND = Industrial
[d] INS = Institutional
[e] OTH = Other urban lands

Note: If an analysis area has no urban area, exclude the analysis area from further investigation.

Use of Urban Land Areas - Measure the residential, commercial, industrial, institutional, and other urban areas. Other urban-related areas are those lands not included in the previous specific land uses but are part of the total area. Examples are divided, limited access highways, railways, and bare ground. The smallest unit of land measured will depend on the base map scale. At a scale of 1 inch = 2,000 feet, a minimum parcel size defined on the map is about one acre. Separate the residential values according to gross lot size. Enter all urban land areas in the appropriate columns.

Type and Class of Receiving Water - The three types of receiving water bodies are (1) stream or river; (2) lake (impounded water of 5 or more acres); and (3) estuary (tidal waters). Identify the primary and secondary receiving water bodies that are downstream of the urban areas in each analysis area. Primary receiving water bodies are immediately downstream from the urban area. Secondary receiving water bodies receive discharges from the primary water body. Enter the types in columns (16) and (18), page 17.

Next assign the appropriate Maryland Water Use Class to each of the primary and secondary receiving water bodies. Current water use classes are identified for all waters of Maryland in the Maryland Water Quality Inventory (1986). Enter the primary and secondary receiving water body classes I, II, III, or IV in columns (17) and (19), page 17.

D. Disregard analysis areas with no urban lands.

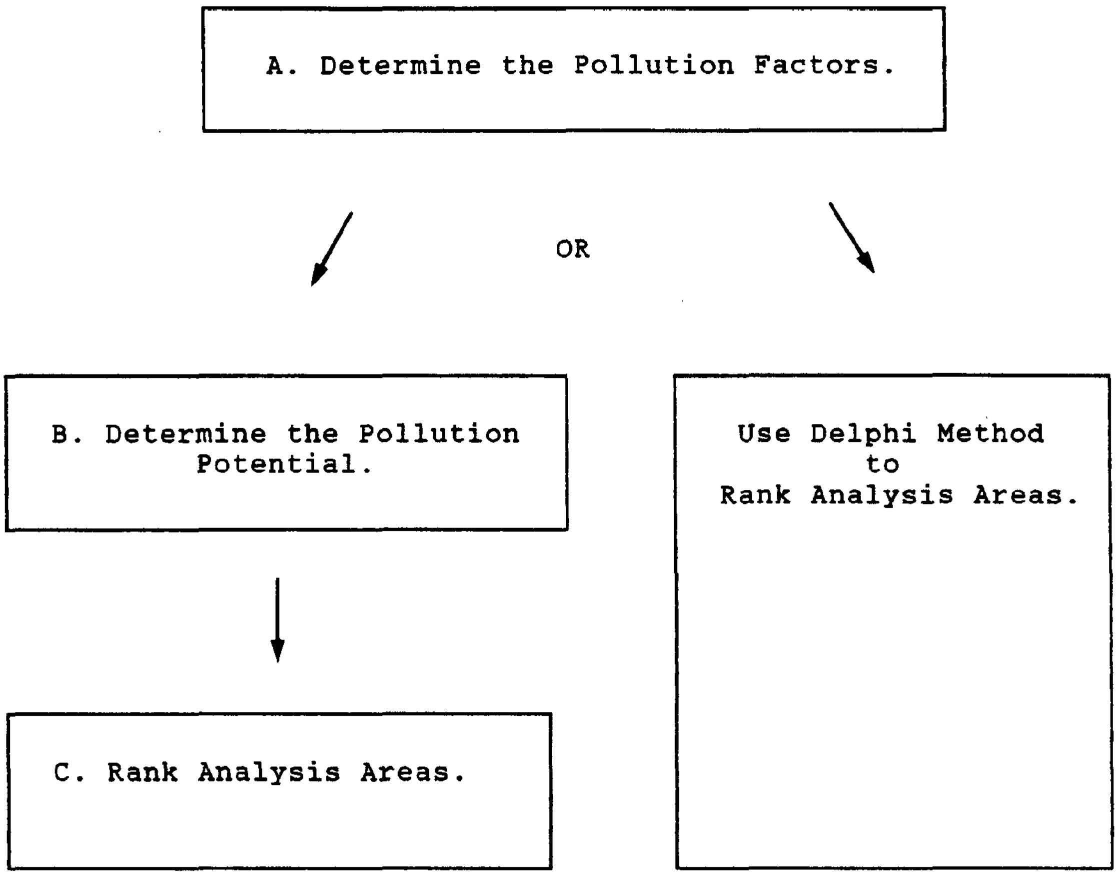
After completing Step 1, A., B., and C., review the maps and Worksheet 1.2 (page 17). Delete any analysis areas that have no urban lands.

Results of Step 2

1. Maps or a digitized database of applicable analysis areas within the watershed.

2. Tabulated physical characteristics of the applicable analysis areas.

Step 3 -- A Synopsis
Determine Pollution Potential and Rank Analysis Areas



Determine Pollution Potential and Rank Analysis Areas

A. Determine the pollution factors.

Six ratios of analysis area physical information, appropriate weights, and the resulting evaluation factors are developed in three Worksheets 1.3, 1.4, and 1.5. Each worksheet and calculation procedures are described in the following actions.

1. Calculate the Composite Runoff Coefficient for Each Analysis Area (Rv). This method is limited to estimation of surface runoff only. For each analysis area (see Worksheet 1.2, page 17), complete a copy of Worksheet 1.3 Composite Runoff Coefficient (page 21).

Area of Land Use - Consult the Analysis Area Information Worksheet 1.2, page 17. Obtain the data from columns (6) - (15) on urban land use. Enter data in column (2) of Composite Runoff Coefficient Worksheet 1.3, page 21.

Percent Imperviousness Value - Assign a value to each urban land use type represented in each analysis area. Examples of urban land use and percentage impervious values are presented in the following chart.

Urban Land Use	Percentage Impervious Value
Residential (avg. lot size)	
2 acres	12
1 acre	20
1/2 acre	25
1/3 acre	30
1/4 acre	38
1/8 acre or less	65
Commercial	85
Industrial	72
Institutional	85

(Extracted from USDA-SCS, June 1986)

(Note: The user may choose impervious factors for the watershed that are more representative of local areas.)

Complete Column (4) - For each category of land use, multiply the area of land use by the percentage impervious value.

Worksheet 1.3 Composite Runoff Coefficient.

Priority Watershed ____________________ Date __________

Analysis Area No. ______ Name ____________________

Use of Land (1)	Area of Land Use (Acre) (2)	Percentage Impervious Area Value (Acre) (3)	Col.(2) x Col.(3) (4)
Residntl. 2 ac.			
Resid. 1 ac.			
Resid. 1/2 ac.			
Resid. 1/3 ac.			
Resid. 1/4 ac.			
Resid. <=1/8ac.			
Commercial			
Industrial			
Institutional			
Other Urban Land			
All Other Land			
Total		----	

Weighted Percentage Impervious Urban Land in Analysis Area = Total col.(4) / Total col.(2) = __________ = ________

Composite Runoff Coefficient (Rv)[a] = 0.05 + 0.009(Wtd. Pct. Imp. Area)
= 0.05 + 0.009( )
= ________________

Transfer Rv for each Analysis Area to col.(12) in Analysis Area Pollution Factor Worksheet.

a source of equation: MWCOG, July 1987.

Calculate the Weighted Percentage of Impervious Urban Land in each Analysis Area - (Equations in Composite Runoff Coefficient Worksheet 1.3, page 21.)

Calculate the Composite Runoff Coefficient (Rv) for the Analysis Area - (Equation in the Composite Runoff Coefficient Worksheet 1.3, page 21.)

2. Determine the Erodibility of Soils and Slope of Land Ratios.

Determine the Erodibility of Soils Ratio - The combined percentage of moderate, high, and very high erodible soils underlying the urban area in each analysis area is determined in five actions:

- o Obtain current soil survey map sheets of the watershed area from the local Soil Conservation District Office.

- o Consult Appendix D. (Information in Appendix D has been exerpted for the Baltimore region counties from Natural Soil Groups of Maryland (1973)). Trace the boundaries of the soil mapping units on an overlay of the soil survey sheets. Match each mapping unit to the appropriate natural soil group in Appendix D and label with the soil group symbol. The result is a natural soil group overlay map of the watershed.

- o Assign each unit on the natural soil group overlay map with a Moderate, High, or Very High erodibility class, if appropriate, to form an erodibility class map . The natural soil groups, erodibility K-factors, and classes are shown in the following chart.

Class	K-Factor	Natural Soil Groups
Very Low	0.17	A1a, A1b, A1c, A2.
Low	0.22 - 0.28	C1a, C1b, C1c, D1a, D1a, D1b, D1c, E1, F2.
Moderate	0.32	B1a, B1b, B1c.
High	0.37	B3, C2, E3.
Very High	0.43	B2a, B2b, B2c, E2a, E2b, F3.
N/A *		F1, G1, G2, G3.
**		H1a, H1b, H1c, H2a, H2b, H2c.

* N/A - Refer to the <u>Natural Soil Groups of Maryland</u> for further explanation and assignment of a K-Factor.

** These groups are too variable to rate. Determine the specific soil series name from the detailed soil survey series map and use the information for the group containing that series.

- Measure those areas discussed above in each analysis area. (Overlay the natural soil group erodibility class map over the urban area map of the same scale.) Enter the total urban area over erodible soils value, for each analysis area, in column (6), Worksheet 1.4 - Erodibility and Slope Factors (page 24). The Worksheet also uses the information in columns (1) - (5) from Worksheet 1.2 - Analysis Area Information, page 17.

- Determine the Erodibility ratio. For each analysis area, compute:

$$\text{Erodibility of Soils Under Urban Area Ratio} = \frac{\text{Total Urban Area over Erodible Soils in an Analysis Area}}{\text{Urban Area in an Analysis Area}} \times 100 \qquad \text{[Eqn.4]}$$

Calculate the Erodibility of soils ratio for each analysis area as follows:

$$\text{Erodibility of Soils Ratio (R)} = \frac{\text{Column (6) Erodibility \& Slope Factors Worksheet 1.4 (page 24)}}{\text{Column (5) Analysis Area Information Worksheet 1.2 (page 17)}} \times 100$$

Worksheet 1.4 Erodibility and Slope Factors.

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Date ________
I.D. ________

Priority Watershed: ____________________

Sub-wtrshd. Name (1)	Analysis Area No. (2)	Analysis Area Name (3)	Land Area of Analysis Area (Acres) (4)	Urban Area (Acres) (5)	Urban Area over Erodible Soils (Acres) (6)	Urban Erodibility Ratio (%) (7)	Urban Area over Moderate & Steep Soils (Acres) (8)	Urban Slope of Land Ratio (%) (9)
Total								

Determine the Slope of Land Ratio - The slope range of land in an urban area can be determined using the natural soil groups or topographic or slope range maps.

Natural Soil Groups.

- o Use the local soil survey map sheets obtained from the Soil Conservation District for defining the erodibility ratio, to also determine land slope classes. Individual soil mapping units are combined into groups on the natural soil group overlay map. Assign each unit on the overlay map with a moderate or steep slope, if appropriate, to form a slope class map. Slope ranges can be identified using the following chart:

Class	Slope Range (percentage)	Natural Soil Groups
Low	0 - 8 or 10	A1a, B1a, B2a, C1a, D1a, E2a, H1a, H2a.
Moderate	8 - 15 10 - 15	A1b, B1b, B2b, C1b, D1b, E2b, H1b, H2b.
High	> 15	A1c, B1c, B2c, C1c, D1c, H1c, H2c.
*		A2, B3, C2, E1, E3, F1, F2, F3, G1, G2, G3.

* To identify the slope range for these natural soil groups, refer to the soil survey report and soil series in these groups.

- o Measure the urban areas in each analysis area overlying soils in the moderate and high slope classes. (Overlay the natural soil group slope class map over the urban area map of the same scale.) Measure the portion of the urban areas in the moderate and high combined slope classes. Tabulate in the Erodibility and Slope Factors Worksheet 1.4, column (8), page 24.

- o Compute the slope of the land ratio.

$$\text{Urban Slope of Land Ratio} = \frac{\text{Total Urban Area over Moderate \& High Soils in an Analysis Area}}{\text{Urban Area in an Analysis Area}} \times 100 \qquad \text{[Eqn. 5]}$$

The slope of land ratio for each analysis area is calculated as follows:

$$\text{Urban Slope of Land Ratio (R)} = \frac{\text{Column (8) Erodibility \& Slope Factors Worksheet 1.4 (page 24)}}{\text{Column (5) Analysis Area Information Worksheet 1.2 (page 17)}} \times 100$$

Topographic or Slope Range Maps.

- o Obtain current topographic or slope maps (see Glossary for definition) covering the watershed. The map scale should be 1 inch = 2,000 feet or larger, depending on the level of detail used in the overall evaluation.
- o Identify the areas on the maps in the three slope classes used for natural soil groups or similar groupings.
- o Measure the urban areas in each analysis area overlying or upslope of the Moderate and High slope classes. (Overlay the slope class map over the urban areas of the same scale.)
- o Tabulate and compute data as in previous actions 2. and 3. under Natural Soil Groups.

3. Complete Worksheet 1.5 Analysis Area Pollution Factors (page 27). Obtain information from Worksheets 1.2 (page 17), 1.3 (page 21), and 1.4 (page 24).

Analysis Area Number and Name - Enter the analysis area number and name in columns (1) and (2) of Worksheet 1.5 (page 27).

Calculate the Urban Area to Watershed Urban Area Ratio (UAWUAR) - The ratio (R) is defined for each analysis area as follows:

$$\text{UAWUAR} = \frac{\text{The Urban Area in an Analysis Area}}{\text{Total Urban Area in \underline{all} Analysis Areas}} \times 100 \qquad \text{[Eqn.6]}$$

Worksheet 1.5 Analysis Area Pollution Factors.

Priority Watershed : ______________________

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Date __________

Analysis Area		UAWUAR			UAAAR			AAWAR			Rv			Erodibility of Soils			Slope of Land		
No.	Name	R (%)	W	F	R (%)	W	F	R (%)	W	F	R (%)	W	F	R (%)	W	F	R (%)	W	F
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)

R = Ratio F = Evaluation Factor W = Weight F = R x W
(See Text for Calculation of Factors and Weights)

UAWUAR - Urban Area to Watershed Total Urban Area Ratio
UAAAR - Urban Area to Analysis Area Ratio

AAWAR - Analysis Area to Watershed Area Ratio
Rv - Composite Runoff Coefficient

This ratio is calculated for each analysis area using results from column (5) in Worksheet 1.2 - Analysis Area Information (page 17):

$$\text{UAWUAR (R)} = \frac{\text{Column (5)}}{\text{Total (column (5))}} \times 100$$

Enter each UAWUAR in column (3) of the Analysis Area Pollution Factors Worksheet 1.5, page 27. Skip columns (4) and (5).

Calculate the Urban Area to Analysis Area Ratio (UAAAR) - The ratio is defined for each analysis area as follows:

$$\text{UAAAR} = \frac{\text{The Urban Area in an Analysis Area}}{\text{Land Area of an Analysis Area}} \times 100 \qquad \text{[Eqn.7]}$$

This ratio is calculated for each analysis area using results from columns (4) and (5) in the Analysis Area Information Worksheet 1.2 (page 17).

$$\text{UAAAR (R)} = \frac{\text{Column (5)}}{\text{Column (4)}} \times 100$$

Enter each UAAAR in column (6) of the Analysis Area Pollution Factors Worksheet 1.5, page 27. Skip columns (7) and (8).

Calculate the Analysis Area to Watershed Area Ratio (AAWAR) - This ratio is defined for each analysis area as follows:

$$\text{AAWAR} = \frac{\text{Land Area of an Analysis Area}}{\text{Total Land Area of Analysis Areas}} \times 100 \qquad \text{[Eqn.8]}$$

This ratio is calculated for each analysis area using results from column (4) in the Analysis Area Information Worksheet 1.2, page 17.

$$\underset{(R)}{\text{AAWAR}} = \frac{\text{Column (4)}}{\text{Total Column (4)}} \times 100$$

Enter each AAWAR in column (9) of the Analysis Area Pollution Factors Worksheet 1.5 (page 27). Skip columns (10) and (11).

Record the Composite Runoff Coefficient for Each Analysis Area (Rv) - Transfer the composite runoff coefficient (Rv) from Worksheet 1.3 (page 21) for each analysis area to column (12) of Worksheet 1.5, page 27. Skip columns (13) and (14).

Record the Erodibility of Soils Ratio - Transfer the erodibility of soils ratio for each analysis area from column (7) in Worksheet 1.4 (page 24) to column (15), Analysis Area Pollution Factor Worksheet 1.5, page 27.

Record the Slope of Land Ratio -

Natural Soil Groups.

- o Transfer the slope of land ratio for each analysis area from column (9) in Worksheet 1.4 (page 24) to column (18), Analysis Area Pollution Factors Worksheet 1.5, page 27.

Or, alternately

Topographic or Slope Range Maps.

- o Transfer the slope of land ratio for each analysis area from column (9) in Worksheet 1.4 (page 24) to column (18), Analysis Area Pollution Factors Worksheet 1.5, page 27.

Assign a Weight for Each Evaluation Factor - In the Analysis Area Pollution Factors Worksheet 1.5 (page 27), enter a numerical value that indicates how important each evaluation factor is. A weight (W) value is assigned to a factor giving it more, equal, or less importance than other factors. If a factor is not considered important to the evaluation, give it a weight value of 0. A factor with a weight value of 1.0 allows an evaluation of the original evaluation factor. A weight value of 2.0 gives the evaluation factor twice the importance of the original factor. The user should base weighting values on the physical characteristics and technical knowledge of the priority watershed. For example, if the composite runoff coefficient is considered to be a more important contributor to runoff pollution than other factors, it should be assigned a weight value in column (13), greater than 1.0. Enter the appropriate weights in columns (4), (7), (10), (13), (16), and (19).

Calculate Weighted Evaluation Factors - For each evaluation factor in the Analysis Area Pollution Factors Worksheet 1.5 (page 27), multiply each ratio (R) by the appropriate weight (W) to obtain a pollution Factor (F) for each analysis area, (R x W = F). Enter the appropriate factors in columns (5), (8), (11), (14), (17), and (20).

B. Determine the pollution potential.

Complete Worksheet 1.6, page 31, Analysis Area Pollution Potential.

Analysis Area Number and Name - Enter identification in columns (1) and (2).

Evaluation Factor Ranks - For each factor, rank the values and record the results in columns (3) - (8); assign an integer from 1 to the total number of analysis areas in the priority watershed with 1 representing the highest value.

Break ties by assigning each tied value the rank equal to the average of the current rank position and the next greater one. For example, analysis area factors for Creek A and Creek B are 55 and 55, respectively. Normally they would be ranked 5th and 6th. However, since both analysis areas have equal values, each area is assigned values of 5.5, the average of ranks 5 and 6.

Rank Score - Add the evaluation factor rank values in columns (3) - (8) for each analysis area and record the sum (Factor Score) in column (9), Worksheet 1.6, page 31.

Determine Receiving Waters Score - Calculate the downstream receiving water score in three actions.

For each analysis area obtain the primary water body type and use classes from the Analysis Area Information Worksheet.

1. Assign scores from the following chart to the primary and secondary water body types. Enter the scores in the appropriate columns (10) and (12) in the Analysis Area Pollution Potential Worksheet 1.6 (page 31).

Worksheet 1.6 Analysis Area Pollution Potential.

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Date ________
I.D. ________

Priority Watershed: ______________________

Analysis Area		Evaluation Factor Ranking						Evaluation Factor Score	Dwnstrm. Receiving Waters					UPS	AA GRAND SCORE
									Primary		Secondary		RW Score		
No.	Name	F 1	F 2	F 3	F 4	F 5	F 6		T	C	T	C			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)

F1 = UAWUAR Factor
F2 = UAAAR Factor
F3 = AAWAR Factor

F4 = Rv Factor
F5 = Erodibility of Soils Factor
F6 = Slope of Land Factor

UPS = Unusual Pollutant Source

T = Type
C = Class

Water Body Type	Score
Stream	2
Lake	1
Estuary	1

2. Assign scores from the following chart to the primary and secondary water use classes. Enter the scores in the appropriate columns (11) and (13), Worksheet 1.6, page 31.

Water Use Class	Score
I	3
II	1
III	1
IV	2

3. Calculate the Receiving Water (RW) Score by adding columns (10); (11); (12); and (13). Enter the RW Score in column (14), Worksheet 1.6, page 31.

Determine if One or More Unusual Pollutant Sources (UPS) Exists - For each analysis area:

Review the sources of land use information used to develop the urban area inventory in Step 2. Determine, if the following land uses or activities exist. If one or more exists, place a "+" in column (15), Worksheet 1.6, page 31. If no source exists, place a "0" in the column.

- Heavy Industry - Those manufacturing facilities that use raw materials such as iron ore, timber, or coal. Included are steel mills, pulp and lumber mills, electric-powered generating plants, oil refineries and tank farms, chemical plants, brick or concrete blockmaking plants, and transportation transfer facilities. Often an identifying feature, stockpiles of raw materials and waste-product disposal areas are visible.

- Junkyards, wrecked automobile storage facilities, and other land uses where raw materials , chemicals, or goods are stored or exposed to the weather.

- Older (more than 30 years), dense urban development consisting of residential or commercial land uses or both with a high degree of impervious area.

- Developed areas with accumulated garbage or debris on streets, in yards, and in alleys - a lack of good community housekeeping.

- Urban areas with no stormwater runoff-related pollutant discharges. Examples include older (more than 30 years old) sanitary sewered areas with potential leaking sewers; industries and automobile service stations with floor drains draining to storm sewers; and areas where chemicals and wastes are dumped.

A user, unable to visit the sites, may obtain the independent assessment of unusual pollutant sources in the urban areas from one or more people who know the area.

Calculate the Analysis Area Grand Score - For each analysis area calculate the AA Grand Score as follows:

$$\text{Analysis Area Grand Score} = \text{Factor Score} \times \text{RW Score} \qquad \text{[Eqn. 9]}$$

The Grand Score is calculated for each analysis area as follows:

$$\text{Column (16)} = \text{Column (9)} \times \text{Column (14)}$$

The result is entered in Worksheet 1.6 (page 31).

C. Rank the analysis areas.

Use the AA Grand Score and the Unusual Pollutant Source indicator combined for each analysis area to rank all analysis areas in the watershed. Consider the analysis area with the lowest grand score as the area having the greatest potential for polluting stormwater runoff.

The user must decide which analysis areas in the watershed to investigate further before beginning Step 4. Ideally, Steps 4 and 5 should be applied to all analysis areas defined in Step 2. Personnel and budget are two factors to consider when defining which analysis areas to retrofit. The user should bear in mind that if a creekshed is selected as the analysis area, the number of analysis areas in the priority watershed normally will range from 5 to 20, more or less. If the analysis area selected is smaller than a creekshed the user will have 30 to 100 or more analysis areas to evaluate.

Instead of analyzing all analysis areas in a single period, the user can set priorities using the factor ranking. For example, the five highest ranked (lowest value) analysis areas in the watershed could be selected for analysis in Steps 4 and 5 and development of retrofit strategies and a plan in Step 6. At a later date, in a second round of analysis, the next highest ranked (lowest value) group of five analysis areas could be chosen, and so on.

Alternative Ranking Procedures.

Two alternative evaluation and ranking procedures for completing Step 3 follow.

Concensus Judgment - is obtained by using the Delphi Technique. This procedure, applied to ranking analysis areas is described as follows:

1. Assemble a panel of participants. Include those knowledgeable of local urban land uses, water quality, and others with more specialized expertise. The panel can include both professional and lay representatives.

2. Without consulting the other panelists, each participant ranks the analysis areas within the watershed. The ranking is based on the amount of urban area in each one, other information from the Analysis Area Pollution Factors Worksheet, and personal knowledge.

3. Compile the results, and calculate the median and range of the rankings and present them to the panelists. From this list, each panelist completes a second round of ranking.

4. The process of gathering the rankings and feeding back the results is continued for one or more rounds.

5. Calculate the median of the final round. Consider it the best estimate of the top rank analysis area. Other analysis area ranks are developed similarly.

Combination of Concensus Judgment and Numerical Scoring - A third method of choosing the analysis areas is a combination of the two methods previously described. Derive a ranking of analysis areas using the Delphi technique. Develop a second ranking of analysis areas by numerical scoring. Compare both lists to derive a combined ranking.

Results of Step 3

1. A ranking of the applicable analysis areas based on their urban area's potential to pollute receiving waters.

2. The pollution potential of the applicable analysis areas.

Step 4 -- A Synopsis
Develop a Profile of Urban Conditions and Retrofit Opportunities

A. Gather and Organize Information.

↓

B. Perform a Site Survey.

↓

C. Develop a Profile of Analysis Area Urban Conditions and Retrofit Opportunities.

↓

D. Disregard Very Low Priority Analysis Areas.

Develop a Profile of Urban Conditions and Retrofit Opportunities

A. Gather and organize information.

Resources consist of, but are not necessarily limited to maps, reports, plans, construction documents, and other information.

- o A wide variety of maps exist that may have information to describe conditions of the urban area within analysis areas. See Appendix E for a summary of 16 kinds of maps, their uses, typical map scales, and common sources. For a specific urban area, the scale is important. Generally, map scales equal to or larger than 1 inch = 1000 feet - depending on the desired information - are adequate for analyzing urban areas.

- o Local, state, or Federal government, or private reports concerning land use, infrastructures, transportation, natural resources, water quality, water resources, parks and recreation, and plant and animal habitats may offer information that better describes the analysis area and the enclosed urban area. An especially useful report is the Local Soil Survey developed by the Soil Conservation Service. The Environmental Impact Assessment or Statement is another important source of environmental information describing the environmental impacts on both physical and biological resources.

- o Information may be available from Federal, state, or local government agencies or private organizations such as U.S. Fish and Wildlife Service; U.S. Soil Conservation Service; U.S. Geological Survey; Maryland Department of Environment; Maryland Department of Planning; Maryland Department of Natural Resources (Forest, Park, and Wildlife Service, Fisheries Division, Coastal Resources Division); Maryland Natural Heritage Program; and County Soil Conservation Districts. Important local agencies to contact include the Departments of Health, Planning and Zoning, and Public Works.

- o Like reports, plans also may have information describing an urban area. Examples include: park and recreation, subdivision storm drain systems, land use, stormwater management, and water and sewer plans.

- o Often construction drawings, plans, specifications, and other related information can point to conditions otherwise obtainable only by special investigation. For example, the soil boring analyses (required for construction of a building or a roadway) can be used to determine the feasibility of infiltration as a water quality retrofit management practice.

- A good supplement to field surveys or a substitute for detailed field surveys is a series of recent aerial photographs of the analysis area. The aerial photos should be less than five years old, if possible, and taken at low altitude. High altitude photos are useful for larger urban areas where detailed information is not required. Sources of aerial photographs include: the (USDA) Agricultural Stabilization and Conservation Service, USDA Soil Conservation Servation, U.S. Department of Commerce National Oceanic and Atmospheric Survey, Maryland Tax Assessment Office, Maryland Gypsy Moth overflights, county-sponsored flights, and private aerial survey companies.

B. Perform a site survey.

An urban area survey is an information gathering task. This information is used to

- check the validity of existing maps, reports, plans, and other information that describes the site,
- note any unusual circumstances such as land uses that generate higher than normal pollutant loads (see Step 3, unusual pollutant sources, pages 32 and 33) or severe unchecked erosion; and
- point out opportunities and constraints for application of water quality retrofit control measures.

An urban area site survey normally is performed by walking through and around the site, and following the drainage system downstream to the nearest receiving water body. If the urban area is large (several hundred acres or more), a windshield survey by automobile may be appropriate.

Review all information obtained before going to the site. The user should have developed or selected a map of the analysis area and urban areas to be used as the base map. The map should have a scale large enough to record accurately detailed information. A reasonable scale for small to medium sized analysis areas is 1 inch = 1,000 feet or larger. Large areas of 2,000 acres or more can be described at scales of 1 inch = 2,000 feet or larger. Set up a series of maps at the same scale which can be overlaid to combine characteristics.

Visit the site. Make a special effort to:

- cross the width of the site from drainage boundary to drainage boundary at several intervals along the length of the area,

- o follow the storm drainage system from the highest to lowest elevations,
- o follow the storm drainage system downstream to the nearest receiving water body,
- o check the conditions of all areas identified in Steps 2 and 3 that have moderate to very highly erodible soils (a K factor of equal to or greater than 0.032) and moderate to steep slopes (equal to or greater than 8%).
- o check out any areas of public ownership for retrofit opportunities.
- o inspect sections of stream for erosion and sedimentation or any indications of problems at stormwater outfalls.

Use the Site Survey Checklist at the end of Step 4 to describe the urban conditions in each analysis area and record the observations on the analysis area base map.

C. Develop a profile of analysis area urban conditions and retrofit opportunities.

Follow up the field survey by investigating and answering any questions resulting from the survey. This data and the Site Survey Checklist is your Urban Area Profile.

When developing a profile of an urban area's existing conditions and retrofit opportunities, use the information collected and the results from this step as well as the data from the Pollution Potential Worksheet 1.6 in Step 3 (page 31), results of the field survey in Step 4, and the site base map and overlays. The profile is a summary of descriptive information presented in outline and map form.

D. Disregard very low priority analysis areas.

When the field survey and Site Survey Checklist are completed for an analysis area, compare the conditions with the relative ranking of analysis areas in Step 3. The analysis area can be disregarded if it has

- o a low pollution potential ranking when compared to other analysis areas,
- o adequately stabilized slopes and drainage channels with no erosion or sedimentation problems,

- no illegal or unusual runoff pollutant sources,
- only very low density residential (> 2 acres per dwelling unit) development with minimal impervious area,
- vegetated buffers along all open drainage channels and receiving waters that reduce the effects of stormwater runoff,
- existing management practices that provide control of stormwater runoff pollutants.

Results of Step 4

1. A profile of the urban conditions and retrofit opportunities in each applicable analysis area.

Site Survey Checklist

Land Use/Cover

1. Describe the land uses and land covers of the site. The information should include:

   a. Type(s)
   b. Density(ies)
   c. Approximate Age of Development
   d. Vegetation - types and densities *
   e. Estimate the proportion of the site taken up by each land useand cover.
   f. Point out areas of open space (such as parks, etc.) and their relationship to other land uses. *

Land Ownership

2. Document which portion(s), if any, of the urban area is publically owned or under public control. *

Hydrology

3. Do the drainage boundaries of the site correspond with those previously mapped? If not, change the mapped boundaries on the site base map. *

4. Estimate the total imperviousness of the site. (See Step 3.)

5. Of the site's total imperviousness, what portion is "hydraulically-effective" (that part of the paved or otherwise impervious area that discharges stormwater runoff to other paved areas which carry the runoff to a storm drain system.) *

   a. Where do the building roof gutters and downspouts drain?
   b. Are the driveways contiguous with the streets?
   c. Are the surface drains paved?

6. Does the hydrologic runoff potential (A,B,C,D) from the Step 3 assessment (Natural Soil Groups) correspond with the individual soil mapping units in the local Soil Survey Report?

7. Are the ground slopes and storm drainage slopes moderate to high (equal to or greater than 8 percent)? *

8. If maps are not available that show the storm drain system, sketch the system. *

   a. show approximate sizes, lengths, and locations of the:
      i. overland flow paths (arrows for direction)
      ii. swales
      iii. ditches
      iv. pipes
      v. storm drain inlets
      vi. gutters

   Note the natural versus artificial sections.

Pollutant Sources and Problems

9. From your observations of land use, are there any activities or sites that could generate greater than normal pollutant concentrations or unusual pollutants? An example is an industry with raw materials stored outside. Also commercial establishments such as service stations, automobile garages, junk yards, accumulated garbage, dry cleaners and other sources that could generate pollutants. If any exist, note the location, type of activity, and materials. *

10. If a pollutant source is found that is suspected to be illegal, note the type and location and contact the proper local or state authorities. * Examples include:

   a. A pipe with a liquid discharge into a ditch, stream, or tidal waters.
   b. Drums or other containers leaking fluids or powders.
   c. Liquid seepage boiling up from the ground or from a cut in a hill slope.
   d. Evidence of failing septic systems.

11. Are there obvious areas of soil erosion on the site? *

   a. Sheet erosion (look on the lawns and other upslope areas for signs).
   b. Rill erosion (downslope areas with small shallow ditches generally a foot or less wide).
   c. Gully erosion (downslope areas, especially flatter areas near streams with obvious ditches, usually several feet across and deep).
   d. Exposed moderate to high slopes (equal to or greater than 8 %).
   e. Bare or poorly vegetated drainage channels.

Locate those areas and name the type of erosion and show the source of flow causing the erosion.

<u>Relationship to Receiving Waters</u>

12. Follow the drainage pathway from the urban source area to the nearest receiving water body.

   a. Estimate the distance.
   b. Is drainage pathway open or a piped system?
   c. Describe the conditions where the urban area runoff discharges into the receiving waters. Streambank erosion? Sedimentation? (look both up and down stream for an indication of an erosion problem.)
   d. What is the receiving water body (a stream, headwater drainage, tidal waters, or wetland)?
   e. What is the orientation of the stormwater outfall and the type?

<u>Retrofit Control Opportunities and Constraints</u>

13. Locate all community open space areas throughout and immediately downstream of the site. *

   a. Point out the publicly owned areas.
   b. Locate those areas coinciding with the storm drainage system.
   c. Describe these areas. (Consider such things as type and vegetation.)

14. Are management practices currently being applied at the site that either affect or could potentially affect water quality or stormwater runoff? Examples include street sweeping, stormwater management structures or dry ponds (probably built after 1970), and riprapping in channels. *

   a. Name, describe, and indicate the location of these practices.
   b. Note the maintenance levels and frequencies.

15. The following list contains examples of land conditions and existing management practices that may coincide with the situation in the urban area under investigation. Check the conditions in the urban area against this list for possible opportunities to implement retrofit management practices. *

   a. Roof downspouts connected to the sanitary sewer, storm sewer system, or paved surface.
   b. Paved sidewalks, parking lots, streets, or surfaces in need of resurfacing or replacement.
   c. Unused or otherwise unnecessary impervious surfaces.

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d. Curb and Gutter in need of replacement on slopes of 4 percent or less. (A potential for installing vegetated swales.)
e. Stormwater inlets or catch basins or both.
f. Paved open drainage channels.
g. Bare foot paths, roads, or parking areas.
h. Road median strips with no curb and gutter.
i. Grass strips adjacent to roadways.
j. Erosion and sedimentation concerns.
k. Communities with unusually dirty conditions.
l. Unused stable pervious surfaces.
m. Unused natural depressions.
n. Dry stormwater management basins.
o. Stormwater outfalls.
p. Utility easements and Rights-of-Way.

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* This information is of the highest priority for collection in a field survey.

Step 5 -- A Synopsis
Develop Urban Retrofit Strategies

A. Evaluate the Urban Areas.

↓

B. Develop an Urban Retrofit Strategy.

↓

C. Repeat Steps 5, A and B for Applicable Analysis Areas.

Develop Urban Retrofit Strategies

A. Evaluate the urban areas.

If the analysis area has existing urban stormwater management practices (unlikely in pre-1970 construction) or an extensive improved storm drainage system, evaluate the individual urban area or clusters to determine if modifications are needed. For example: an urban area drains to a dry stormwater management (detention) basin designed to retain a 2-, 10-, or 100-year runoff event. The retrofit analysis may point out an opportunity to retrofit the basin into an extended detention basin designed to hold smaller runoff events for water quality benefits as well as control larger events that cause stream erosion and flooding.

The evaluation procedure for existing management practices:

1. Compare the Urban Conditions Profile with:

   Table 1.1 Source Control Management Practices.

   Table 1.2 Erosion Control Management Practices.

   Table 1.3 Characteristics of Urban (Stormwater Runoff) Retrofit Management Practices.

   at the end of Step 5, pages 51 through 58.

2. Consider whether changing an existing source control management practice shown in the profile would improve control. (See the Resource Directory, page Res-1, for specific information about source controls.)

3. Assign the appropriate erosion controls listed in Table 1.2 (page 53) to the erosion problems and past correction efforts identified by the site survey in Step 4. Note that a combination of practices normally is needed to address erosion and manage stormwater runoff. The user also must evaluate the upslope contributing drainage area and use of stormwater controls (Tables 1.2 and 1.3)

4. Review the list of stormwater runoff management practices and characteristics in Table 1.3 (pages 54-58) and the Urban Area Profile. Consider any management practice in the urban area a candidate for retrofitting. However, in construction of the 1970's, the most common stormwater management practice covering a large drainage area was the dry detention basin, designed to control the 2-, 10-, or 100-year runoff event. (See Appendix F, Summaries of Urban Retrofit Management Practices, for information about specific management practices.)

Also consider the stormwater runoff management practices used in residential and commercial areas to handle building roof runoff. In typical lower density residential areas, roof runoff drains to splash blocks and lawns. However, in some residential communities and commercial districts, roof drains are drain to paved areas or are connected by pipes to streets, storm drains, or even sanitary sewers.

After evaluating the urban area for opportunities to modify existing management practices, a second evaluation is necessary to determine the potential for applying new practices. Evaluate each urban area:

1. Examine the source control management practices listed in Table 1.1 (pages 51-52) for possible application to the urban area. Many of these practices can be implemented in large geographic areas - throughout the priority watershed or the local jurisdiction.

2. Potentially the most cost-effective set of management practices to apply in the urban area is where evidence of erosion is seen in the field surveys (Step 4) or indicated in the pollutant potential scoring (Step 3). These controls (shown in Table 1.2) normally are applied with stormwater runoff management practices (Table 1.3), to address both the effects of erosion and the source of stormwater runoff.

3. Compare the Urban Area Profile to the Characteristics of Urban Retrofit Management Practices Table (Table 1.3, pages 54-58).

   - Using the site base map, follow the pathways of storm runoff noting the drainage features. Compare each segment of the system and the Urban Area Profile with appropriate management practices and characteristics in Table 1.3, summaries of management practices in Appendix F, and supporting information in the Resource Directory.

   - Define the approximate drainage area that will be treated by the management practice and record any practice that matches the site profile conditions. Also record the characteristics of the practice and location.

Urban Retrofit Measures.

Urban retrofit measures improve the quality of stormwater runoff by either: (1) reducing or removing the supply of pollutants on the land prior to or between storm events or (2) delaying, infiltrating, storing, or treating the water as it runs off the land. The stormwater runoff can pick up pollutants from the land and, because of the volume, velocity or both, generate pollutants by eroding the land surface, drainage channels, or stream beds and banks. Certain management practices for stormwater runoff also can be designed to handle the volume and rate of release.

Known management practices considered applicable for retrofitting in existing urban areas are grouped in the following three categories:

1. Source controls - are nonstructural, that is they are human activities and living patterns rather than physical structures. Source controls are not restrained by drainage boundaries and can be applied to large areas. These controls affect the supply of pollutants on the land surface before rainfall by (1) preventing the introduction of pollutants to the land surface; (2) reducing or timing the frequency of application of potential pollutants to the land; or (3) removing the accumulated pollutants from the land.

Some controls require implementation by the individual. Others are best carried out at the community or municipal level. Initial costs often are low but increase with operation and maintenance activities. See Table 1.1, pages 51-52.

2. Erosion controls - Although erosion is a result of stormwater runoff over susceptible land (erodible soils or steep slopes or both), it has a separate category of controls. Erosion problems are, by comparison to other urban runoff issues, more easily identified by a site survey. When a specific erosion problem has been identified, the control practices include ground covers and earth retention devices. Stormwater runoff controls also are applied to manage the water source. See Table 1.2, page 53.

3. Runoff controls - generally are organized by location along the path of flow. The management practices should be used as a guide for performing a "downslope" retrofit assessment. (The user begins at the top of the drainage area boundary and investigates retrofit control options while proceeding down the slope to the stream or other receiving water body.)

The characteristics of runoff controls vary with each control. See Table 1.3, pages 54-58. Unlike source controls, the initial costs of runoff controls are often substantial - usually because of the land and construction requirements. See Table 1.4, page 59, for a summary of approximate costs.

The user must study the characteristics of each practice being considered for the retrofit plan to determine if the practice will be suitable for the areas. The characteristics of the control practices for retrofitting an urban area are listed in Table 1.3. The table is divided into four parts : (1) Physical Site Conditions and Requirements; (2) Management Capability; (3) Environmental Impacts; and (4) Costs and Responsibility. The user also can determine all the possible management practices that may be applicable in a specific urban area.

The user should use the table to

- weigh the advantages and disadvantages of the practices being considered,
- achieve a reasonable removal of pollutants at a minimum estimated cost,
- choose practices that can be implemented with minimal impacts to the environment and community, and
- select combinations of practices with minimum operations and maintenance burdens.

An important purpose for retrofitting an existing urban area is to reduce the pollutants in stormwater runoff. Studies by the State of Maryland (see summaries in Water Quality Inventories 1975-86), U.S. Environmental Protection Agency (Dec. 1983), Martin (1985 and 1986), MWCOG (1986 and July 1987) have found that urban runoff is a significant contributor to the impairment or denial of beneficial uses in receiving waters. Typical pollutants found in runoff that help cause water quality problems include: sediment, both nitrogen and phosphorus nutrients, oxygen demanding organic substances, heavy metals (lead, zinc, copper, chromium), and other toxics. Management practices for retrofitting should be selected to remove the most cost-effective quantity of the pollutants that have been shown to cause the local receiving water quality problems.

Note: Table 1.3 can be expanded to include any new practices or modifications of existing practices. Also, Appendix F (which includes a brief description of each management practice listed in Table 1.3) and the Resource Directory (which lists pertinent literature) may help the user understand and select the best management practices.

B. Choose retrofit strategies.

Combine the results of the two evaluation procedures. The results become the retrofit strategy for urban areas in the analysis area. The strategy should include:

- Categories and specific management practices recommended.

- Locations of existing management practices recommended for retrofitting and the approximate drainage area treated by each practice.

- Approximate locations or areas where new management practices are recommended and the approximate drainage area treated by each practice.

- Special conditions or characteristics that can affect implementation of the strategy in the analysis area.

- Estimates of the relative costs of management practices. The ability to estimate costs depends on the amount of information available, level of detail of the retrofit analysis, and adequate information about costs.

- A summary of possible opportunities for retrofitting that require more information before including in the retrofit strategy.

An urban water quality retrofit strategy developed for an analysis area's urban lands does not represent replace engineering analyses for determining the use of certain practices. It is a preliminary analysis of the potential for applying one or more practices. If later engineering studies show that a specific practice cannot be applied or should be modified, disregard or modify the strategy.

C. Repeat Steps 5, A and B for applicable analysis areas.

After completing the retrofit analysis described in Steps 5, A and B, repeat for all applicable analysis areas in the priority watershed.

Result of Step 5

1. Retrofit strategy for the urban lands in each applicable analysis area of the priority watershed.

Table 1.1 Source Control Management Practices continued.

Management Practice Category	Specific Practice	Environmental Impacts: Natural — Wldlfe. Habitat	Recreation	Therml. Dschg.	L. Flow Strm. Mtn.	Grdwtr. Rechg.	Dnstrm. Aquatic Life	Human — Health	Safety	Aesthetics/Lndscpe.	Costs	Responsibility: Municipality	Community	Private (Business)	Private (Indiv.)
Urban Surface Cleaning	Street Sweeping (Manual or Machine)	O	O	O	O	O	+	+	+	+	Per lb. removed: manual - $0.39-1.21 machine- $0.04	●	●	O	O
	Parking Lot Sweeping (Manual or Machine)	O	O	O	O	O	+	+	+	+	Per operating hour: manual - $12.41 machine- $35.31	●	●	●	O
Solid Waste Handling	Trash Packaging, Handling, & Collection	O	O	O	O	O	+	+	+	+	Packaging & Handling - Low Collection - Mod.-High	●	●	●	●
Fertilizer Application Control		O	O	O	O	O	+	O	O	-	Implement - Low (Cost Savings)	●	●	●	●
Pesticide Application Control		+	+	O	O	O	+	+	O	O	Implement - Low (Cost Savings)	●	●	●	●
Roadway Deicing Control		O	O	O	O	O	+	-	-	+	Implement - Low (Cost Savings)	●	●	●	●
Pet Waste Management		O	-	O	O	O	+	+	O	+	Implement - Low	●	●	●	●
Materials & Chemicals Spill Control		+	+	O	O	O	+	+	+	+	Implement - Low (Cost Savings)	●	●	●	●

Impacts
+ - Beneficial Impacts
0 - Neutral or No Impacts
- - Negative Impacts

● - Applicable
◐ - Sometimes Applicable
O - Not Applicable

Table 1.1 Source Control Management Practices.

Management Practice Category	Specific Practice	Physical Site Conditions/ Requirements	Debris	Sediment	T. Nitrogen	T. Phosphorus	Tr. Metals	Oxygen Demand	Bacteria
			Water Quality Management Capability						
Urban Surface Cleaning	Street Sweeping (Manual or Machine)	Paved surfaces in good condition with curbs. Moderate to low slopes.	●	◑	◑	◑	◑	○	
	Parking Lot Sweeping (Manual or Machine)	Paved surfaces in good condition with curbs. Low slopes.	●	◑	◑	◑	◑	○	
Solid Waste Handling	Trash Packaging, Handling, & Collection	Applicable in all urban areas, including residential, commercial, industrial, institutional.	●						
Fertilizer Application Control		Residential, commercial, industrial, and institutional vegetated areas.	○	○	⦶	⦶	○	○	○
Pesticide Application Control		Residential, commercial, industrial, and institutional, vegetated areas. Use in residential building construction.	○	○	○	○	○	○	○
Roadway Deicing Control		Use on snow or ice-covered roads, streets, sidewalks, parking lots, and other paved areas.	○	◑					
Pet Waste Management		Applicable in residential areas with >20 percent imperviousness (1 acre or smaller lots).	○	○	●	●	○	○	●
Materials & Chemicals Spill Control		Applicable on urban lands where materials or chemicals can be spilled or dumped and become pollutants in stormwater runoff.				Varies with the material or chemical			

<u>Water Quality</u>

● - 76 - 100 % Removal (long Term) ⦶ - 26 - 50 % Removal Blank - Inadequate Data Available
◑ - 51 - 75 % " ○ - 0 - 25 % "

Table 1.2   Erosion Control Management Practices.

Stormwater Runoff as an Erosion Cause

A. See Urban Stormwater Runoff Management Practices in Table 1.3.

Sheet Erosion

A. Mulch (temporary control)
B. Permanent Vegetation (grasses, sod, shrubs,etc.)
C. Contour-Wattling *
D. Contour-Brush-Layering (green branches or rooted cuttings) *
E. Reed-Trench Terracing (Reed grass) *
F. Brush Matting *
G. Live Staking (sprigging or willow staking) *
H. Revetments *
   - o riprap
   - o gabion mattresses
   - o rubber tire networks
   - o sand-cement sacks
   - o articulated, precast concrete blocks
   - o cellular grids

Rill and Gully Erosion

A. Check Dams
   - o porous - rock, brush, posts
   - o nonporous - concrete, sheet steel, wet masonry

B. Live Staking
C. Regrade Site and Plant in Permanent Vegetation
D. Structural Protection *
   - o revetments
   - o toe - walls
   - o retaining structures

Steep Slope Erosion

A. Toe - Walls *
   - o rock breast walls
   - o gabion walls
   - o crib walls (timber or concrete)
   - o welded-wire walls
   - o reinforced earth

B. Retaining Structures *
   - o gravity walls
   - o crib or bin walls
   - o reinforced earth
   - o cantilever & counterfort walls
   - o gabions & welded-wire walls
   - o pile walls
   - o tie-back walls

C. Revetments (armoring) *
   (see sheet erosion section)

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* Note: See Gray and Leiser, 1982 for detailed explanation.

Table 1.3 Characteristics of Urban Retrofit Management Practices.

Practice Function	Management Practice	PHYSICAL SITE CONDITIONS/REQUIREMENTS: SOILS — Soil Type "A"	"B"	"C" or "D"	Soil Infiltration Capacity (Inch/Hour) >0.17	≤0.17	Depth to Bedrock (Inches) 0-72	>72	Depth to Seasonal High Wtr. Table (Feet) 0-2	>2-6	>6	SLOPE (%) 0-5	6-20	>20
Infiltration	Dry Well	●	◑	○	●	○	○	●	○	○	●	●	○	○
	Trench: o Full Exfiltration o Partl. Exfiltration o WQ Trench	●	◑	○	●	○	○	●	○	○	●	●	○	○
	Basin: o Full Exfiltration o w/ Detention Basin o Off-line Trench	●	◑	○	●	○	○	●	○	○	●	●	●	○
	Porous Pavement: o Full Exfiltration o Partl. Exfiltration o Water Quality	●	◑	○	●	○	◑	●	○	◑	●	●	○	○
	Modular Paving	●	◑	○	●	○	○	●	○	◑	●	●	○	○
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale	●	◑	○	●	○	◑	●	○	◑	●	●	◑	○
	Grassed Filter Strip	●	◑	○	●	○	○	●	○	◑	●	●	◑	○
Trapping	Water Quality Inlet (Oil & Grit Separator)	●	●	◑	●	◑	◑	●	○	◑	●	●	◑	○
Storage/ Release	Parking Lot Storage	●	●	●	●	●	◑	●	○	●	●	●	○	○
	Dry Pond	◑	●	●	●	●	◑	●	○	●	●	●	●	●
	Extended Detention: o Dry Pond o Dry Pond w/ Marsh o Wet Pond	◑	●	●	●	●	◑	●	○	●	●	●	●	●
	Wet Pond: o Wet Pond o Wet Pond w/ Marsh o Wet Pond w/ Forebay	○	◑	●	●	●	◑	●	○	●	●	●	●	●
Natural System	Shallow Marsh	○	◑	●	○	●	●	●	●	◑	○	●	●	◑
Physical Treatment	Sand Filter	●	●	●	●	◑	◑	●	◑	◑	●	●	◑	○
	Swirl Concentrator/ Helical Bend	●	●	●	●	●	●	●	◑	●	●	●	◑	◑
	Plate/Tube Separator	●	●	●	●	●	●	●	●	●	●	●	◑	◑
	Screens	●	●	●	●	●	●	●	●	●	●	●	◑	◑

MANAGEMENT PRACTICE IS:

● - Applicable

◑ - Sometimes Applicable under certain site/ or design conditions.

○ - Not Applicable

Table 1.3 Characteristics of Urban Retrofit Management Practices continued.

Practice Function	Management Practice	PHYSICAL SITE CONDITIONS/REQUIREMENTS cont. Max. Contributing D.A. Managed by Practice (Acres) 0 - 1	>1 - 5	>5 - 10	>10 - 100	>100 - 400	Applicable Land Uses: Low Density	Med. Density	High Density	Space Required by Practice (% of Site Area) 0 - 5	6 - 15	16 - 25	26 - 75	Distance from Septic System or Wtr. Sup. Well (Feet) < 100	≥ 100
Infiltration	Dry Well	●	○	○	○	○	●	●	◑	●	○	○	○	◑	●
	Trench: o Full Exfiltration o Partl. Exfiltration o WQ Trench	●	●	○	○	○	●	●	◑	○	●	○	○	○	●
	Basin: o Full Exfiltration o w/ Detention Basin o Off-line Trench	○	○	●	◑	○	●	●	◑	○	●	○	○	○	●
	Porous Pavement: o Full Exfiltration o Partl. Exfiltration o Water Quality	●	●	●	○	○	●	●	●	○	○	◑	●	○	●
	Modular Paving	●	●	◑	○	○	●	●	◑	○	◑	●	●	○	●
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale	●	●	◑	○	○	●	●	◑	◑	◑	●	○	○	●
	Grassed Filter Strip	●	●	●	◑	○	●	●	◑	◑	◑	●	○	○	●
Trapping	Water Quality Inlet (Oil & Grit Separator)	●	○	○	○	○	●	●	●	●	○	○	○	◑	●
Storage/ Release	Parking Lot Storage	●	◑	○	○	○	○	●	●	●	◑	○	○	◑	●
	Dry Pond	○	○	●	●	●	●	●	●	●	●	○	○	○	●
	Extended Detention: o Dry Pond o Dry Pond w/ Marsh o Wet Pond	○	○	●	●	●	●	●	●	●	●	○	○	○	●
	Wet Pond: o Wet Pond o Wet Pond w/ Marsh o Wet Pond w/ Forebay	○	○	○	●	●	●	●	●	◑	●	○	○	○	●
Natural System	Shallow Marsh	○	○	○	◑	●	●	●	◑	●	●	○	○	○	●
Physical Treatment	Sand Filter	○	○	●	◑	○	○	●	●	●	◑	○	○	○	●
	Swirl Concentrator/ Helical Bend	○	○	●	◑	○	○	●	●	●	○	○	○	●	●
	Plate/Tube Separator	○	○	●	◑	○	○	●	●	●	○	○	○	●	●
	Screens	○	●	●	◑	○	○	●	●	●	○	○	○	●	●

MANAGEMENT PRACTICE IS:

● - Applicable

◑ - Applicable Sometimes under certain site/or design Conditions

○ - Not Applicable

Table 1.3 Characteristics of Urban Retrofit Management Practices continued.

Practice Function	Management Practice	MANAGEMENT CAPABILITY: STORMWATER: Peak Discharge 2yr.	10yr.	100yr.	Volume Control	Groundwater Recharge	Streambank Erosion	WATER QUALITY (Pollutant Removal): Debris	Sediment	T. Nitrogen	T. Phosphorus	Tr. Metals	Oxygen Demand	Bacteria
Infiltration	Dry Well	○	○	○	●	●	●	○	●	◑	◑	●	●	●
	Trench:													
	o Full Exfiltration	●	●	○	●	●	●	○	●	◑	◑	●	●	●
	o Partl. Exfiltration	●	●	○	●	●	●	○	◑	◑	◑	●	◑	◑
	o WQ Trench	○	○	○	●	●	●	○	◑	◑	⦶	●	◑	◑
	Basin:													
	o Full Exfiltration	●	●	◑	●	●	●	●	●	◑	◑	●	●	●
	o w/ Detention Basin	●	●	●	●	●	●	●	●	◑	◑	●	●	●
	o Off-line Trench	●	○	○	●	●	●	●	◑	⦶	⦶	●	◑	◑
	Porous Pavement:													
	o Full Exfiltration	●	●	◑	●	●	●	○	●		◑			
	o Partl. Exfiltration	●	●	◑	●	●	●	○	●	●	⦶	●	●	
	o Water Quality	○	○	○	●	●	○				⦶			
	Modular Paving	●	○	○	●	●	●							
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale	◑	○	○	◑	◑	○	○	○	○	○	○	○	
	Grassed Filter Strip	◑	○	○	◑	◑	○	○	○	○	◑	○	○	
Trapping	Water Quality Inlet (Oil & Grit Separator)	○	○	○	○	○	○	⦶	○	○	○	⦶	○	
Storage/ Release	Parking Lot Storage	●	○	○	○	○	○							
	Dry Pond	●	●	●	○	○	●	◑	⦶	○	○	○	○	
	Extended Detention:													
	o Dry Pond	●	●	●	○	○	●	●	⦶	○	⦶	◑	⦶	
	o Dry Pond w/ Marsh	●	●	●	○	○	●							
	o Wet Pond	●	●	●	○	○	●	●	◑	○	⦶	◑	⦶	
	Wet Pond:													
	o Wet Pond	●	●	●	○	●	●	●	◑	○	⦶	◑	⦶	
	o Wet Pond w/ Marsh	●	●	◑	○	●	●							
	o Wet Pond w/ Forebay	●	●	◑	○	●	●							
Natural System	Shallow Marsh	●	●	●	○	●	○							
Physical Treatment	Sand Filter	○	○	○	○	○	○	●	●	⦶	⦶	⦶	●	●
	Swirl Concentrator/ Helical Bend	○	○	○	○	○	○		◑	○	○	◑	◑	
	Plate/Tube Separator	○	○	○	○	○	○		◑					
	Screens	○	○	○	○	○	○	●	⦶					

Stormwater
- ● – Yes
- ◑ – Yes, under certain design conditions
- ○ – No
- NA – Not Applicable

Water Quality
- ● – 76-100 % Removal (Long Term)
- ◑ – 51-75 %
- ⦶ – 26-50 %
- ○ – 0-25 %
- Blank – No Data Available.

Table 1.3 Characteristics of Urban Retrofit Management Practices continued.

Practice Function	Management Practice	ENVIRONMENTAL IMPACTS									
		NATURAL							HUMAN		
		Disturb Surrounding Area During Const.	Wildlife Habitat	Recreation	Thermal Dischg.	Low Flow Stream Maintenance	Groundwtr. Recharge	Downstream Aquatic Habitat	Health	Safety	Aesthetics/ Landscape
Infiltration	Dry Well	O	O	O	+	+	+	+	O	+	O
	Trench: o Full Exfiltration o Partl. Exfiltration o WQ Trench	O	O	O	+	+	+	+	O	+	O
	Basin: o Full Exfiltration o w/ Detention Basin o Off-line Trench	—	+	+	+	+	+	+	O	O	O
	Porous Pavement: o Full Exfiltration o Partl. Exfiltration o Water Quality	—	O	O	+	+	+	+	O	+	O
	Modular Paving	—	+	O	+	+	+	+	O	O	O
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale	O	+	O	O	O	O	O	O	O	+
	Grassed Filter Strip	O	+	O	+	+	+	O	O	O	+
Trapping	Water Quality Inlet (Oil & Grit Separator)	O	O	O	O	O	O	O	O	O	O
Storage/ Release	Parking Lot Storage	O	O	—	—	O	O	+	O	—	—
	Dry Pond	—	O	O	+	O	O	+	O	—	—
	Extended Detention: o Dry Pond o Dry Pond w/ Marsh o Wet Pond	—	+	O	+	—	+	+	O	—	—
	Wet Pond: o Wet Pond o Wet Pond w/ Marsh o Wet Pond w/ Forebay	—	+	+	—	+	+	—	O	—	+
Natural System	Shallow Marsh	—	+	O	O	+	+	+	O	—	—
Physical Treatment	Sand Filter	—	O	O	O	O	O	O	O	O	—
	Swirl Concentrator/ Helical Bend	O	O	O	O	O	O	O	O	O	—
	Plate/Tube Separator	O	O	O	O	O	O	O	O	O	—
	Screens	O	O	O	O	O	O	O	O	O	—

IMPACTS

+ - Beneficial Impacts

- - Neutral or No Impacts

— - Negative Impacts

Table 1.3 Characteristics of Urban Retrofit Management Practices continued

Practice Function	Management Practice	COSTS/RESPONSIBILITY: Costs * – Construction / O&M	Costs * – Economies of Scale	Maintenance Responsibility – Municipal	Maintenance Responsibility – Community	Maintenance Responsibility – Private (Business)	Maintenance Responsibility – Private (Individual)	Unusual Maintenance Needs	Maintenance Frequency
Infiltration	Dry Well		○	○	●	●	●	●	S
	Trench: o Full Exfiltration o Partl. Exfiltration o WQ Trench		○	○	●	●	●	●	S
	Basin: o Full Exfiltration o w/ Detention Basin o Off-line Trench		●	◑	●	●	○	○	S
	Porous Pavement: o Full Exfiltration o Partl. Exfiltration o Water Quality		○	●	●	●	◑	◑	F
	Modular Paving		○	●	●	●	●	○	F
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale		○	●	●	●	●	○	F
	Grassed Filter Strip		○	●	●	●	●	○	F
Trapping	Water Quality Inlet (Oil & Grit Separator)		○	●	●	●	○	◑	F
Storage/ Release	Parking Lot Storage		○	◑	●	●	○	○	S
	Dry Pond		●	●	●	●	○	○	S
	Extended Detention: o Dry Pond o Dry Pond w/ Marsh o Wet Pond		●	●	●	●	○	◑	S
	Wet Pond: o Wet Pond o Wet Pond w/ Marsh o Wet Pond w/ Forebay		●	●	●	●	○	●	S
Natural System	Shallow Marsh		●	●	●	●	○	●	S
Physical Treatment	Sand Filter		◑	●	●	●	○	●	F
	Swirl Concentrator/ Helical Bend		●	●	●	●	○	◑	F
	Plate/Tube Separator		●	●	●	●	○	◑	F
	Screens		●	●	●	●	○	◑	F

* See Table 1.4 for a summary of relative capital and O & M costs.

● – Applicable
◑ – Sometimes Applicable under certain conditions or site design changes.
○ – Not Applicable.

Maintenance Frequency
F – Frequent
S – Seldom
N – None

Table 1.4 Urban Stormwater Runoff Management Practice Costs.

Practice Function	Management Practice	Costs: Capital	Costs: Operation & Maintenance
Interception	Urban Forestry	Preserve Trees = Low [a] Seedlings = $100-200/ acre Saplings = $1000- 5000/acre	Low
Infiltration	Dry Well		
	Trench	C = 26.6 * Vs**0.63 [a]	Total = 5 to 15% * C [a]
	Basin	C = 10.7 * Vs**0.69 [a]	Total = 3 to 5% * C [a]
	Porous Pavement	Variable [a]	Routine < Pond C [a] Non-routine > C [a]
	Modular Paving	C = $1.55/sq. ft. (1979) [c]	Low
Infiltration/ Filtration/ Flow Attenuatn.	Grassed Swale	C = $4.50 to $7.75/linear Foot [b]	
	Grassed Filter Strip	C = $1,450 (hyroseed) - $10,900 (sod) / acre [a]	Low
Trapping	Water Quality Inlet (Oil & Grit Separator)	C = $5,000 to $15,000 [a]	Low [a]
Storage/ Release	Parking Lot Storage	C = estimated low over conventional	Low
	Dry Pond (Retrofit)	< $2,000 [a]	?
	Extended Detention	C = 1.25 * (10.71 * Vs**0.69) [a]	Total = 3 to 5% * C [a]
	Wet Pond (<100k cu.ft.) (>100k cu.ft.)	C = 1.25 * (6.1 * Vs**0.75) [a] C = 1.25 * (34.0 * Vs**0.64) [a]	Total = 3 to 5% * C [a]
Natural System	Shallow Marsh	Planting C = $1,000-3,000/acre [a]	Low
Physical Treatment	Sand Filter		Moderate
	Swirl Concentrator/ Helical Bend	C = $4,500/mgd [c]	Moderate
	Plate/Tube Separator	C = $2,000/acre drainage area [d]	Moderate
	Screens	C = $19,000/mgd [c]	Moderate - High

Sources:
a MWCOG, July, 1987.
b Md. WRA, 1985.
c Tourbier & Westmacott, 1981.
d USEPA, July 1979.

C = Construction Costs in 1985 $.
Vs = Storage Volume of Void Space (for Infil. Trench).
Vs = Stg. Vol. up to crest of emer. spillway (basin & pond).

Step 6 -- A Synopsis
Assemble and Implement Urban Retrofit Plan

A. Assemble Retrofit Strategies.

↓

B. Assign Order of Implementation.

↓

C. Implement the Urban Retrofit Plan.

Assemble and Implement Urban Retrofit Plan

A. Assemble retrofit strategies.

Assemble the strategies developed in Step 5 for applicable analysis areas into a single document. The individual retrofit strategies become part of the Urban Retrofit Plan for the priority watershed. A local jurisdiction with more than one watershed can combine individual watershed retrofit plans into a comprehensive plan for the entire jurisdiction. Most retrofit strategies will require management practices intercepting drainage areas of varying sizes. Under certain conditions however, a management practice is better applied to areas larger than a single analysis area. Examples include pollutant source controls such as solid waste management, street sweeping, leaf collection, domestic animal waste management, and urban forestry.

B. Assign order of implementation.

The second component of the Urban Stormwater Retrofit Plan is a schedule of implementation.

At least two methods of developing an implementation schedule are possible:

1. Implement retrofitting according to the analysis area urban pollution potential ranking from Worksheet 1.6 (page 31) in Step 3. For example, all management practices in highest ranked analysis area would be implemented before addressing the next highest ranked analysis area.

2. Implement all management practices that meet specific criteria. The user selects the criteria based on the resources, needs, or priorities of the local jurisdiction. Examples of criteria include

    - o measures with the lowest capital and maintenance costs.

    - o measures with the highest removal effectiveness for one or more specific pollutants.

    - o measures with a defined level of pollutant removal at a minimum total cost.

    - o measures with the lowest social and environmental impacts.

C. Implement The Urban Retrofit Plan.

Implement the Plan by the following four actions:

1. Verify that each proposed management practice can be used or constructed at the desired site. Develop the necessary site plans, specifications, and costs for construction and operation. For any measure that requires construction, such as an extended detention basin or infiltration device, the site must be investigated and found to meet local and state requirements. If the site is suitable for the proposed device, construction plans and specifications should be developed and construction and maintenance costs should be estimated. If the site does not meet the requirements, perhaps the retrofit strategy can be modified by altering the conditions for application of the management practice or proposing a different measure.

2. Verify that suggested source management practices, those not requiring construction, are legally and administratively acceptable. Check for duplication in existing government programs. Estimate the costs to implement these control measures. Consult the Resource Directory (page Res-1) for detailed information on estimating costs for implementing the retrofit strategies.

3. Estimate the total costs for implementing the Urban Stormwater Retrofit Plan, identify funding sources, and obtain funding. Funding sources may include one or more of the following:

   - stormwater management utility user fees;
   - Chesapeake Bay Critical Area mitigation fees for required offsets;
   - state or local special bonds or both;
   - Federal and State Chesapeake Bay Initiatives funds;
   - Federal Clean Water Act appropriations;
   - private (individual or organization) funds or corrective actions;
   - annual state and local funds for public works, capital project construction, and maintenance.
   - related Federal, state, or local government program funds.

4. Implement the Urban Stormwater Retrofit Plan for the Priority Watershed or, in the case of several watersheds, the local jurisdiction.

Results of Step 6

1. An Urban Stormwater Retrofit Plan for the priority watershed.

2. If a jurisdiction has more than one watershed, combined Urban Stormwater Retrofit Plans for the entire jurisdiction.

Part II

The Method Applied

INTRODUCTION

The following example is an application of the Urban Retrofit Planning Method to Anne Arundel County and the Magothy River Watershed. It shows the results of applying the method to a watershed with extensive developed areas and stressed receiving waters.

Anne Arundel County is located on the western shore of the Chesapeake Bay, in the Atlantic Coastal Plain, south of Baltimore City, Maryland. It is bounded on the west by the Patuxent River and on the east by the Chesapeake Bay. With the county topography varying from flat to rolling, a large number of small streams in eight major drainage areas provide good surface drainage. The Chesapeake Bay's tidal estuaries penetrate as much as 13 miles inland and form a series of peninsulas with irregular shorelines and tidal marshes. In a number of places, the estuaries are shallow.

Step 1 -- The Priority Watershed

Anne Arundel County's drainage areas are shared by three Maryland Subbasins. These are: (1) the Patapsco River (13-09), (2) the Patuxent River (13-11), and (3) the West Chesapeake (13-10) - a collection of small rivers and creeks draining directly to tidal waters of the Chesapeake Bay. The major drainage watersheds of Anne Arundel County were mapped and are shown in Figure 2.1, page 66.

The basic physical, water quality, and socioeconomic information was collected for each watershed and is summarized in Table 2.1, page 67. Scores were assigned for water quality, watershed priority, the percentage of urban land, and population density and also listed in the Table. Total scores were summed from individual scores for each watershed.

A review of the total scores in Table 2.1 revealed four watersheds with the highest scores: Patapsco-Tidal (15), Magothy River (12), Little Patuxent River (12), and Patapsco-Nontidal (11). Any of these watersheds could be selected as the priority watershed to study first. The Magothy River Watershed was selected the priority watershed in this example because

- o a good database of land use, water quality, and other information is available.
- o the estuarine water quality and aquatic resources are stressed.
- o the level of public and local government interest is high.

Figure 2.1 Watersheds in Anne Arundel County.

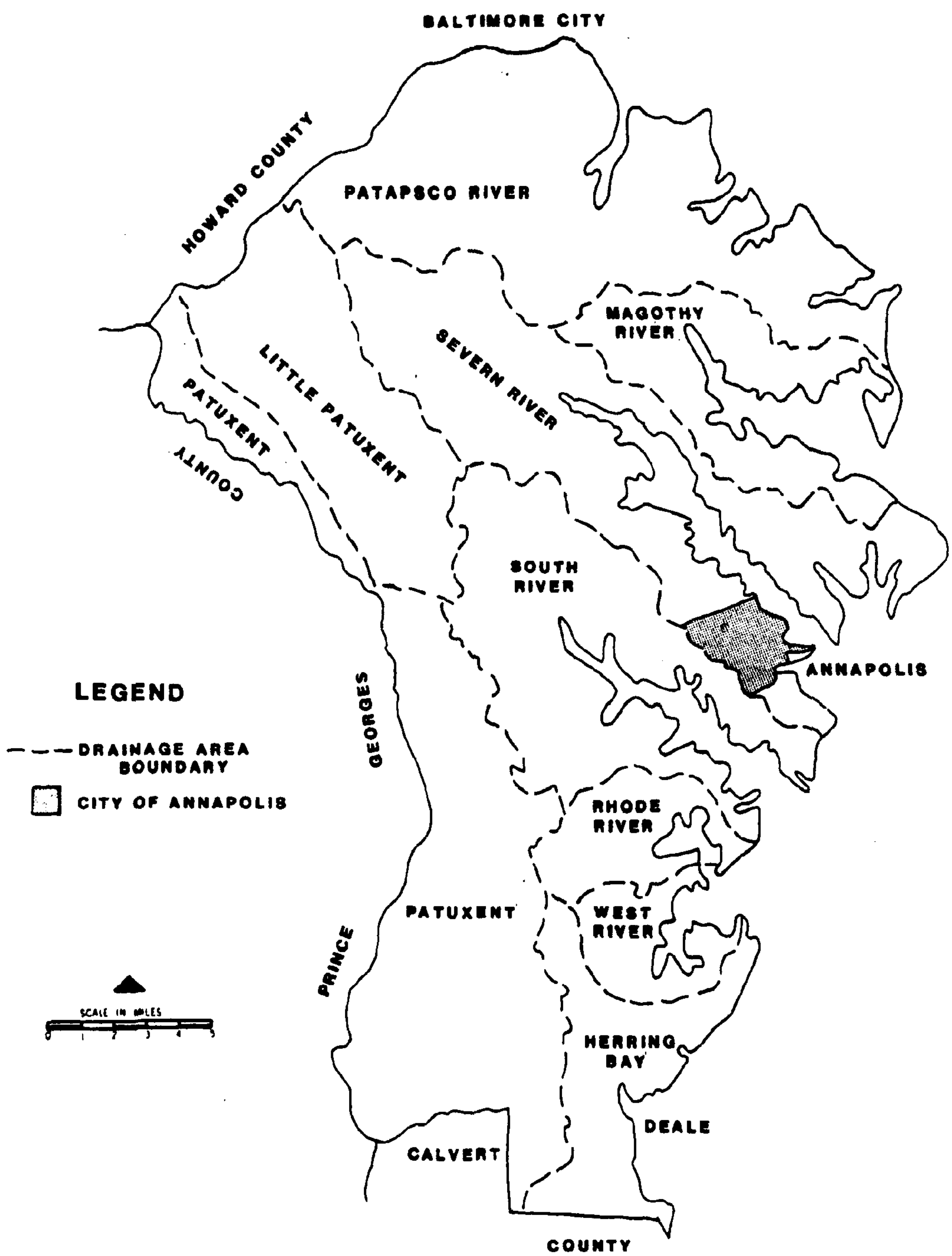


Table 2.1 Comparison of Anne Arundel County Watersheds.

Jurisdiction Name: Anne Arundel County

Date: 10/1987
I.D.: SRM

Watershed Name (1)	Total Area (Acres) (2)	Urban Area (Acres) (3)	Urban Land 1 (%) (4)	Wtrshd. Popultn 2 (1985) (5)	Popultn. Density (Pop/Ac) (6)	Wtr. Qual Evalutn. Score 3 (7)	Wtrshd. Priority Score 4 (8)	Urban Land Score (9)	Density Score (10)	Total Score (11)
Patapsco-Tidal	25500	15555	61	107868	4.2	3	1	6	5	15
Patapsco-Nontidal	11669	6651	57	23548	2	3	1	5	2	11
Bodkin Creek	5393	2103	39	6833	1.3	3	1	3	2	9
Magothy River	22759	11607	51	55044	2.4	3	1	5	3	12
Severn River	32559	12047	37	50505	1.6	3	1	3	2	9
South River	34510	8973	26	33859	0.7	3	1	2	1	7
Rhode River	8319	1249	15	4032	0.5	3	0	1	1	5
West River	5504	936	17	3383	0.6	3	0	1	1	5
Herring Bay	11552	2310	20	8727	0.8	2	0	2	1	5
Patuxent River	47411	6163	13	16443	0.3	3	1	1	1	6
Little Patuxent R.	28112	19116	68	46851	1.7	3	1	6	2	12
TOTALS	233288	86709		357093						

1 Total Urban includes Residential (1,2,5,& 15-22 DU/Ac.), Commercial, & Industrial Lands.

2 Population estimated by overlaying watersheds, transportation zones, & sewer service areas and known population counts.

3 Maryland Subbasin & Segment Water Quality Evaluations in 1986 305(b) Report.

4 Maryland Watershed Priority List (1986).

Step 2 -- Analysis Area Characteristics Defined

The Magothy River Watershed has a land area of approximately 31.5 square miles. A watershed of this size can be analyzed adequately using a map scale of 1 inch = 2,000 feet.

Information obtained about the watershed included:

- o Land use/cover inventories - available on recent (1984) aerial photography at a scale of 1 inch = 1,000 feet.
- o Topographic maps - available at several scales including: U.S. Geologic Survey maps at 1 inch = 2,000 feet and County topographic maps at 1 inch = 1,000 feet and 1 inch = 200 feet.
- o Maps of water and sanitary sewer service areas in the County Water and Sewer Plan.

Several levels of drainage area scales were available for possible analysis areas. See Figure 2.2, page 72, for four types of drainage area in the Magothy - the watershed, creekshed or subwatershed, subcreekshed, and storm drain system catchment. Based on the size of the watershed, the resources available, and the drainage patterns, the analysis area scale chosen was the subwatershed or creekshed. If a smaller analysis drainage area were selected, more detailed information would be required and the costs of analysis would increase.

In Figure 2.3, page 74, the drainage boundaries of the 18 analysis areas selected for the Magothy River Watershed are shown. These areas are defined topographically from the 1 inch = 1,000 feet scale maps provided by the county. The analysis areas range from 311 acres each for Broad Creek (4) and Spriggs Cove (14) to 3,390 acres for the Upper Magothy River (8). The analysis areas generally are numbered counterclockwise from the Otter pond drainage area on the north shore and are named by the creek name or community name.

A planimeter was used to derive the physical characteristics of the priority watershed and each of the 18 analysis areas (see Figure 2.4). The characteristics are listed in Table 2.2, page 72. The methods used to derive the characteristics appear in chart form.

Figure 2.2 Alternative analysis area scales.

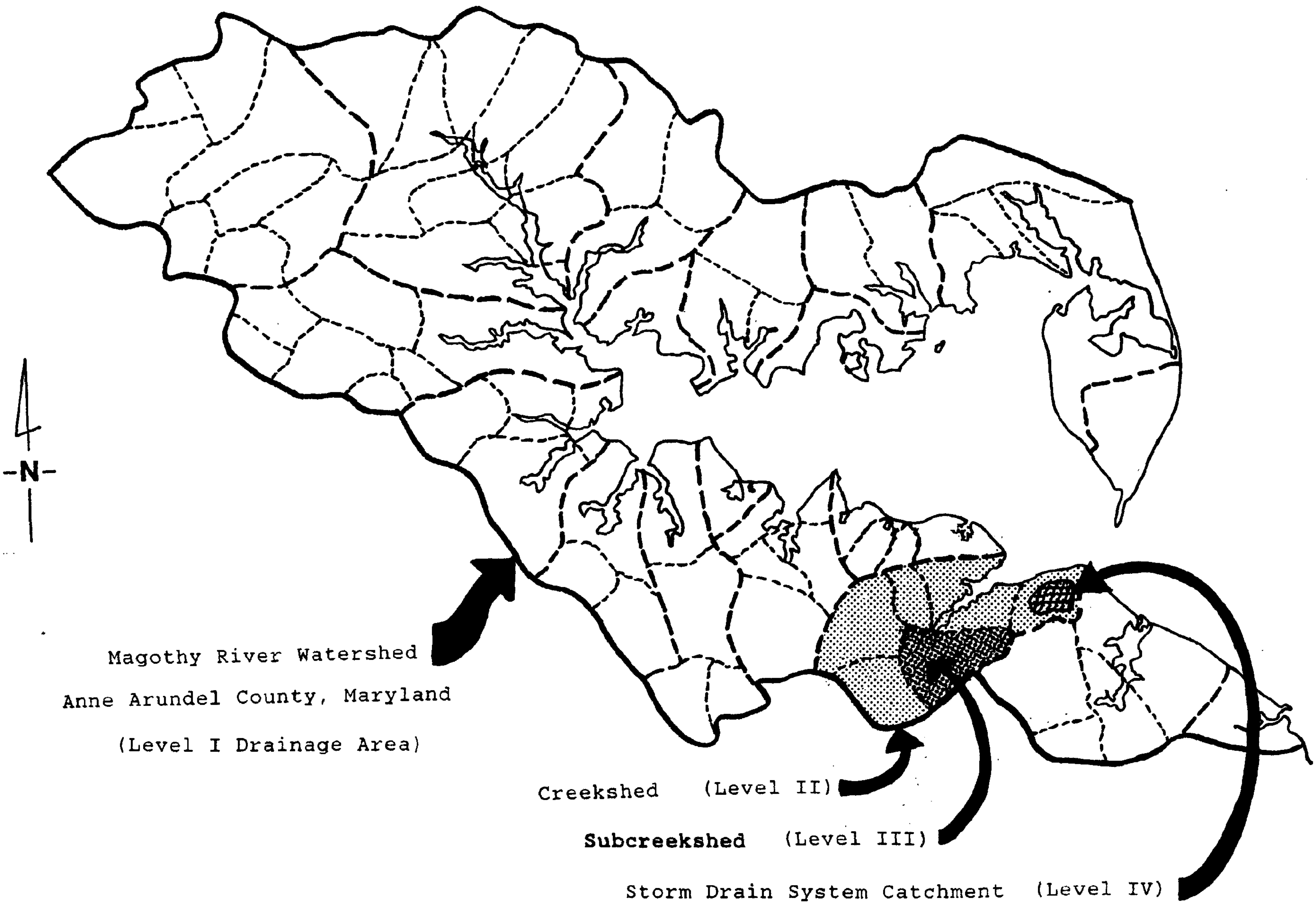
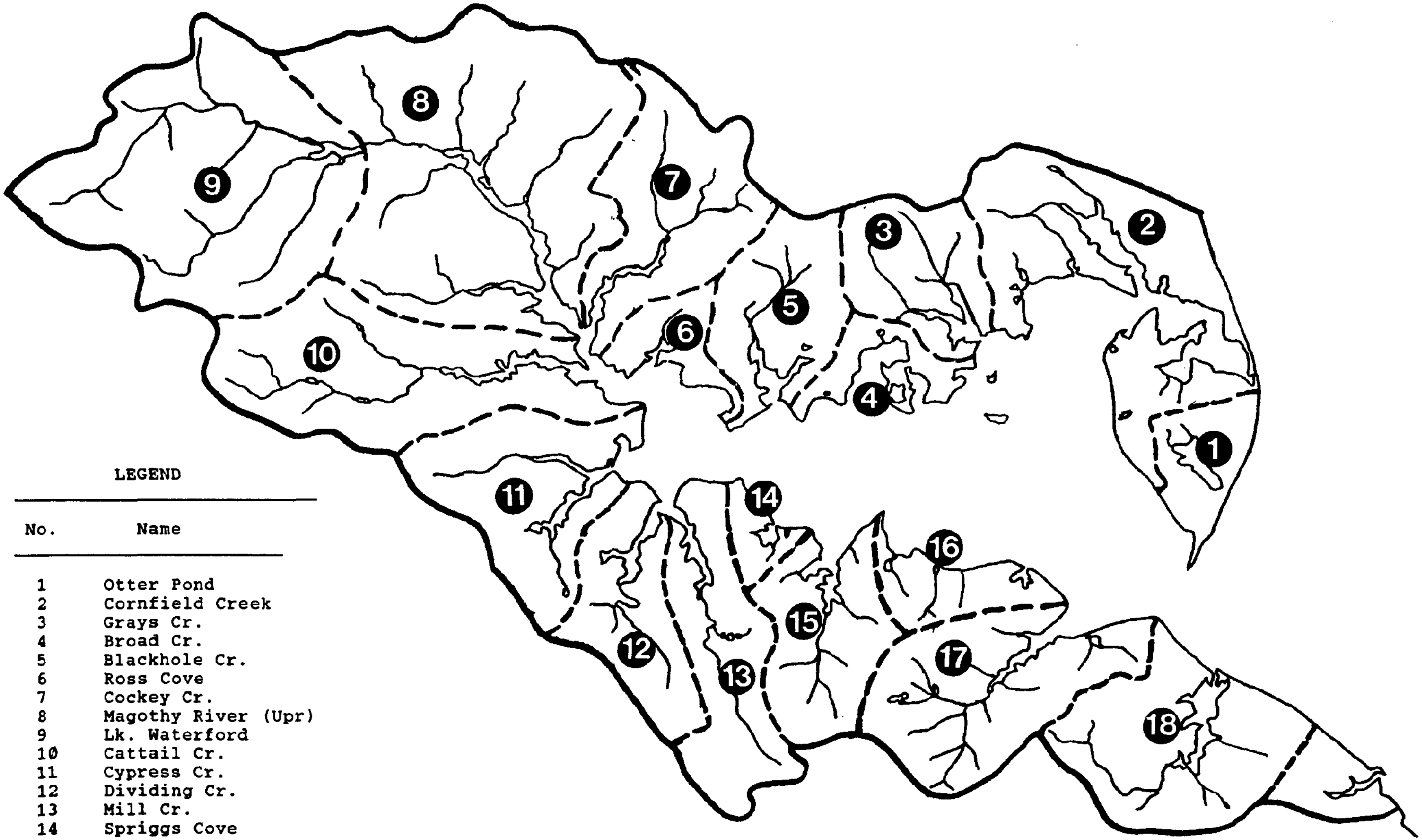


Figure 2.3 Analysis area boundaries in the Magothy River Watershed.



LEGEND

No.	Name
1	Otter Pond
2	Cornfield Creek
3	Grays Cr.
4	Broad Cr.
5	Blackhole Cr.
6	Ross Cove
7	Cockey Cr.
8	Magothy River (Upr)
9	Lk. Waterford
10	Cattail Cr.
11	Cypress Cr.
12	Dividing Cr.
13	Mill Cr.
14	Spriggs Cove
15	Forked Cr.
16	Bayberry
17	Deep Cr.
18	Ltl. Magothy R.

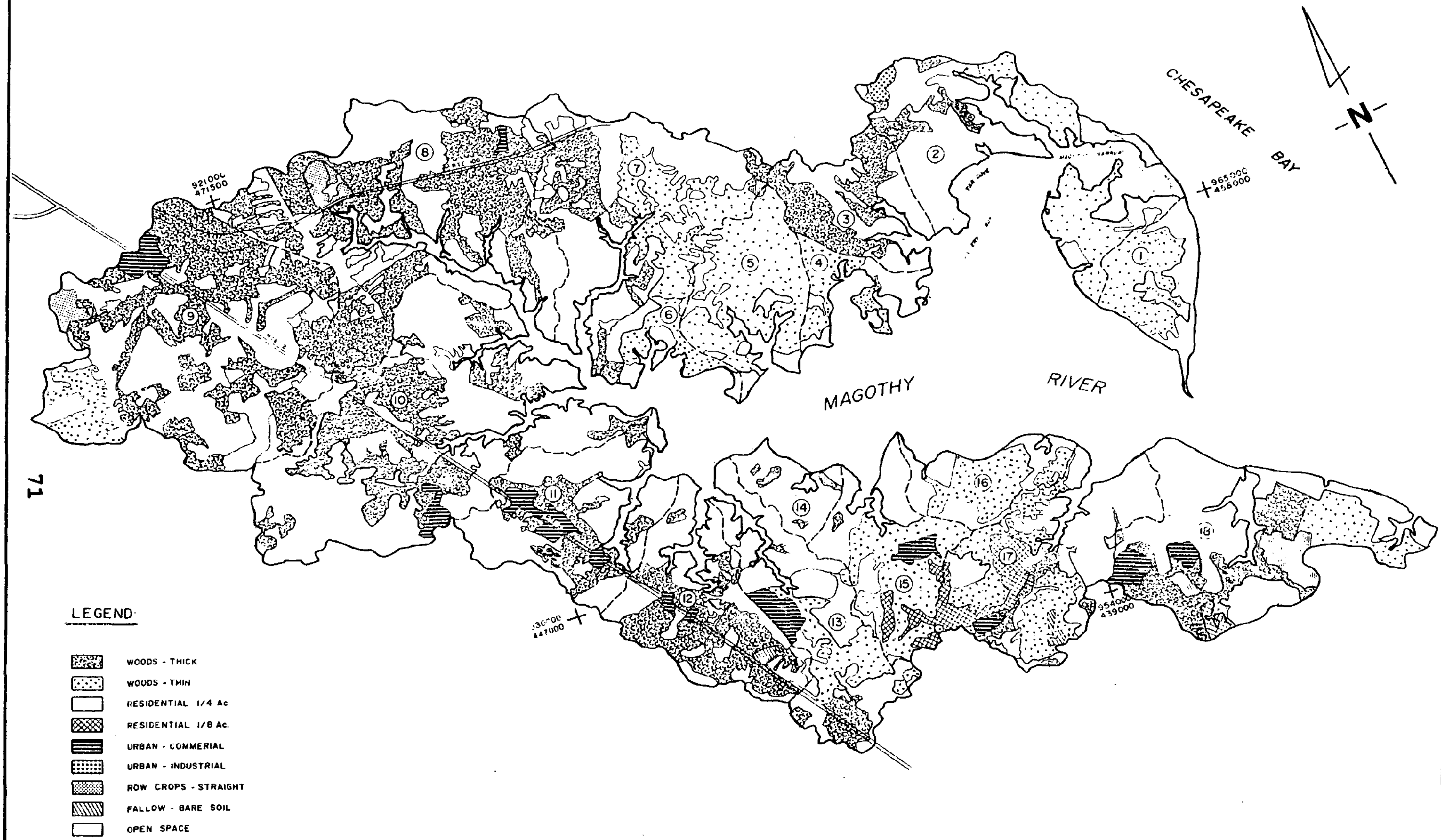


Figure 2.4 Land use map of the Magothy River Watershed.

Table 2.2 Magothy River Analysis Area Information.

Priority Watershed: Magothy River (Anne Arundel County, Maryland)

Total Watershed Area: 22522 Acres

Page: 1 of 1
Date: 10/87
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Subwtrshd Name No. (1)	Analysis Area No. (2)	Analysis Area Name (3)	Land Area Analysis Area (Acre) (4)	Urban Area (Acre) (5)	Urban Land Areas By Use: Residential (lot size) 2 Acre (6)	1 Acre (7)	1/2 Ac (8)	1/3 Ac. (9)	1/4 Ac. (10)	1/8 Ac. (11)	Comm. (12)	Indus. (13)	Instit. (14)	Other (15)	Type & Class of Receiving Wtr. Body: Primary Type (16)	Primary Class (17)	Secndry. Type (18)	Secndry. Class (19)
Otter Pond	1	same	395	131		0			130.9	0	0	0		0	1	I	3	II
Cornfield Creek	2	"	1537	684		0			677.8	0	0	6.7		0	1	I	3	II
Grays Cr.	3	"	762	307		0			307	0	0	0		0	1	I	3	II
Broad Cr.	4	"	311	124		44			80	0	0	0		0	1	I	3	II
Blackhole Cr.	5	"	777	142		0			141.6	0	0	0		0	1	I	3	II
Ross Cove	6	"	286	115		0			115.2	0	0	0		0	1	I	3	II
Cockey Cr.	7	"	1787	897		0			896.8	0	0	0		0	1	I	3	II
Magothy Rvr. (Upr)	8	"	3390	1586		0			1568.8	0	8.3	8.6		0	1	I	3	II
Lk. Waterford	9	"	2915	1254		0			1115.1	0	68.9	69.6		0	1	I	2	I
Cattail Cr.	10	"	1978	1308		0			1227	0	39.5	41.7		0	1	I	3	II
Cypress Cr.	11	"	1363	992		0			786.4	0	99.2	106.4		0	1	I	3	II
Dividing Cr.	12	"	1076	463		0			417	0	22	24		0	1	I	3	II
Mill Cr.	13	"	1170	617		0			461	0	75.3	80.2		0	1	I	3	II
Spriggs Cove	14	"	311	287		0			286.8	0	0	0		0	1	I	3	II
Forked Cr.	15	"	866	435		0			166.7	84.5	45.9	137.7		0	1	I	3	II
Bayberry	16	"	504	225		0			224.8	0	0	0		0	1	I	3	II
Deep Cr.	17	"	1349	853		0			628.4	201.4	22.8	0		0	1	I	3	II
L. Magothy R.	18	"	1745	1085		0			831.2	32.1	91.1	0		131	1	I	3	II
TOTALS			22522	11505		44			10062.5	318	473	474.9		131				

Derivation of Analysis Area Characteristics

Characteristics	Source	Method
Area of priority watershed	Map	Planimeter
Area of analysis area	Map	Planimeter
Area of urban land according to use	Mylar sheet overlay on Aerial Photo (1"=1,000')	Planimeter
Urban land area in analysis area	Individual Urban Land Uses	Sum of individual land uses

Step 3 -- Analysis Areas Ranked by Pollution Potential

A Composite Runoff Coefficient was calculated for each analysis area using the land uses in Table 2.2 and estimated percentage imperviousness values. An example of the calculations is included in Table 2.3, page 74, for the Deep Creek analysis area. The results are shown in Table 2.5, column (12), page 81.

The soils in the Magothy River Watershed with moderate, high, and very high erodibility (K = 0.32, 0.37, 0.43, respectively) were defined by tracing the soil mapping units with these characteristics on an overlay of the Anne Arundel County Soil Survey map sheets. The results are shown in the map labelled Figure 2.5, page 75. This map overlaid on the land use map (Figure 2.4) resulted in the map presented as Figure 2.6, page 76. The results were summarized by analysis area in Table 2.4, page 77.

Using the Anne Arundel County Soil Survey maps and the Natural Soil Groups classification system, soils with moderate (s = 8-15 or 10-15 percent) and high (s >= 15 percent) slope ranges were mapped. These soils are shown in the map, Figure 2.7, page 78. The map was then overlaid on the land use map (Figure 2.4). This overlay is presented in Figure 2.8, page 79. These results are also summarized in Table 2.4.

Table 2.3 Deep Creek Analysis Area Composite Runoff Coefficient.

Priority Watershed Magothy River Date 10/87

Analysis Area No. 17 Name Deep Creek

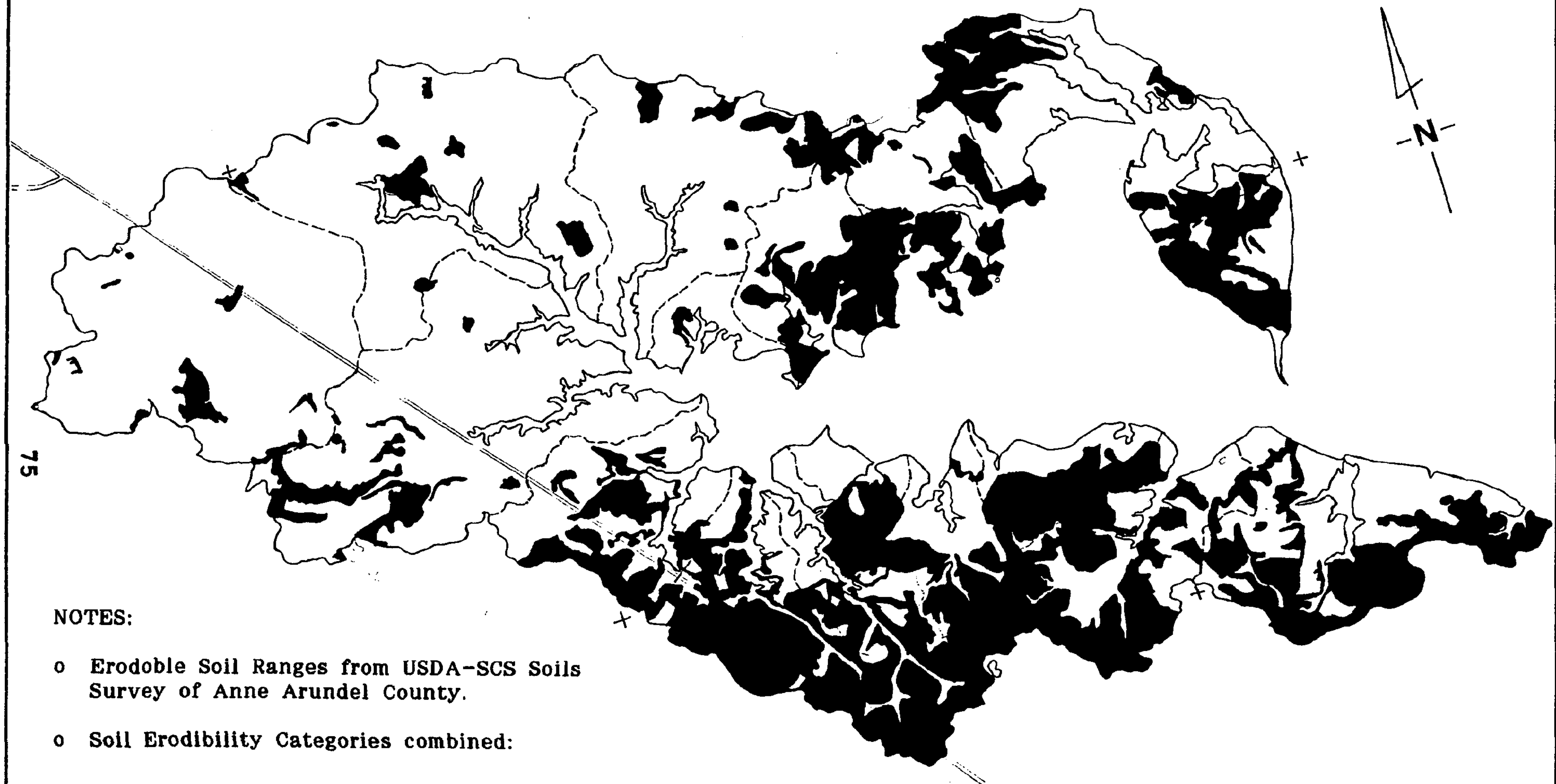
Use of Land (1)	Area of Land Use (Acre) (2)	Percentage Impervious Area Value (Acre) (3)	Col.(2) x Col.(3) (4)
Residntl. 2 ac.			
Resid. 1 ac.			
Resid. 1/2 ac.			
Resid. 1/3 ac.			
Resid. 1/4 ac.	628.4	38	23,879
Resid. <=1/8ac.	201.4	65	13,091
Commercial	22.8	85	1,938
Industrial			
Institutional			
Other Urban Land			
All Other Land	496.4		
Total	1349	----	38,908

Weighted Percentage Impervious Urban Land in Analysis Area $= \dfrac{\text{Total col.(4)}}{\text{Total col.(2)}} = \dfrac{38{,}908}{1349} = 29$

Composite Runoff Coefficient (Rv)[a] = 0.05 + 0.009(Wtd. Pct. Imp. Area)
= 0.05 + 0.009(29)
= 0.31

Transfer Rv for each Analysis Area to col.(12) in Analysis Area Pollution Factor Worksheet.

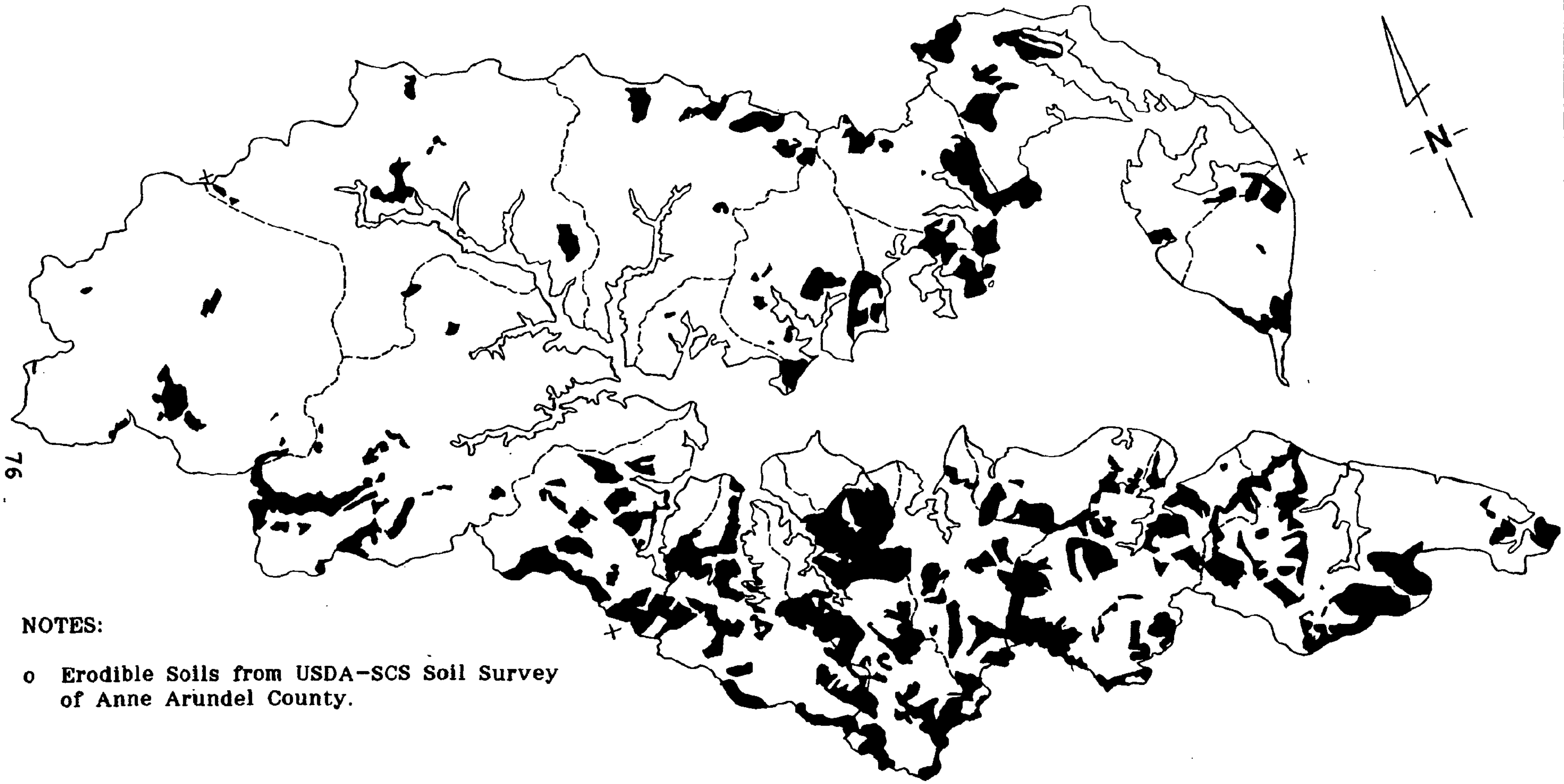
a source of equation: MWCOG, July 1987.



NOTES:

- o Erodoble Soil Ranges from USDA-SCS Soils Survey of Anne Arundel County.
- o Soil Erodibility Categories combined:

Figure 2.5 Erodible Soils in the Magothy River Watershed.



NOTES:

o Erodible Soils from USDA-SCS Soil Survey of Anne Arundel County.

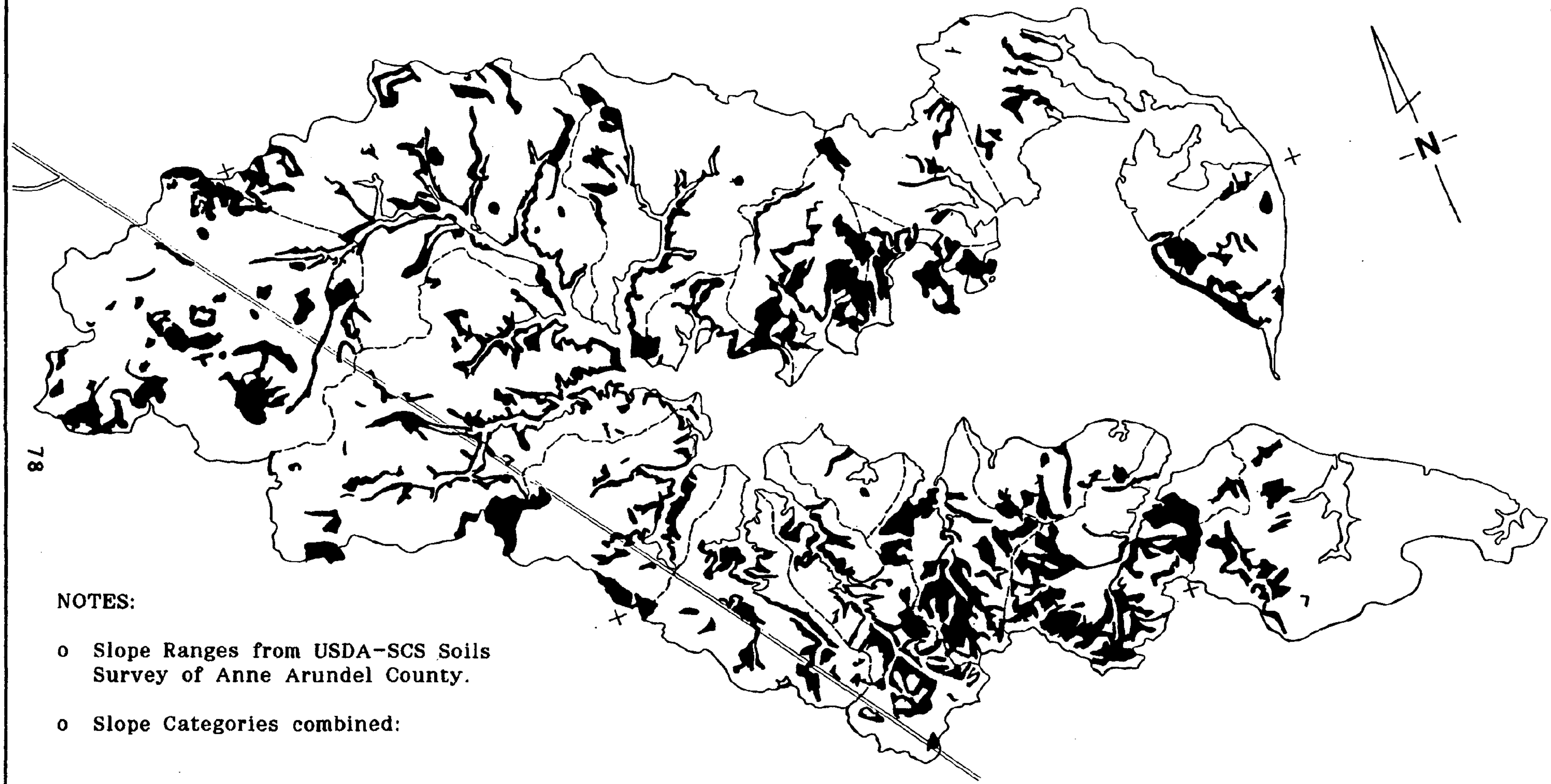
Figure 2.6. Land use map overlaid on erodible soils.

Table 2.4 Magothy River Analysis Area Erodibility and Slope Factors.

Priority Watershed: Magothy River Watershed Anne Arundel County Maryland

Page:
Date:
I.D.:

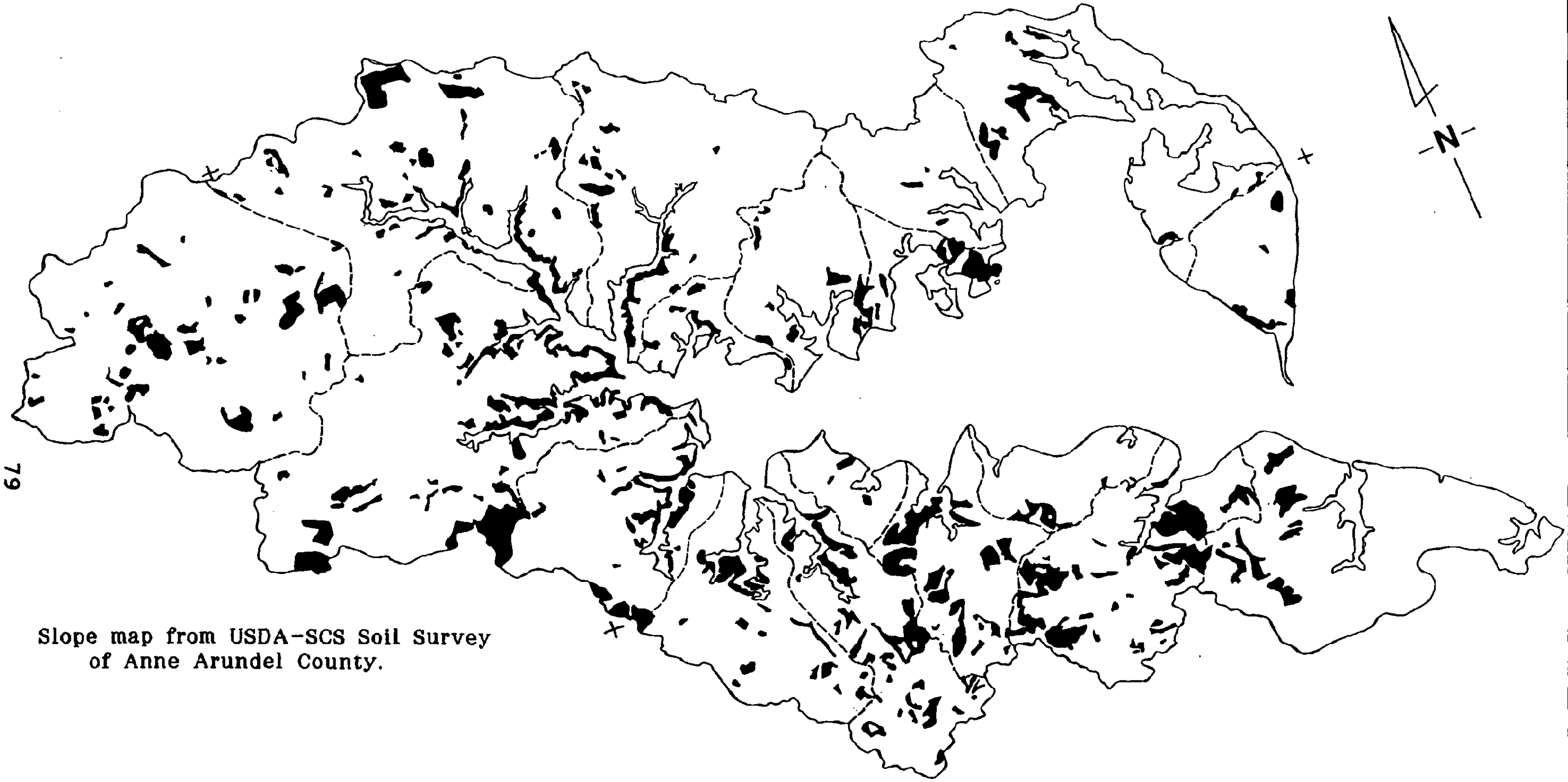
Subwatershed Name (1)	Analysis Area No. (2)	Analysis Area Name (3)	Land Area of Analysis Area (Acres) (4)	Urban Area (Acres) (5)	Urbn Area over Erdble. Soils (Acres) (6)	Urban Erdblty. Ratio (%) (7)	Urbn Area over Mod./Stp. Soils (Acres) (8)	Urban Slope of Land Ratio (%) (9)
Otter Pond	1	same	395	131	65.9	50.31	26.9	20.53
Cornfield Creek	2	"	1537	684	187.8	27.46	75.1	10.98
Grays Cr.	3	"	762	307	121.7	39.64	10.6	3.45
Broad Cr.	4	"	311	124	88.8	71.61	57.6	46.45
Blackhole Cr.	5	"	777	142	57.9	40.77	43.6	30.70
Ross Cove	6	"	286	115	6.7	5.83	24.8	21.57
Cockey Cr.	7	"	1787	897	95.5	10.65	69.8	7.78
Magothy R. (Upr.)	8	"	3390	1586	61.5	3.88	180.4	11.37
Lk. Waterford	9	"	2915	1254	74.4	5.93	155.9	12.43
Cattail Cr.	10	"	1978	1308	189.4	14.48	289.7	22.15
Cypress Cr.	11	"	1363	992	275.2	27.74	155.9	15.72
Dividing Cr.	12	"	1076	463	326.2	70.45	84.0	18.14
Mill Cr.	13	"	1170	617	423.6	68.65	157.0	25.45
Spriggs Cove	14	"	311	287	100.8	35.12	10.8	3.76
Forked Cr.	15	"	866	435	196.7	45.22	149.4	34.34
Bayberry	16	"	504	225	92.1	40.93	30.1	13.38
Deep Cr.	17	"	1349	853	422.4	49.52	241.3	28.29
L. Magothy R.	18	"	1745	1085	403.4	37.18	84.5	7.79
Total			22522	11505	3190		1947.4	



NOTES:

- o Slope Ranges from USDA-SCS Soils Survey of Anne Arundel County.
- o Slope Categories combined:

Figure 2.7 Slope map of the Magothy River Watershed.



Slope map from USDA-SCS Soil Survey
of Anne Arundel County.

Figure 2.8 Land use map overlaid on slope map.

Using the Magothy River analysis area information and maps and a planimeter, data on pollutant factors were obtained. The tabulated data for each of the 18 analysis areas are shown as ratios (R) in Table 2.5, page 81. The table also includes the composite runoff coefficients, urban area over erodible soils, and urban slope of land ratios taken from Tables 2.3 (page 74) and 2.4 (page 77).

Each of the pollution potential ratios in Table 2.5 were, for illustrative purposes, assumed to be of equal significance and assigned weights (W) of 1. An evaluation factor (F) is equal to each ratio (R) multiplied by a weight (W).

The Pollution Potential Scoring Matrix (Table 2.6, page 82) for the Magothy River is organized by the 18 analysis areas.

The pollutant potential factors developed, each have been converted to rankings for all 18 analysis areas based on each factor's magnitude. A rank value of "1" represents the highest rank and "18" is the lowest. Note that the composite runoff coefficients are equal for Grays Creek and Ross Cove. In the ranking process, without a tie, one value would rank 14 th and the other one would rank 15 th. Because a tie exists, both analysis areas are ranked 14.5. Note that the lowest factor score represents the highest pollution potential.

The assignment of weights to the Pollution Potential Factors in Table 2.3 will influence the ranking. Each evaluation factor in the Magothy River example (Table 2.6) is assumed to have an equal influence on the pollution potential. An example of unequal weights is shown in Table 2.7, page 83. The Composite Runoff Coefficient has a weight of 2, and the Erodibility of Soils and Slope of Land ratios each have 0 weights.

In the Magothy River Watershed example, only one unusual pollutant source is noted. No Field assessment was made. However, according to several concerned citizens an automobile "junkyard" located in Cypress Creek (adjacent to tidal waters), is exposed to rainfall-runoff. This source can generate pollutants, some of which are toxic. A "+" sign is placed in Table 2.6.

Table 2.5 Magothy River Analysis Area Pollution Factors Matrix.

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Priority Watershed: Magothy River (Anne Arundel County Maryland)

Analysis Area No. (1)	Name (2)	UAWUAR R (2) (3)	UAWUAR W (4)	UAWUAR Fe (5)	UAAAR R (2) (6)	UAAAR W (7)	UAAAR F (8)	AAWAR R (2) (9)	AAWAR W (10)	AAWAR F (11)	Rv R (2) (12)	Rv W (13)	Rv F (14)	Erodibility of Soils P (2) (15)	Erodibility of Soils W (16)	Erodibility of Soils F (17)	Slope of Land R (2) (18)	Slope of Land W (19)	Slope of Land F (20)
1	Otter Pond	1.14	1	1.14	33.16	1	33.16	1.75	1	1.75	16.30	1	16.30	50.31	1	50.31	20.53	1	20.53
2	Cornfield Creek	5.95	1	5.95	44.50	1	44.50	6.82	1	6.82	20.40	1	20.40	27.46	1	27.46	10.98	1	10.98
3	Grays Cr.	2.67	1	2.67	40.29	1	40.29	3.38	1	3.38	18.80	1	18.80	39.64	1	39.64	3.45	1	3.45
4	Broad Cr.	1.08	1	1.08	39.87	1	39.87	1.38	1	1.38	16.30	1	16.30	71.61	1	71.61	46.45	1	46.45
5	Blackhole Cr.	1.23	1	1.23	18.28	1	18.28	3.45	1	3.45	11.20	1	11.20	40.77	1	40.77	30.70	1	30.70
6	Ross Cove	1.00	1	1.00	40.21	1	40.21	1.27	1	1.27	18.80	1	18.80	5.83	1	5.83	21.57	1	21.57
7	Cockey Cr.	7.80	1	7.80	50.20	1	50.20	7.93	1	7.93	22.20	1	22.20	10.65	1	10.65	7.78	1	7.78
8	Magothy R. (Upr)	13.79	1	13.79	46.78	1	46.78	15.05	1	15.05	21.20	1	21.20	3.88	1	3.88	11.37	1	11.37
9	Lk. Waterford	10.90	1	10.90	43.02	1	43.02	12.94	1	12.94	21.40	1	21.40	5.93	1	5.93	12.43	1	12.43
10	Cattail Cr.	11.37	1	11.37	66.13	1	66.13	8.78	1	8.78	29.10	1	29.10	14.48	1	14.48	22.15	1	22.15
11	Cypress Cr.	8.62	1	8.62	72.78	1	72.78	6.05	1	6.05	35.40	1	35.40	27.74	1	27.74	15.72	1	15.72
12	Dividing Cr.	4.02	1	4.02	43.03	1	43.03	4.78	1	4.78	21.30	1	21.30	70.45	1	70.45	18.14	1	18.14
13	Mill Cr.	5.36	1	5.36	52.74	1	52.74	5.19	1	5.19	27.80	1	27.80	68.65	1	68.65	25.45	1	25.45
14	Spriggs Cove	2.49	1	2.49	92.28	1	92.28	1.38	1	1.38	36.50	1	36.50	35.12	1	35.12	3.76	1	3.76
15	Forked Cr.	3.78	1	3.78	50.23	1	50.23	3.85	1	3.85	31.60	1	31.60	45.22	1	45.22	34.34	1	34.34
16	Bayberry	1.96	1	1.96	44.64	1	44.64	2.24	1	2.24	20.30	1	20.30	40.93	1	40.93	13.38	1	13.38
17	Deep Cr.	7.41	1	7.41	63.23	1	63.23	5.99	1	5.99	31.00	1	31.00	49.52	1	49.52	29.29	1	28.29
18	L. Magothy R.	9.43	1	9.43	62.18	1	62.18	7.75	1	7.75	30.80	1	30.80	37.18	1	37.18	7.79	1	7.79

R = Ratio F= Evaluation Factor W = Weight F = R x W
(See Text for Calculation of Factors and Weights.)

UAWUAR = Urban Area to Watershed Total Urban Area Ratio AAWAR = Analysis Area to Watershed Area Ratio
UAAAR = Urban Area to Analysis Area Ratio Rv = Composite Runoff Coefficient

Table 2.6 Magothy River Analysis Area Pollution Potential Matrix - Equal Weights.

Priority Watershed: Magothy River Watershed Anne Arundel County Maryland

Page: 1 of 1
Date: 10/97
I.D.: SRM

Analysis Area No.	Name	F 1	F 2	F 3	F 4	F 5	F 6	Evalutn. Factor Score	Downstream Receiving Waters Primary T	Primary C	Secondry. T	Secondry. C	RW Score	UPS	AA GRAND SCORE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Otter Pond	16.5	17	15	16.5	4	8	77	1	1	2	3	7		539
2	Cornfield Cr.	8	11	6	12	13	14	64	1	1	2	3	7		448
3	Grays Cr.	12	14	12.5	14.5	9	18	80	1	1	2	3	7		560
4	Broad Cr.	16.5	16	16.5	16.5	1	1	67.5	1	1	2	3	7		472.5
5	Blackhole Cr.	15	18	12.5	18	8	3	74.5	1	1	2	3	7		521.5
6	Ross Cove	17	15	18	14.5	17	7	88.5	1	1	2	3	7		619.5
7	Cockey Cr.	6	7.5	4	8	15	15.5	56	1	1	2	3	7		392
8	Magothy R. (Upr.)	1	9	1	11	18	13	53	1	1	2	3	7		371
9	Lk. Waterford	3	12.5	2	9	16	12	54.5	1	1	2	1	5		272.5
10	Cattail Cr.	2	3	3	6	14	6	34	1	1	2	3	7		238
11	Cypress Cr.	5	2	7	2	12	10	38	1	1	2	3	7	+	266
12	Dividing Cr.	10	12.5	10	10	2	9	53.5	1	1	2	3	7		374.5
13	Mill Cr.	9	6	9	7	3	5	39	1	1	2	3	7		273
14	Spriggs Cove	13	1	16.5	1	11	17	59.5	1	1	2	3	7		416.5
15	Forked Cr.	11	7.5	11	3	6	2	40.5	1	1	2	3	7		283.5
16	Bayberry	14	10	14	13	7	11	69	1	1	2	3	7		483
17	Deep Cr.	7	4	8	4	5	4	32	1	1	2	3	7		224
18	L. Magothy R.	4	5	5	5	10	15.5	44.5	1	1	2	3	7		311.5

F1 = UAWUAR Factor
F2 = UAAAR Factor
F3 = AAWAR Factor
F4 = Rv Factor
F5 = Erodibility of Soils Factor
F6 = Slope of Land Factor
UPS = Unusual Pollutant Source.

Table 2.7 Magothy River Analysis Area Pollution Potential Matrix - Unequal Weights.

Page: 1 of 1
Date: 10/87
I.D.: SRM

Priority Watershed: Magothy River Watershed Anne Arundel County Maryland

Analysis Area		Evaluation Factor Ranking						Evalutn. Factor Score	Downstream Receiving Waters					UPS	AA GRAND SCORE
No.	Name	F 1	F 2	F 3	F 4	F 5	F 6		Primary T	Primary C	Secondry. T	Secondry. C	RW Score		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Otter Pond	16.5	17	15	16.5	0	0	65	1	1	2	3	7		455
2	Cornfield Cr.	8	11	6	12	0	0	37	1	1	2	3	7		259
3	Grays Cr.	12	14	12.5	14.5	0	0	53	1	1	2	3	7		371
4	Broad Cr.	16.5	16	16.5	16.5	0	0	65.5	1	1	2	3	7		458.5
5	Blackhole Cr.	15	18	12.5	18	0	0	63.5	1	1	2	3	7		444.5
6	Ross Cove	17	15	18	14.5	0	0	64.5	1	1	2	3	7		451.5
7	Cockey Cr.	6	7.5	4	8	0	0	25.5	1	1	2	3	7		178.5
8	Magothy R. (Upr.)	1	9	1	11	0	0	22	1	1	2	3	7		154
9	Lk. Waterford	3	12.5	2	9	0	0	26.5	1	1	2	1	5		132.5
10	Cattail Cr.	2	3	3	6	0	0	14	1	1	2	3	7		98
11	Cypress Cr.	5	2	7	2	.0	0	16	1	1	2	3	7	+	112
12	Dividing Cr.	10	12.5	10	10	0	0	42.5	1	1	2	3	7		297.5
13	Mill Cr.	9	6	9	7	0	0	31	1	1	2	3	7		217
14	Spriggs Cove	13	1	16.5	1	0	0	31.5	1	1	2	3	7		220.5
15	Forked Cr.	11	7.5	11	3	0	0	32.5	1	1	2	3	7		227.5
16	Bayberry	14	10	14	13	0	0	51	1	1	2	3	7		357
17	Deep Cr.	7	4	8	4	0	0	23	1	1	2	3	7		161
18	L. Magothy R.	4	5	5	5	0	0	19	1	1	2	3	7		133

F1 = UAWUAR Factor
F2 = UAAAR Factor
F3 = AAWAR Factor
F4 = Rv Factor
F5 = Erodibility of Soils Factor
F6 = Slope of Land Factor
UPS = Unusual Pollutant Source.

The Grand Scores from Tables 2.6 and 2.7 from lowest to highest values. The Magothy Watershed Water Quality Pollution Potential follows.

Analysis Area	Table 2.6 (page 82) Score	Rank	Table 2.7 (page 83) Score	Rank
Deep Creek	**224**	**1**	161	6
Cattail Cr.	238	2	**98**	**1**
Cypress Cr.	266	3	112	2
Mill Cr.	273	4	217	8
Forked Cr.	280	5	227.5	10
L. Magothy Rvr.	308	6	133	4
Dividing Cr.	371	7	297.5	12
Magothy R. (Upr.)	371	8	154	5
Cockey Cr.	399	9	178.5	7
Spriggs Cove	417	10	220.5	9
Cornfield Cr.	448	11	259	11
Broad Cr.	476	12	458.5	18
Bayberry	483	13	357	13
Lk. Waterford	495	14	132.5	3
Blackhole Cr.	518	15	444.5	15
Otter Pond	536	16	455	17
Grays Cr.	564	17	371	14
Ross Cove	627	18	451.5	16

The ordered ranking with equal weights indicates that Deep Creek has the highest water quality pollution potential. If the erodibilty and slope are not considered important, the alternate ranking shows that Cypress Creek would be the highest pollution potential. Generally the results of both analyses indicate that the analysis areas in the western part and south shore of the Magothy Watershed are important urban pollution potential sources. This could provide a focus for the further investigations and development of retrofit strategies in Steps 4, 5, and 6. <u>In this example, however, only the Deep Creek analysis area will be used in the application of Steps 4, 5, and 6</u>.

Step 4 -- A Profile of Deep Creek

Additional Information

A range of additional information was available for Deep Creek including:

- Aerial photographs at 1 inch = 1,000 feet scale (1984).
- County topographic maps with a photogrammetric background at 1 inch = 1,000 feet and 1 inch = 200 feet.
- County Soil Survey Report (1973).
- Information about public lands and facilities.
- County land use and zoning information.
- Nontidal wetland maps from the National Survey.
- Detailed records of storm drainage systems.

The 1 inch = 1,000 feet county topographic map with a photogrammetric background for Deep Creek is shown in Figure 2.9. The County Soil Survey scale was enlarged to overlay the topographic map. Using the soil survey, the following characteristics were mapped: hydrologic soil groups (A, B, C, or D) (Figure 2.10), erodibility (Figure 2.11), and slope ranges (Figure 2.12).

Field Survey

Given the amount of additional information available for Deep Creek and limited labor resources, a windshield field survey was performed. The entire subwatershed was covered by driving the major roads. Survey personnel used a Survey Checklist (see Step 4), a current road map, a topographic map, and a tape recorder. The recorded notes were later interpreted in developing a profile of the subwatershed.

Profile of Urban Conditions and Retrofit Opportunities

The urban conditions and retrofit opportunities in the Deep Creek subwatershed are summarized in Table 2.8, page . These were developed from the additional information and results of the field survey.

The profile of existing conditions and retrofit opportunities for Deep Creek is the compilation of a composite of Figures 2.9 through 2.12, the results of the field survey, and the summary of conditions and opportunities.

Source: Anne Arundel County 1"= 1,###' map series.

Figure 2.9 Land use and topography in Deep Creek.

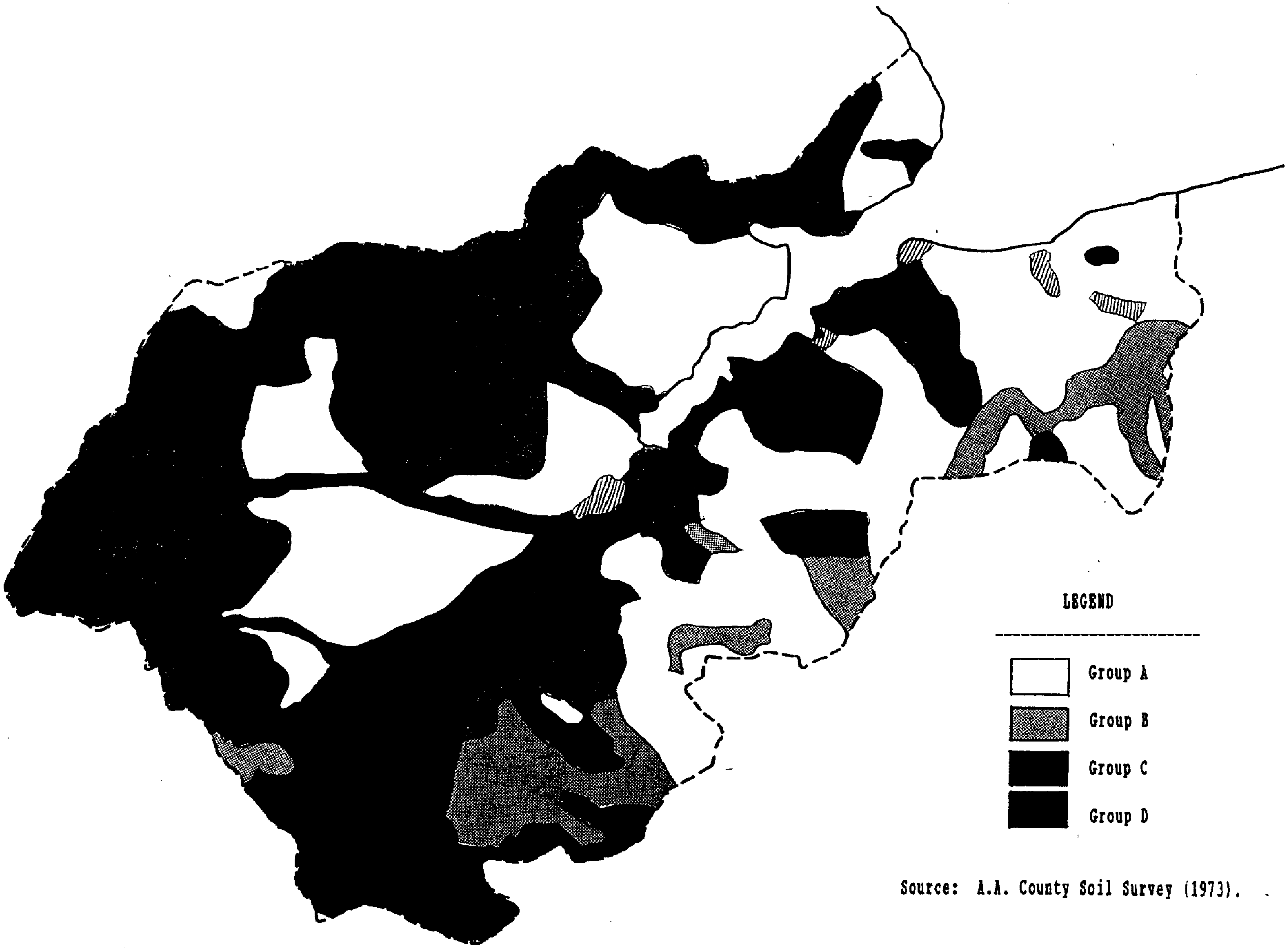


Figure 2.10 Hydrologic soil groups in Deep Creek.

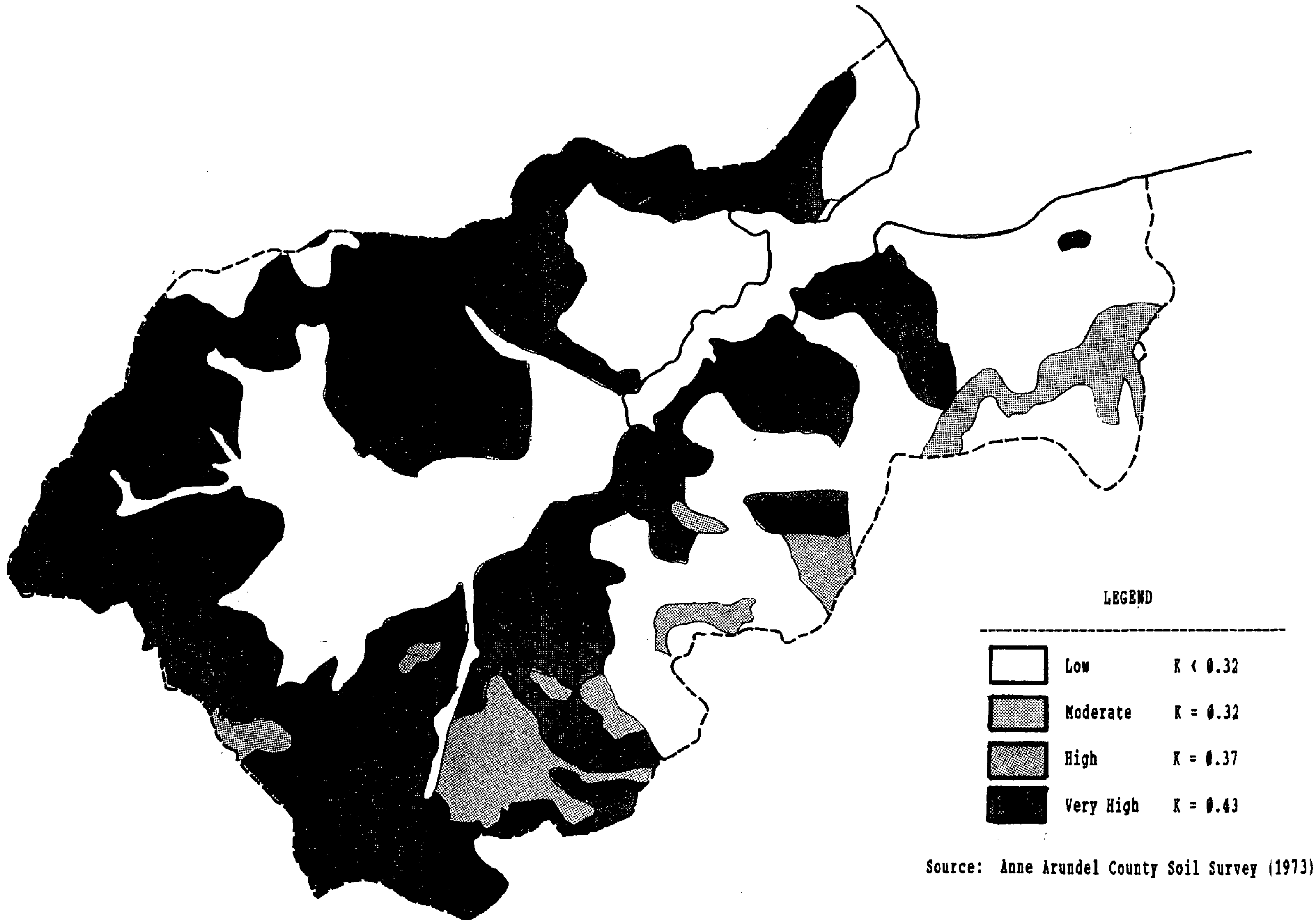
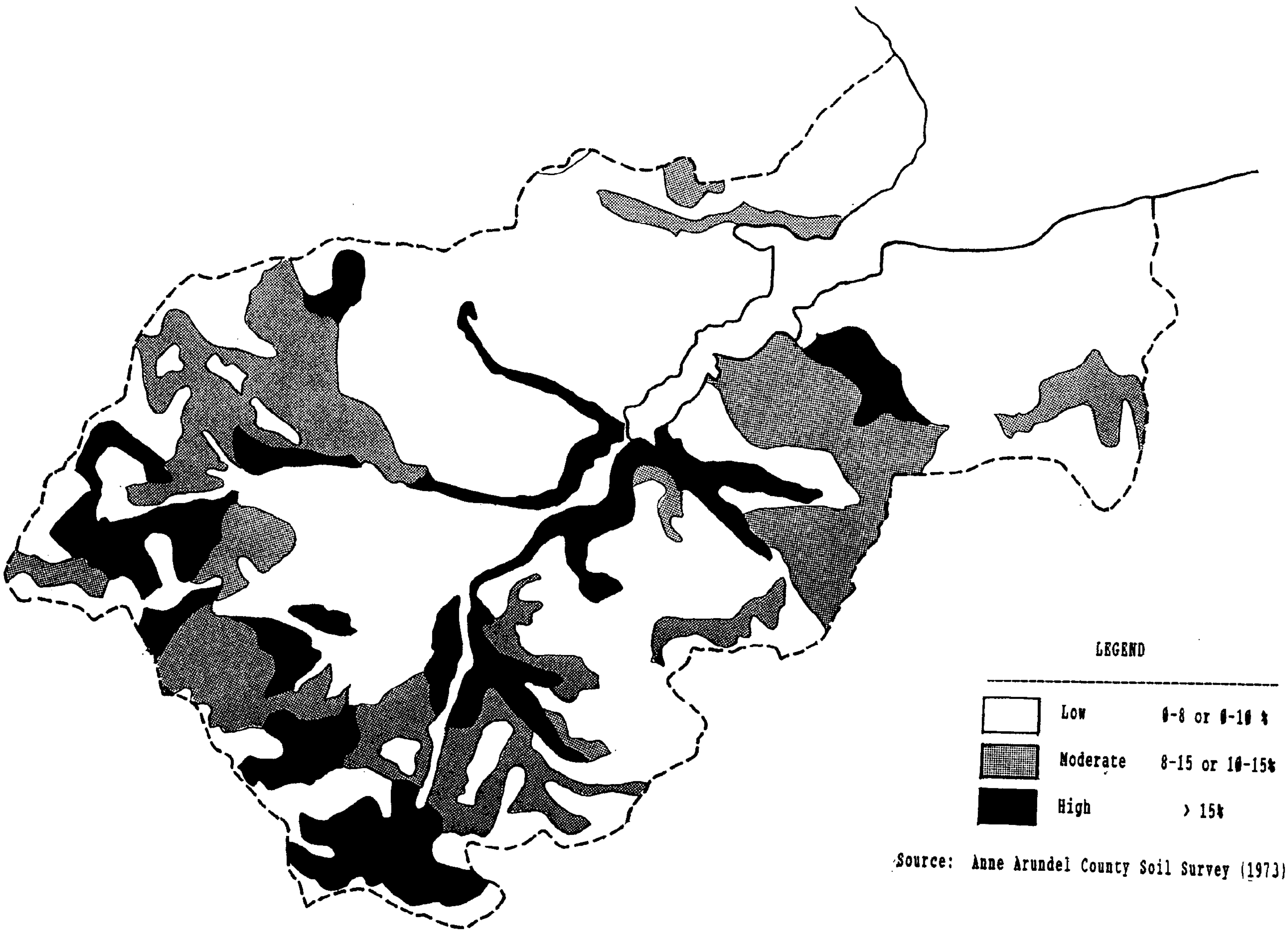


Figure 2.11 Soil erodibility in Deep Creek.



Source: Anne Arundel County Soil Survey (1973).

Figure 2.12 Slope ranges in Deep Creek.

Table 2.8 Survey results of Deep Creek subwatershed.

Land Use/Cover

- o Land uses in the subwatershed:
  - + predominantly residential - mostly single family with a few concentrated areas of apartments and townhouses.
  - + residential age ranges from pre-1950's to current development.
  - + older residences scattered throughout watershed but concentrated near estuarine waters.
  - + streams and floodways are heavily wooded.
  - + tree cover in developed areas is estimated to range from 0 to 40 %, predominantly hardwoods.
  - + commercial development is recent and concentrated along major roads, except for four marinas which are located along the estuary.

Land Ownership

- o The majority of land in the subwatershed is privately owned. Streets and roads are public with some rights-of-way.

Hydrology

- o Subwatershed drainage boundaries visually match 1 inch = 1,000 feet topographic map boundaries. However, for a more detailed assessment, smaller drainage area boundaries may have to be checked in the field.

- o Imperviousness estimates based on mapped land uses are reasonable.

- o The overall subwatershed has the following "hydraulically -effective" characteristics:
  - + many house roof downspouts drain to lawns.
  - + most driveways are paved and are contiguous with the street.
  - + curbs and gutters are located on some streets and roads - most are in recently developed and higher density communities.
  - + storm inlets and small drainage systems are located throughout the subwatershed - most in recent developments.

- o The subwatershed's ground slopes are generally moderate to high. Flatter slopes are located near the tidal waters and near College Parkway in the upslope areas.

Table 2.8 Survey results of Deep Creek subwatershed continued.

Stream valley and drainageway slopes are moderate to steep.

- o The typical storm drain system is composed of a paved surface (roofs, streets, sidewalks, parking areas) draining the runoff to either a pervious swale or a storm inlet. Inlets are connected to short pipes emptying to natural drainageways.

Pollutant Sources and Problems

- o From field observations, the residential and most commercial land uses, as pollutant sources, fall within the land uses monitored in the USEPA NURP study.
- o The four marinas are potential sources of pollutants not normally found in residential or commercial runoff. This is especially true in handling gasoline and oils. Any spills could be washed by runoff directly into tidal waters.
- o Streams and natural drainageways generally show signs of gully erosion. Steep banks appear to be sloughing. Some roads without curbs show minor sheet and rill erosion.

Relationship to Receiving Waters

- o The total drainage pathway distance throughout the subwatershed is generally less than 2,000 feet.
- o Receiving waters include small streams and wetlands in low areas draining to tidal waters. Runoff is delivered rapidly to Deep Creek and the main Magothy River estuaries.

Retrofit Control Opportunities and Constraints

- o From the available information, the locations of public lands are not obvious.
- o Wet Ponds - a series of four small wet ponds are in the Bay Hills Golf Course along two small southwest tributaries of Deep Creek. The ponds are shallow and used as visual and recreational amenities.
- o Existing detention basin located in drainage area 17.1 (see Figure 2.9).

Table 2.8 Survey results of Deep Creek subwatershed continued.

- o Subwatershed conditions as possible opportunities for retrofitting:
  - + roof downspouts draining to paved surfaces.
  - + stormwater inlets
  - + bare foot paths
  - + pervious areas adjacent to roads
  - + stormwater outfalls
  - + utility easements and rights-of-way
  - + wooded, natural drainageways and stream valleys.

Step 5 -- The Urban Retrofit Strategy

Using the procedures of Step 5 (see Part I), the Deep Creek subwatershed was evaluated for urban retrofits. This involved comparing the Urban Retrofit Profile (see Step 4, page 90) to both existing and potential management practices.

Existing Management Practices

Source Controls

An evaluation of management practices in use was made concerning source controls in Deep Creek urban areas. Using Table 1.1 (page 51) from Part I, existing management practices are:

- No public street sweeping is performed.
- The county manages solid waste collection based on the Solid Waste Management Plan (April 1983). Although the County provides routine collection services, community cleanup, and bulk collection, other actions are needed, including public education, especially as it relates to water quality and the environment. Secluded areas are posted for no dumping but may not be effective. This requires more community action.
- All fertilizer and pesticide management is the land owner's responsibility.
- The County's roadway de-icing policies vary with the snow and ice conditions. The policies should be closely examined, especially in drainage areas that are environmentally sensitive.
- Pet waste management is the pet owner's responsibility.
- No materials handling or small spill policy is in effect for commercial marinas.

Erosion Controls

A brief field investigation did not reveal any past erosion control efforts, other than in development areas. These appear to be adequate. However, a more extensive investigation is necessary to locate and define the types of eroded areas requiring controls. First priority should be the correction of problems on publicly controlled lands, especially along roadsides, urban lands, stormwater systems and outfalls.

Runoff Controls

Deep Creek has detention basin in area number 17.1 (see Figure 2.9.) The basin is a candidate for retrofitting as an extended detention basin to control small storm events for water quality. Using the criteria from Table 1.3 (page 54) and a site investigation, the retrofit potential can be better defined.

Four small wet ponds are in the Bay Hills Golf Course, privately owned. From drainage area maps, these appear to be located off the tributaries and function as visual and recreational amenities. Without more information about the contributing drainage areas to these structures and the physical characteristics, their potential as water quality management devices is unknown.

From the Profile, most single family residential roofs drain to lawns and appear to be performing adequately. However, some were seen in the survey to drain onto paved driveways. Also the higher density multi-family and commercial areas should be more closely investigated. For those residential areas located in hydrologic soil groups A or B (see Figure 2.10), on low slopes, with a low water table, and with adequate land area, dry wells or trenches are appropriate. Where limitations exist, downspouts to splash blocks and a vegetated buffer is an alternative.

New Management Practices

Source Controls

From Table 1.1 in Part I, Step 5 (page 51) and the results for existing management practices, the following new source control retrofit practices are appropriate:

- Street sweeping and parking area cleaning are appropriate only in the multi-family townhouse and apartment communities and commercial facilities. These are private facilities and should be cleaned privately.

- The County should develop a two phase program for control fertilizers and pesticides applications. The first phase would be education. The second phase, an ordinance and regulations, would be implemented only if phase one is not successful.

- Pet waste management is a private responsibility. Initial control efforts should focus on education and be targeted in areas with > 1 dwelling unit per acre.

- The County should provide education to marina owners and users about proper materials and chemicals handling. Marina owners should provide proper facilities for chemicals handling and disposal of waste products.

Erosion Controls

- The Profile and Figures 2.11 and 2.12 show that the primary drainageways and stream valleys are subject to erosion. The brief field survey revealed some current erosion, especially on steep, exposed slopes and in the channel. Where the drainageways and streams are in public ownership, appropriate erosion control management practices should be implemented. Table 1.2 (page 53) lists a range of controls. Suggested measures to retain area's natural character in protecting the slopes should consist of permanent vegetation. However, other measures such as contour-wattling, contour-brush-layering, Reed-trench terracing, brush matting, and live staking will help stabilize the slope until the vegetation is established. For gullies and severe stream bank erosion, check dams, live staking, and regrading and planting with permanent vegetation are recommended measures.

Runoff Controls

- A site has been identified for a possible basin (see Figure 2.13). Using Table 1.3 in Part I, Step 5 (page 54), the site is suitable for a wet pond. If adequate water is available, a shallow marsh can be added as a forebay. The structure, although not as good a water quality management practice as an extended detention basin, will also serve as a community amenity. The basin is expected to control most of the debris and sediment, moderate levels of phosphorus and oxygen demanding substances, and lower levels of heavy metals. Little nitrogen control is expected.

- An area suitable for temporary storage of runoff behind a roadway embankment is shown in Figure 2.13. This area, subject to field inspection, has the potential as an extended detention structure or shallow marsh system.

- Stormwater inlets, located in areas of recent development, are candidates for retrofitting. The two conversion options are: remove the bottom and infiltrate some of the runoff volume or expand the inlet into a water quality inlet which traps pollutants.

- The Deep Creek Profile indicates that tree cover in developed areas ranges from 0 to 40 percent. In stream valleys, tree cover is 50 to 90 percent. The county should develop an urban forestry program on public lands and encourage private urban forestry. The Maryland Forest, Park, and Wildlife Service sales tree seedlings at low cost and is a good source of help.

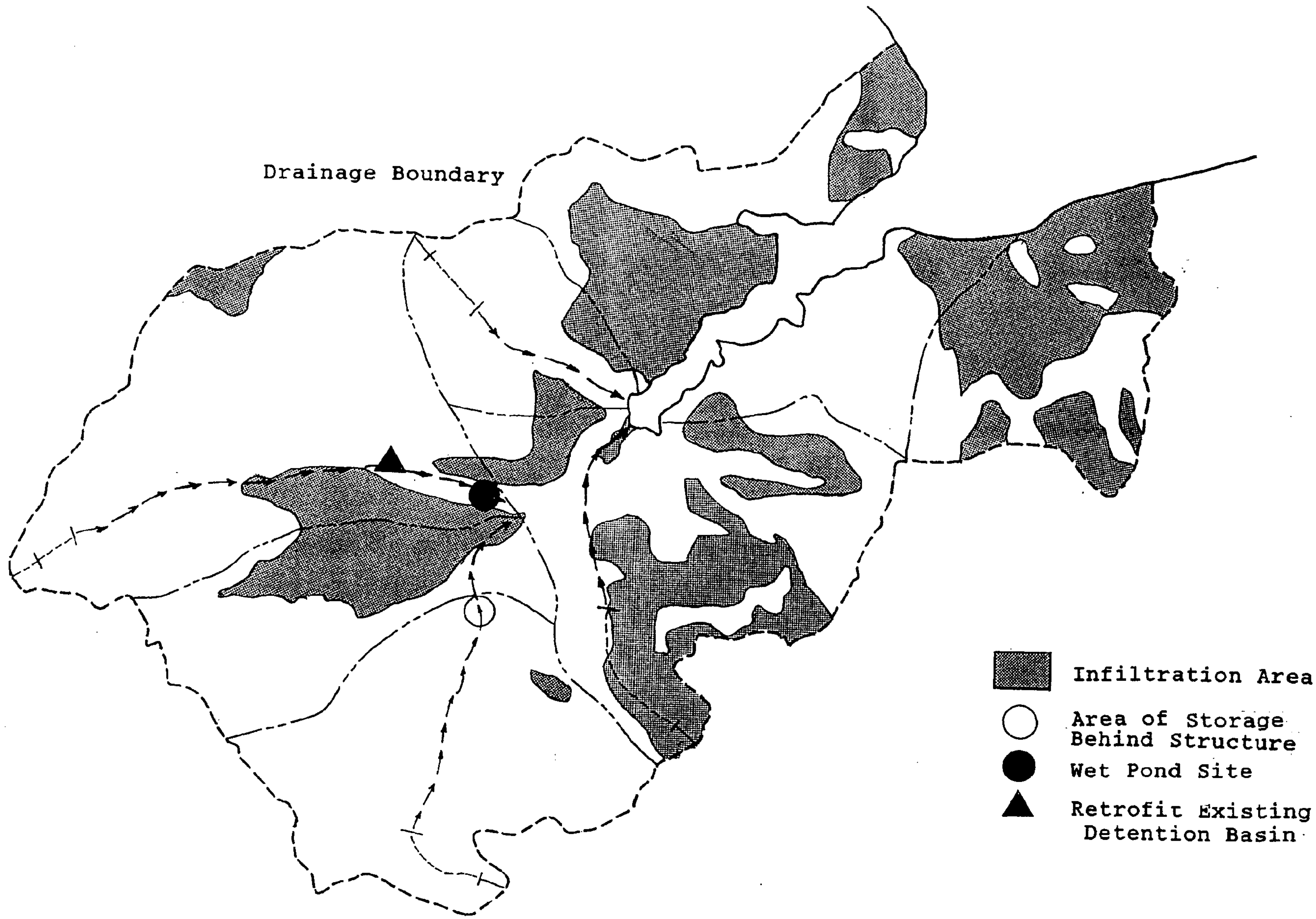


Figure 2.13 Possible locations for retrofit control measures.

- o Drainage pathways on public lands or rights-of-way are subject to retrofitting. High priority areas include runoff from roads and other paved areas. Management practices are specific to a site and the existing conditions. However, Table 1.3 lists potential control measures. These include grassed swales, vegetated filter strips, and infiltration trenches (see Figure 2.13 for possible areas where infiltration is feasible).

The management practices specified for source, erosion, and runoff control, combined with Figures 2.9 - 2.13, are the retrofit strategy for the Deep Creek analysis area.

The procedure to develop the retrofit strategy for Deep Creek should be repeated for other appropriate analysis areas in the Magothy Priority Watershed using the ranks in Table 2.6.

Step 6 -- A Watershed Retrofit Plan

Assemble the Retrofit Strategies

A retrofit plan for the Magothy River Priority Watershed is the collection of retrofit strategies of the appropriate analysis areas. These strategies can be summarized in a single report and summarized in tables of actions necessary to retrofit an analysis area. See Table 2.8 (page 99) for an example of the strategy, actions, relative costs, and implementation sources for Deep Creek.

Assign Order of Implementation

A second component of The Urban Retrofit Plan is a schedule of implementation. The easiest schedule would be implementation by analysis area by order of ranking in Table 2.6. In our example, Deep Creek analysis area has the highest rank. Its strategy should be implemented first. Remember that some management practices prescribed for Deep Creek can also be applied to the entire watershed. If this is true and the implementation cost is low, then the practices applicable in large areas should be implemented as a high priority. Source controls often meet these conditions.

This analysis assumes that the Magothy River is the highest priority watershed for retrofitting. Other watersheds in Anne Arundel can also be analyzed using these methods. The collection of the individual urban retrofit plans would be the comprehensive plan for the County.

Implement the Urban Retrofit Plan

To implement the Plan, four actions are required.

1. Detailed site investigations should be performed and any necessary engineering designs be drawn. For example: Deep Creek shows promising sites for infiltration and a wet pond. These areas would be inspected and have plans developed.

2. The suggested source controls under public management must be inspected more closely for legal and administrative feasibility.

3. Costs of implementation would be estimated for all feasible control measures in each analysis area strategy. Based on the estimated costs and type of control, funding sources will be selected.

4. Finally Anne Arundel County would implement The Magothy River Urban Stormwater Retrofit Plan by acting on the strategies in the Plan.

The same series of actions are also implemented for other priority watersheds in the County in order of rank.

Table 2.9 Deep Creek Urban Retrofit Strategy.

Category	Management Practice	Location(s)	Action Required	Estimated Cost	Funding Source
Existing Management					
Source Control	Solid waste management	All Deep Creek	Evaluation of mgmt. & public education.	Low/Low	1
	Roadway de-icing	All roads subject to de-icing	Evaluation of policy. & change for sensitive areas.	Low/Low	1
Erosion Control	Publically-owned lands	Need site surveys	Install where necessary.	Low/Low-Mod.	1,2,3,7
Runoff Control	Detention basin	See Figure 2.13	Site survey & design for retrofit.	Low/Low	2,3,5,6
	Four small wet ponds	See Figure 2.9	Site survey & evaluation of feasibility.	Low/Low-Mod.	2,3,5,6,7
	Residential roof & lot drainage	All Deep Creek	Site identification & public education.	Low/Low	1,2,7
New Management					
Source Control	Street & parking lot sweeping	Higher density resid. & commercial areas	I-Site identification & public education.	Low/Low-Mod.	1,2,7
			II-Ordinance.	Low/Low-Mod.	1,2,7
	Public fertilizer & pesticide control	All Deep Creek	I-Public education	Low/Low	1,2,6,7
			II-Ordinance	Low/Low-Mod.	1,2,6,7
	Pet waste management	All Deep Creek - focus on higher density residential areas.	I-Education	Low/Low	1,2,6,7
			II-Ordinance	Low/Low-Mod.	1,2,6,7
	Marina materials & chemicals handling	See Figure 2.9	Public education	Low/Low	1,2,6,7
Erosion Control	Drainageways & stream valleys	Potentially all areas (see Figure 2.9)	Site surveys & install.	Low/Mod.-High	1,2,3,4,5,7
Runoff Controls	Potential wet pond	See Figure 2.13	Site survey & design.	Low/ High	1,2,3,4,5,6
	Area for temporary runoff storage	See Figure 2.13	Site survey & design.	Low/Mod.-High	1,2,3,4,5,6
	Stormwater inlets	Storm drain system maps or detailed site survey.	Site survey & designs.	Low/Mod.-High	1,2,3,5,6
	Urban forestry	All Deep Creek	Public education & install on public lands.	Low/Low	1,2,3,5,7
	Drainage pathways on public lands	Storm drain system maps or detailed site survey.	Site survey, design, & install.	Low/Low-Mod.	1,2,3,4,5

Funding Source:
1 - Operating Budget. 3 - Critical Area Mitigation Fees. 5 - Chesapeake Bay Initiatives. 7 - Private.
2 - SWM Utility Fees. 4 - State or Local Special Bonds. 6 - Federal Clean Water Act.

Appendices

APPENDIX A

Segments in the Baltimore Region

Maryland Major Water Drainage Area Classification System

Basin	Sub-Basin		Segment	
02	12-02	Lower Susquehanna R.	01	L. Susquehanna R. Area
			02	Deer Creek
			03	Octoraro Creek
			04	Conowingo Dam Area
02	13-07	Bush River	01	Bush River
			02	Lower Winters Run
			03	Atkisson Reservoir
			04	Bynum Run
			05	Aberdeen Proving Grd.
			06	Swan Creek
02	13-08	Gunpowder River	01	Gunpowder River
			02	Lower Gunpowder Falls
			03	Bird River
			04	Little Gunpowder Falls
			05	Loch Raven Reservoir
			06	Prettyboy Reservoir
			07	Middle Rvr./Browns Cr.
02	13-09	Patapsco River	01	Back River
			02	Bodkin Creek
			03	Baltimore Harbor
			04	Jones Falls
			05	Gwynns Falls
			06	Patapsco Rvr.-Mainstem & Lower North Branch
			07	Liberty Reservoir
			08	Patapsco Rvr.-South Branch
02	13-10	West Chesapeake	01	Magothy River
			02	Severn River
			03	South River
			04	West River
			05	Other Drainages

Maryland Major Water Drainage Area Classification System

Basin	Sub-Basin		Segment	
02	13-11	Patuxent River	01	Patuxent Rvr. Mainstem -Mouth to Ferry Lndg.
			02	Patuxent Rvr. Mainstem -Ferry Lndg. to Rt.214
			03	Western Branch
			04	Patuxent Rvr. Mainstem -Rt.214 to Rocky Gorge Dam
			05	Little Patuxent Rvr.
			06	Middle Patuxent Rvr.
			07	Rocky Gorge Dam Area Drainage
			08	Patuxent Rvr.-Brighton Dam to headwaters
02	14-03	Middle Potomac River	01	Potomac Rvr.- Shenandoah Rvr. to Monocacy Rvr.
			02	Lower Momocacy Rvr.
			03	Upper Momocacy Rvr.
			04	Double Pipe Creek
			05	Catoctin Creek

Source: Maryland Office of Environmental Programs. Baltimore. April 15, 1986.

APPENDIX B

Water Quality Evaluation Values

Legend

(E) - Excellent water quality
(G) - Good water quality
(F) - Fair water quality
(P) - Poor water quality

(+) - meets fishable/swimmable criteria
(-) - does not meet fishable/swimmable criteria

Comparison of sub-basin and segment water quality evaluations from 1982, 1984 and 1986 Maryland 305(b) reports

Code	*Sub-basin / Segment*	*1982*	*1984*	*1986*	*Comments*
21301	Ocean/Coastal		G	G	
-01	Atlantic Ocean	E		E	
-02	Assawoman Bay	G		G	
-03	Isle of Wight Bay	+		P/G	
-04	Sinepuxent Bay	+		G	
-05	Newport Bay	G		G/E	
-06	Chincoteague Bay	E		E	
21302	Pocomoke River		G	G	
-01	Pocomoke Sound	+		G	
-02	Lower Pocomoke River	+		F	
-03	Upper Pocomoke River	+		F	
-04	Dividing Creek	+		F	
-05	Nassawango Creek	+		F	
-06	Tangier Sound	E		E	
-07	Big Annemessex River	+		G	
-08	Manokin River			F/G	
21303	Nanticoke/Wicomico River		G	G	
-01	Lower Wicomico River	+		F/G	
-02	Monie Bay	+		G	
-03	Wicomico Creek	+		G	
-04	Wicomico River Headwaters	+		F	
-05	Nanticoke River	+		G	
-06	Marshyhope Creek	+		G	
-07	Fishing Bay	E		E	
-08	Transquaking River	+		G	
21304	Choptank River		G	G	
-01	Honga River	E		E	
-02	Little Choptank River	G		G	
-03	Lower Choptank River	+		G	
-04	Upper Choptank River	+		G	
-05	Tuckahoe Creek	+		G	
21305	Chester River		G	F/G	
-01	Eastern Bay	+		G	
-02	Miles River	+		G	
-03	Wye River	+		F/G	
-04	Kent Narrows/Prospect Bay	+		F/G	
-05	Lower Chester River	+		G	
-06	Langford Creek	+		G	
-07	Corsica River	+		F/G	
-08	Southeast Creek	+		F	
-09	Middle Chester River	+		F	
-10	Upper Chester River	+		F	
-11	Kent Island	+		G	

Code	Sub-basin / Segment	1982	1984	1986	Comments
21306	Elk River		G	G	
-01	Lower Elk River	G		G	
-02	Bohemia River	+		G	
-03	Upper Elk River	+		F	
-04	Back Creek	+		G	
-05	Little Elk River	+		F	
-06	Big Elk Creek	+		F	
-07	Christina River	+		F	
-08	Northeast River	+		G	
-09	Furnace Bay	+		G	
-10	Sassafras River	+		G	
-11	Still Pond/Fairlee	+		G	
20503	Conewago Creek	new basin		G	
-01	Conewago Creek				
21202	Lower Susquehanna River		+	G	
-01	Lower Susquehanna River	+		G	
-02	Deer Creek	+		G	
-03	Octoraro Creek			G	
-04	Conowingo Dam/Susquehanna Run	+		G	
-05	Broad Creek	+		G	
21307	Bush River		G	G	
-01	Bush River	+		F	
-02	Lower Winters Run	+		G	
-03	Atkisson Reservoir	+		G	
-04	Bynum Run	+		G	
-05	Aberdeen Proving Ground	+		G	
-06	Swan Creek	+		F	
21308	Gunpowder River		G	F/G	
-01	Gunpowder River	+		F	
-02	Lower Gunpowder Falls	+		G	
-03	Bird River	+		F	
-04	Little Gunpowder Falls	+		G	
-05	Loch Raven Reservoir	+		F/G	
-06	Prettyboy Reservoir	+		G	
-07	Middle River/Browns Creek	+		G	

Code	Sub-basin / Segment	1982	1984	1986	Comments
21309	Patapsco River		F	P/G	
-01	Back River	+		P	
-02	Bodkin Creek	+		F	
-03	Baltimore Harbor	-		P/F	
-04	Jones Falls	+/-		P/G	
-05	Gywnns Falls	+/-		P/G	
-06	Patapsco - Lower North Branch	+		F/G	
-07	Liberty Reservoir	+		G	
-08	South Branch Patapsco	+		G	
21310	West Chesapeake		±	F	
-01	Magothy River	+		F	
-02	Severn River	+		F	
-03	South River	+		F	
-04	West River	+		F	
-05	West Chesapeake Bay Area	+		G	
21311	Patuxent River		±	F	
-01	Patuxent - Mouth to Ferry Ldg	+		G	
-02	Patuxent - Ferry Ldg to Rt 214	+		F	
-03	Patuxent - Western Branch	+		F	
-04	Patuxent - Rt 214 to Rocky Gorge	F		F	
-05	Little Patuxent	+		F	
-06	Middle Patuxent	+		G	
-07	Rocky Gorge Dam Area	+		G	
-08	Patuxent - Brighton Dam	E		G/E	
21399	Chesapeake Bay		F/G	F/G	
-96	Upper Chesapeake Bay	+		F	
-97	Middle Chesapeake Bay	+		F	
-98	Lower Chesapeake Bay	+		G	
21401	Lower Potomac River		G/E	G	
-01	Potomac - Smith Pt to Mouth	G/E		G/E	
-02	Potomac - Marshall Hall to Smith Pt	G		F/G	algal blooms
-03	St. Mary's River	G		G	
-04	Breton Bay	G/E		G/E	
-05	St. Clements Bay	G		G	
-06	Wicomico River	G		G	
-07	Gilbert Swamp	G		G	
-08	Zekiah Swamp	G		G	
-09	Port Tobacco River	G		F	algal blooms
-10	Nanjemoy Creek	G		G	
-11	Mattawoman Creek	G		F/G	

Code	Sub-basin / Segment	1982	1984	1986	Comments
21402	Potomac River - Washington Metro		F/G	F/G	
-01	Potomac - Chain Br to Marshall Hall	G/P		F	
-02	Potomac - Monocacy to Chain Br	G		G	
-03	Piscataway Creek	G		F	algal blooms
-04	Oxon Run	G		F	
-05	Anacostia River	F		F/G	
-06	Rock Creek	F/P		F/G	82 report included DC
-07	Cabin John Creek	F/G		F/G	
-08	Seneca Creek	F/G		G	
21403	Middle Potomac River		G	F/G	
-01	Potomac - Shenandoah to Monocacy	F		G	error in 82 report
-02	Lower Monocacy	F/G		F/G	
-03	Upper Monocacy	F/G		F/G	
-04	Double Pipe Creek	G		F/G	
-05	Catoctin Creek	G		G	
21405	Upper Potomac River		G/E	G	
-01	Potomac - Hancock to South Branch	G		G	
-02	Antietam Creek	G		F/G	Hagerstown impact
-03	Marsh Run	F		G	-
-04	Conococheague Creek	G		G	
-05	Little Conococheague Creek	G		G	
-06	Licking Creek	G		G	
-07	Tonoloway Creek	G		G	
-08	Allegany County Drainage	G		G	
-09	Little Tonoloway Creek	G		G	
-10	Sideling Hill Creek	E		G/E	
-11	Fifteen Mile Creek	G		G	
-12	Town Creek	G		G	
21410	North Branch Potomac		E	E	
-01	Lower North Branch	F		F/G	Bloomington Reservoir
-02	Evitts Creek	G		G	
-03	Wills Creek	G		P/G	acid mine drainage
-04	Georges Creek	P		P	
-05	Upper North Branch	P		P	
-06	Savage River	G/E		G/E	
50202	Youghiogheny River		G	P/G	
-01	Youghiogheny River	G		F/G	swimming ban
-02	Little Youghiogheny River	G		P/G	swimming ban
-03	Deep Creek Lake	G		G	
-04	Casselman River	G		F	swimming ban

Source: Maryland Office of Environmental Programs. Baltimore. April 15, 1986.

APPPENDIX C

Maryland Watershed Priority List

1986 Maryland Watershed Priority List

Segment	Segment Code	Sub-basin	Miles Impacted	Effect of Impact
Loch Raven Reservoir	02-13-08-05	Gunpowder River	26	Algal blooms (primary water supply)
Back River	02-13-09-01	Patapsco River	3	Algal blooms, fish kills
Upper Chesapeake Bay	02-13-99-96	Chesapeake Bay	23	Algal blooms, fish kills, swimming ban
Lower Susquehanna River	02-12-02-01	Susquehanna River	2	
Middle Chesapeake Bay	02-13-99-97	Chesapeake Bay	24	Algal blooms
Lower Chesapeake Bay	02-13-99-98	Chesapeake Bay	71	Algal blooms, low oxygen
Patuxent River - Mouth to Ferry Ldg	02-13-11-01	Patuxent River	2	Swimming ban, shellfish ban, aquatic life stressed
- Ferry Ldg to Rt 214	02-13-11-02		11	
- Rt 214 to Rocky Gorge	02-13-11-04		24	
- Western Branch	02-13-11-03		16	
Little Patuxent River	02-13-11-05		35	
Potomac - Smith Point to Marshall Hall	02-14-01-02	Lower Potomac River	24	Algal blooms, aquatic life stressed
- Marshall Hall to Chain Br.	02-14-02-01	Washington Metro Area	34	
Baltimore Harbor	02-13-09-03	Patapsco River	7	Swimming ban, fish kills, aquatic life stressed
Bodkin Creek	02-13-09-02		5	
Jones Falls	02-13-09-04		9	
Gwynns Falls	02-13-09-05		12	
Isle of Wight Bay	02-13-01-03	Ocean/Coastal	6	Shellfish closures, aquatic life stressed
Lower Monocacy River	02-14-03-02	Middle Potomac	24	Aquatic life stressed
Upper Monocacy River	02-14-03-03		34	
Double Pipe Creek	02-14-03-04		30	
Liberty Reservoir	02-13-09-07	Patapsco River	17	Algal blooms (primary water supply)

1986 Maryland Watershed Priority List - Continued

	Segment	Segment Code	Sub-basin	Miles Impacted	Effect of Impact
12	Magothy River	02-13-10-01	West Chesapeake	11	Shellfish closures, algal blooms, fish kills
	Severn River	02-13-10-02		16	
	South River	02-13-10-03		16	
13	Lower Choptank River	02-13-04-03	Choptank River	10	Shellfish closures, algal blooms
14	Wicomico River headwaters	02-13-03-04	Nanticoke/Wicomico River	10	Swimming ban, algal blooms
15	Prettyboy Reservoir	02-13-08-06	Gunpowder River	13	Algal blooms (secondary water supply)
16	Upper North Branch Potomac	02-14-10-05	North Branch Potomac	27	Aquatic life stressed
	Georges Creek	02-14-10-04		17	
17	Youghiogheny River	05-02-02-01	Youghiogheny River	1	Swimming ban, aquatic life stressed
	Little Youghiogheny River	05-02-02-02		2	
18	Mattawoman Creek	02-14-01-11	Lower Potomac River	10	Algal blooms, aquatic life stressed
	Piscataway Creek	02-14-02-03	Washington Metro Area	5	
19	Miles River	02-13-05-02	Chester River	8	Shellfish closure
	Wye River	02-13-05-03		7	
20	Lower North Branch Potomac	02-14-10-01	North Branch Potomac	52	Aquatic life stressed
	Wills Creek	02-14-10-03		14	
21	Casselman River	05-02-02-04	Youghiogheny River	12	Swimming ban, aquatic life stressed
22	Anacostia River	02-14-02-05	Washington Metro Area	5	Aquatic life stressed

Source: Maryland Office of Environmental Programs. Baltimore. April 15, 1986.

APPENDIX D

Using Natural Soil Groups to Assess Existing Urban Areas

The following material has been excerpted from the Maryland Department of State Planning publication:

Natural Soil Groups of Maryland, Technical Report, December 1973.

The enclosed information includes:

1. "Natural Soil Group Identification Symbols", pg. 20.
2. "How to Use a Natural Soil Group Map", pg. 57.
3. Table 1. "Estimated Physical and Chemical Properties", pgs. 61 and 62.
4. "Engineering Uses of Soils", explanation of Table 1, pgs. 58-60.
5. Appendix A - Listing of Natural Soil Group Map Symbols by County.

a. Anne Arundel County	pgs. 77-80
b. Baltimore County	81-85
c. Carroll County	90-92
d. Harford County	108-110
e. Howard County	111-113

DESCRIPTION OF NATURAL SOIL GROUPS IN MARYLAND

NATURAL SOIL GROUP INDENTIFICATION SYMBOLS

Each soil group is designated on the Natural Soil Group Map by a capital letter and a number, such as B1. If a group contains soils that have a wide range in slope, then the group is subdivided into slope ranges indicated by the addition of a lower case letter (see Figure 6). A lower case letter **a** means that slopes range from 0 to 8 or 10 percent; **b**, 8 to 15 or 10 to 15 percent; and **c**, steeper than 15 percent. On the Eastern Shore, practically all soils mapped have slopes of less than 10 percent; therefore, to reduce map clutter, only the capital letter and number are designated for soils on the Eastern Shore. For example, B1 on the Eastern Shore and B1a in the Piedmont region both indicate soils in Group B1 with slopes of 0 to 10 percent.

The Natural Soil Group symbols are not connotative, although the lower case letters a, b, and c indicate specific slope ranges. In general, the Natural Soil Groups are arranged in order of increasing limitations or problems for most uses. Drainage class or wetness is one of the prime considerations in land use. Thus, the system is connotative in that the soils, in general, get progressively wetter moving from A to G in the alphabet. Also, in general, the number designation indicates the intensity of an unfavorable feature such as wetness, droughtiness, or very high or low permeability. For example, the soils in Group A are sandy and droughty, but A1 is not so droughty as A2. The soils in Groups B1, B2, and B3 are all deep and well drained, but have progressively slower permeability. Thus, the numbers indicate increasing limitations within the capital letter designation. In most groups, the numbers represent increasing limitations of permeability.

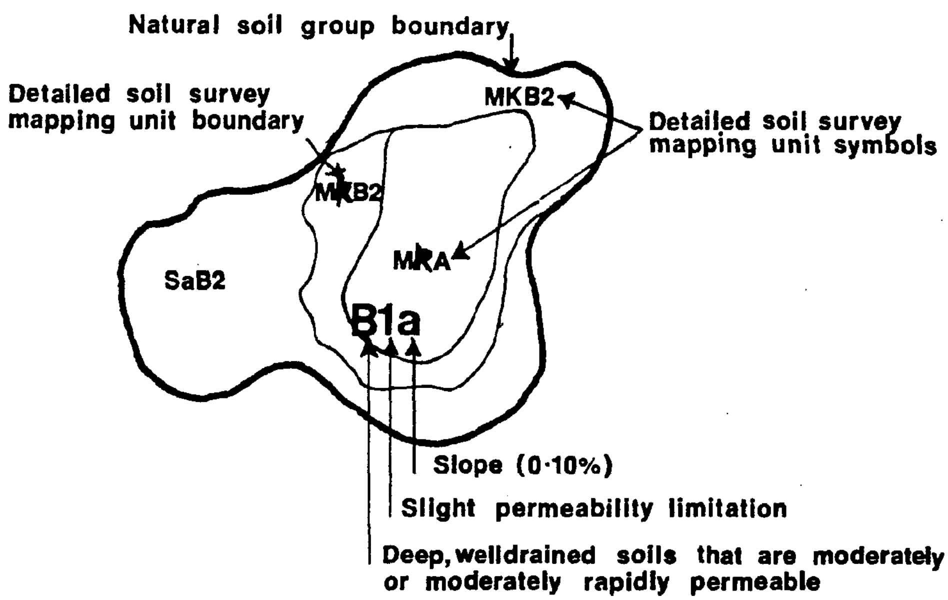


FIGURE 6

HOW TO USE A NATURAL SOIL GROUP MAP

1. Locate the area of interest on the Natural Soil Group Map.
2. Observe the Natural Soil Group symbol or symbols consisting of a capital letter, a number, and a lower case letter. (See "Natural Soil Group Identification Symbols" for a detailed explanation of the natural soil group symbolization.)
3. Refer to "Description of Natural Soils Groups" in the table of contents. Move to the section on "Discussion of Each Natural Soil Groupings." Locate the appropriate description. They are listed in alphabetical order, from A1 to H2.
4. Read the introductory paragraphs. Specific interpretations are made for each Natural Soil Group under the headings for Unique Value, Cropland, Urban, Recreation, Wildlife and Woodland. These interpretive statements may apply to more than one specific natural soil group if slope does not have an important effect. For example, specific groups B2a and B2b are interpreted together for recreation in broad group B2.
   Note: It is important that users read the two or three introductory paragraphs of each natural soil group description. These paragraphs describe the important soil characteristics and features that would affect most uses. They are important supplements to the specific use interpretations under the various headings.
5. For specific use interpretations not noted in the descriptions, turn to the interpretive tables further in this text. From the information in these tables, color soil interpretation maps can be prepared by coloring any area rated slightly limited or good with green; moderately limited or fair with yellow; and severely limited or poor with red. This system is analogous to the traffic light system where green indicates no special hazards; yellow a caution color; and red a full stop or a serious hazard. Ratings of slight, moderate, and severe indicate the relative degree of problems to be overcome to make an area suitable for a specific use.
6. Keep in mind that Natural Soil Groups were devised for broad land use planning, not for detailed interpretations of specific acres or lots. If a rather specific interpretation for a small area is needed, spot this area on the map and read the detailed soil map symbol with a magnifying glass, if the natural soil group map has a detailed soil map base. Locate this detailed map symbol in the Guide to Mapping Units in the appropriate published soil survey report, determine the soil name, and trace out the detailed descriptions and interpretations. If the natural soil group map is not on a detailed soil map base, specifically identify the area on interim sets of detailed maps available for reference at the county field office of the Soil Conservation Service and refer to manuscript copies of the detailed soil descriptions and interpretations.

   On-site detailed investigations are needed for specific sites.

   Note: The primary value of soil surveys is to provide resource information for planning prediction, not absolute land use descriptions for specific acres or lots.

TABLE 1. ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES

Natural Soil Groups	Depth to		Depth from surface	Classification			Erodibility (K factor)	Runoff potential (Hydrologic group)	Sprinkler irrigation maximum application rates	Permeability	Percolation	Available water capacity	Reaction	Shrink swell potential	Frost action potential
	Bedrock	Seasonal high water table		Dominant USDA textures	Unified	AASHO									
	(inches)	(feet)	(inches)						(in./hr.)	(in./hr.)	(min./in.)	(in./in. of soil)	(pH) value)		
A1a, A1b, A1c	72+	4+	0-60	Loamy sand, sand or sandy loam	SM, SP	A-2, A-3, A-4	Very low (.17)	Low (A)	1.0	> 6.0	Faster than 45	.02-.06	4.0-5.0	Low	Low
A2	72+	1-10	0-60	Sand	SP or SP-SM	A-3	Very low (.17)	Low (A)	N/A	>6.0	Faster than 45	<0.06	5.0-8.0	Low	Low
B1a, B1b, B1c	72+	3+	0-60	Silt loam, loam, fine sandy loam, sandy loam, silty clay loam, clay loam, silty clay, clay	ML, CL, SM, SC, CH, MH	A-4, A-6, A-7, A-5	Moderate (.32)	Moderately low (B)	0.4-0.6	0.60-2.0	45-60	.12-.24	4.5-6.5	Low to Moderate	Moderate
B2a, B2b, B2c	72+	4+	0-60	Silt loam, loam, gravelly loam, clay loam, silty clay loam	ML, CL, GM	A-4, A-6, A-7, A-2	Very high (.43)	Moderately high (C)	0.3-0.4	0.20-0.60	Slower than 60	.12-.24	4.5-7.3	Low to Moderate	Moderate
B3	72+	5+	0-60	Clay, silty clay, silt loam, loam, loamy sand	CH, CL, ML, SM	A-7, A-6, A-4, A-2	High (.37)	Moderately high (C)	0.3	<0.60	Slower than 60	.06-.24	4.0-5.0	Low to Moderate	Moderate
C1a, C1b, C1c	20-40	In bedrock	0-40	Silt loam, loam, shaly silt loam, shaly loam, channery loam, channery silt loam, sandy loam	ML, CL, GM, SM	A-4, A-6, A-2	Low (.22)	Moderately high (C)	0.3	0.60-6.0	Faster than 60	.12-.24	4.0-7.3	Low	Moderate
C2	20-40	3+	0-40	Silty clay loam, silty clay, clay	CH, CL	A-7, A-6	High (.37)	Moderately high (C)	0.3	<0.60	Slower than 60	.12-.20	5.0-7.5	Moderate to High	Moderate
D1a, D1b, D1c	Less than 20	In bedrock	0-20	Shaly silt loam, shaly loam, clay, silty clay loam, silty clay	GM, GC, ML, CL, CH	A-2, A-4, A-6, A-7	Low (.28)	Moderately high to high (C or D)	0.3	0.60-6.0	Slower than 60 to faster than 45	.18-.24	4.0-7.3	Low to Moderate	Moderate
E1	72+	1½-2½	0-60	Sandy loam, sandy clay loam, loamy sand, sand	SM, SC, SP	A-2, A-4, A-3	Low (.28)	Moderately high (C)	0.4-0.6	0.60-6.0	Faster than 60	.12-.24	4.0-5.0	Low	High
E2a, E2b	72+	1-3	0-60	Silt loam, loam, silty clay loam, fine sandy loam, sandy clay loam	ML, CL, SM, SC	A-4, A-6, A-7, A-2	Very high (.43)	Moderately high (C)	0.3-0.4	<0.60	Slower than 60	.12-.24	4.0-6.5	Low to Moderate	High
E3	72+	1½-2½	0-60	Silt loam, loam, silty clay loam	ML, CL, SM	A-4, A-6, A-2	High (.37)	Moderately high (C)	0.4	0.20-0.60	Slower than 60	.18-.24	4.5-5.5	Low to Moderate	High
F1	72+	0-1	0-60	Loamy sand, sand	SM-SP	A-2, A-3	N/A	High (D)	1.0	>6.0	Faster than 45	<0.06	3.5-5.0	Low	High

TABLE 1. ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES (CONT'D.)

Natural Soil Groups	Depth to		Depth from surface	Classification			Erodibility (K factor)	Runoff potential (Hydrologic group)	Sprinkler irrigation maximum application rates	Permeability	Percolation	Available water capacity	Reaction	Shrink-swell potential	Frost-action potential
	Bedrock	Seasonal high water table		Dominant USDA textures	Unified	AASHO									
	(inches)	(feet)	(inches)						(in./hr.)	(in./hr.)	(min./in.)	(in./in. of soil)	(pH value)		
F2	72+	0-1	0-60	Sandy loam, fine sandy loam, sandy clay loam, loam, loamy sand	SM, ML, SC, SP	A-2, A-4, A-3	Low (.28)	High (D)	0.4-0.6	0.60-2.0	Faster than 60	.12-.24	4.0-5.0	Low	High
F3	72+	0-1	0-60	Silty clay loam, clay loam, silty clay, clay, loam, silt loam	CL, CH, ML, SC, SM, MH	A-6, A-7, A-4, A-2	Very high (.43)	High (D)	0.3	<0.60	Slower than 60	.18-.24	4.0-7.8	Moderate to High	High
G1	72+	3+	0-60	Silt loam, loam, fine sandy loam, sandy loam, silty clay loam	ML, CL, MH, SM, SP	A-4, A-6, A-5, A-2, A-3	N/A	Moderate-ly low to Mod. high (B or C)	0.5-0.7	0.20-2.0	Faster than 45 to Slower than 60	.12-.24	4.0-7.3	Low to Moderate	Mod. to High
G2	72+	0-1	0-60	Silt loam, silty clay loam, silty clay, fine sandy loam, sandy loam, loam, muck	ML, CL, SM, OL, Pt	A-4, A-6, A-2, A-5	N/A	High (D)	0.5	0.60-6.0	Faster than 45 to Slower than 60	.18-.24	4.0-7.3	Low to High	High
G3	72+	0	0-60	Variable	Variable	Variable	N/A	N/A	N/A	Variable	Variable	Variable	3.5-9.0	Low to High	Variable
H1a, H1b, H1c	Too variable to rate. Determine the specific soil series name from the detailed soil map and use the information for the group that series is in.														
H2a, H2b, H2c	Too variable to rate. Determine the specific soil series name from the detailed soil map and use the information for the group that series is in.														

ENGINEERING USES OF SOILS

TABLE 1

Table 1, "Estimated Physical and Chemical Properties," lists soil properties relevant to the engineering uses of soils. The properties are given for each Natural Soil Group; therefore, a wide range of properties is covered. The primary purpose of the table is to provide some properties of soils that will help users select large areas that have potential for the use they have in mind, and to help them quickly eliminate some others that obviously do not have the desired properties and features.

Table 1 does not eliminate the need to use detailed soil maps and soil survey reports for any Natural Soil Group area, nor does it eliminate the need for further investigation at sites selected for specific engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in Table 1. Also, inspection of sites, especially small ones, is needed because the Natural Soil Group delineations contain some inclusions of other soil delineations that have properties and features different from the Natural Soil Group in which they occur. Even the detailed soil map delineations may have inclusions of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

The following paragraphs explain the meaning and purpose of each individual column in Table 1, "Estimated Physical and Chemical Properties."

Natural Soil Groups - All of the Natural Soil Groups are listed in this column. Slope has little effect on the physical and chemical properties of soils. Therefore, some groups that are alike except for slope are grouped together in this table.

Depth to Bedrock - This is the distance from the surface of the soil downward to the surface of the rock layers. For the Natural Soil Groups that occur in the Coastal Plain (A1 and A2), depth to bedrock is shown as 72+ inches. Actually, over most of the Coastal Plain depth to bedrock is many hundreds of feet, but, in mapping, the soils were observed only to a depth of 6 feet. Therefore, depth greater than 72 inches is assumed but not specified.

Depth to Seasonal High Water Table - This is the distance from the surface of the soil downward to the highest level reached in most years by ground water. It is the highest part of the soil or underlying rock material that is wholly saturated with water. Most of the soils in Natural Soil Groups E2a and E2b have a perched water table above a fragipan or clayey layer which may be separated from a lower water table by a dry zone many feet thick; thus, the water table referred to in this column may or may not be continuous with a water table from which water is drawn for use in the home. If the water table is in bedrock, rather than in the soil, it is so indicated.

Depth from Surface - Unless the soil is located less than 60 inches above bedrock, the depth from surface is expressed as 0-60 inches. This does not imply that the soils are only 60 inches deep, but rather that the estimates in the accompanying columns are for the 0-60 inch depth and not below.

Dominant U.S.D.A. Textures - These are expressed in standard terms used by the U.S. Department of Agriculture. These terms take into account relative percentages of sand, silt and clay in a soil sample that is less than 2 millimeters in diameters. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly" loam or "shaly" loam. Percentages of material passing various sieve sizes are not estimated in Table 1 because of the many different soils comprising each Natural Soil Group; however, sieve data for specific soil series are available in published soil survey reports for detailed soil maps.

Textures described are those that may be encountered within the 0-60 inch depth of the soils in a Natural Soil Group. Textures are listed in order of dominance for the group. In general, the heaviest (most clayey) textures ordinarily occur in the subsoil at depths of 1 to 4 feet and are less clayey above and below these depths.

Unified Classification - In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as PT. Soils on the borderline between two classes are designated by symbols for both classes, for example SP-SM.

In this column, Unified classifications are grouped for the entire 0-60 inch depth. Where CL and CH classes are shown, they can be expected to occur between depths of 1 and 4 feet, or in what is commonly called the "subsoil". Unified classes are listed in order of dominance within the group.

AASHO Classification - This system is used to classify soils according to those properties that affect use in highway construction and maintenance. A soil is placed in one of seven basic groups based on grain-size distribution, liquid limit and plasticity index. In group A-1 are gravelly soils of high bearing strength, the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest mineral soils for subgrade.

In this column in Table 1, where classes A-6 or A-7 occur, they are generally in the subsoil, or at depths between 1 and 4 feet. AASHO classifications are listed in this column in order of dominance for the Natural Soil Group.

Erodibility (K factors) - This is a measure of the susceptibility of bare surface soil to erosion. The K-factor is a component of an established formula for estimating potential erosion from a field or watershed by the "soil loss formula", which also considers vegetation, climate, slope, and other factors.

The K factors shown are for surface soil only. They are not suitable for estimating erosion from development sites where the subsoils or substrata have been exposed by grading. The subsoils and substrata have different erodibility (K factors).

Runoff potential (Hydrologic Group) - The qualitative rating is given along with the Hydrologic Group symbol, in parenthesis. When fully saturated, soils in Hydrologic Group **A** have the lowest runoff potential and those in Group **D** the highest. Hydrologic soil group descriptions are used in watershed planning to estimate runoff from rainfall. To determine the groups, soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil **after prolonged wetting.** The influence of vegetative cover, conservation practices, and topography is not treated in hydrologic soil groups. The following are definitions of the four hydrologic groups:

A. (Low runoff potential). Soils having high infiltration rates even **when thoroughly wetted.** These consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission in that water readily passes through them.

B. (Moderately low runoff potential). Soils having moderate infiltration rates **when thoroughly wetted.** These consist chiefly of deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. (Moderately high runoff potential). Soils having slow infiltration rates **when thoroughly wetted.** These consist chiefly of soils with a layer that impedes downward movement of water, soils with moderately fine to fine texture, or soils with moderately high water tables. These soils may be somewhat poorly drained. They have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates **when thoroughly wetted.** These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Sprinkler Irrigation Maximum Application Rates - This column shows the maximum rate in inches per hour that irrigation water can be applied to the soils in each group. Although these rates were established for application of ground or stream water by sprinkler on cropland, they can also be used as guides for applying waste water to land.

A rapid application rate, such as 1.0 inch per hour for Group A1a, A1b, and A1c, simply means that the surface soil has the capability to absorb irrigation or waste water applied at that rate. For the overall ratings of Natural Soil Groups as sites for disposal of waste water, see Table 2.

Permeability - This is the quality of a soil that enables it to transmit water or air, expressed in inches per hour. Accepted as a measure of this quality is the rate at which soil transmits water while saturated. That rate is the "saturated hydraulic conductivity" of soil physics. The estimates shown are for downward movement only and not lateral movements, such as along the surfaces of fragipan, plow pans and surface crusts. Permeability rates shown are based on the least permeable section of the soil, which is generally the "subsoil" or that section of soil between depths of 1 and 4 feet.

The permeability classes and corresponding numerical ranges are shown below:

Permeability class	Numerical range (inches per hr.)
Very slow	Less than 0.06
Slow	0.06 - 0.20
Moderately slow	0.20 - 0.60
Moderate	0.60 - 2.0
Moderately rapid	2.0 - 6.0
Rapid or very rapid	greater than 6.0

Percolation - This is the rate, in minutes per inch, at which water can move through a soil with moisture at field capacity. Classes of permeability can be rated to classes of percolation although the correlation is not perfect. Permeability rates shown in Table 1 were measured as a hydraulic conductively rate by the Uhland core method, while the corresponding estimated percolation rates were measured by the Auger hole method. Estimated percolation rates shown in Table 1 are for the depths at which tile lines for shallow sub-surface septic tank absorption fields are generally placed and **not for substrata in which deep, dry wells are placed.**

The following are the permeability-percolation relationships used in Table 1. Each corresponding class is not a mathematical reciprocal of the other because the method of measuring each is different.

Permeability in./hr.	Percolation min./in.
More than 1.0	Faster than 45
1.0 - 0.6	45 - 60
Less than 0.6	Slower than 60

Available Water Capacity - This is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount in the soil at the wilting point of most crop plants. The ranges shown in Table 1 for each Natural Soil Group cover the range in texture for each of the groups.

Reaction - This is the degree of acidity or alkalinity of a soil group, expressed in pH values. In Table 1 the values shown are the estimated ranges necessary to cover all of the soils within a group. Since soil reaction was not one of the major soil characteristics used for establishing the Natural Soil Groups, the range in values for some groups in Table 1 is wide.

The following are the numerical ranges for each of the reaction classes:

Class	pH
Extremely acid	4.5
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Medium acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Neutral	6.6 - 7.3
Mildly alkaline	7.4 - 7.8
Moderately alkaline	7.9 - 8.4
Strongly alkaline	8.5 - 9.0
Very strongly alkaline	9.0

Shrink-swell potential - This is the quality of the soil that determines its volume change with changes in moisture content. It is influenced by the amount of moisture change and the amount and kind of clay in the soil. Building foundations, roads, and other structures may be severely damaged by shrinking and swelling of soil. The three classes of shrink-swell used in Table 1 can be related to a quantitative method of measuring shrink-swell, known as "the coefficient of linear extensibility" (COLE), as follows:

Classes	COLE
Low	0.03
Moderate	.03-.06
High	0.06

Frost-action Potential - The action pertains to not only the heaving of soil as freezing progresses but also to the excessive wetting and loss of strength during thaw. Both the textures of soils and their potential for forming expansion ice lenses from a sustained source of water were considered in determining the frost-action potential.

ANNE ARUNDEL COUNTY

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
AdA	Adelphia sandy loam, 0 to 2 percent slopes	IIw-5	580	E1
AdB	Adelphia sandy loam, 2 to 5 percent slopes	IIe-36	1670	E1
AsA	Adelphia silt loam, 0 to 2 percent slopes	IIw-1	220	E1
AsB	Adelphia silt loam, 2 to 5 percent slopes	IIe-16	250	E1
BeB2	Beltsville silt loam, 2 to 5 percent slopes, moderately eroded	IIe-13	430	E2a
BlB	Beltsville-Urban land complex, 0 to 5 percent slopes	------	430	E2a
Bm	Bibb silt loam	IIIw-7	11,000	G2
BuA	Butlertown silt loam, 0 to 2 percent slopes	IIw-1	490	B2a
BuB2	Butlertown silt loam, 2 to 5 percent slopes, moderately eroded	IIe-16	2,200	B2a
BuC2	Butlertown silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-16	260	B2a
BuC3	Butlertown silt loam, 5 to 10 percent slopes, severely eroded	IVe-9	350	B2a
BuD3	Butlertown silt loam, 10 to 15 percent slopes, severely eroded	VIe-2	200	B2b
CaB2	Chillum silt loam, 2 to 6 percent slopes, moderately eroded	IIs-7	320	B2a
CaC2	Chillum silt loam, 6 to 12 percent slopes, moderately eroded	IIIe-7	330	B2a
CbB	Chillum-Urban land complex, 0 to 6 percent slopes	------	370	B2a
CcB2	Christiana silt loam, 2 to 5 percent slopes, moderately eroded	IIe-42	1,350	B3
CcC2	Christiana silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-42	430	B3
CdC3	Christiana clay, 5 to 10 percent slopes, severely eroded	IVe-3	440	B3
Ce	Coastal beaches	VIIIs-2	280	A2
Ch	Codorus silt loam	IIw-7	150	G1
Ck	Colemantown sandy loam	IIIw-6	1,390	F3
Cm	Colemantown silt loam	IIIw-7	730	F3
CnB2	Collington loamy sand, 2 to 5 percent slopes, moderately eroded	IIs-4	750	B1a
CnC2	Collington loamy sand, 5 to 10 percent slopes, moderately eroded	IIIe-33	650	B1a
CoA	Collington fine sandy loam, 0 to 2 percent slopes	I-5	390	B1a
CoB2	Collington fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-5	4,250	B1a
CoC2	Collington fine sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-5	1,630	B1a
CoC3	Collington fine sandy loam, 5 to 10 percent slopes, severely eroded	IVe-5	2,700	B1a
CoD2	Collington fine sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-5	960	B1b
CoD3	Collington fine sandy loam, 10 to 15 percent slopes, severely eroded	VIe-2	1,600	B1b
CoE	Collington fine sandy loam, 15 to 40 percent slopes	VIe-2	5,400	B1c
CpA	Collington silt loam, 0 to 2 percent	I-4	130	B1a
CpB2	Collington silt loam, 2 to 5 percent slopes, moderately eroded	IIe-4	460	B1a
CpuB	Collington-Urban land complex, 0 to 5 percent slopes	-----	640	B1a
CpuD	Collington-Urban land complex, 5 to 15 percent slopes	-----	470	B1b
Cr	Comus silt loam	I-6	110	G1
CsC2	Croom gravelly sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-9	700	B2a
CsD2	Croom gravelly sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-7	430	B2b

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
CsE	Croom gravelly sandy loam, 15 to 40 percent slopes	VIIe-2	340	B2c
CtD	Croom-Urban land complex, 5 to 15 percent slopes	------	360	B2b
CuB	Cut and fill land, 0 to 5 percent slopes	------	4,500	Ma
CuD	Cut and fill land, 5 to 15 percent slopes	------	910	Ma
CuE	Cut and fill land, 15 to 30 percent slopes	------	250	Ma
DnA	Donlonton fine sandy loam, 0 to 2 percent slopes	IIw-9	1,170	E2a
DnB2	Donlonton fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-36	1,390	E2a
DuB	Donlonton-Urban land complex, 0 to 5 percent slopes	------	340	E2a
Ek	Elkton sandy loam	IIIw-11	530	F3
En	Elkton silt loam	IIIw-9	7,330	F3
EoB	Evesboro loamy sand, 0 to 6 percent slopes	IVs-1	21,045	A1a
ErB	Evesboro loamy sand, clayey substratum, 0 to 5 percent slopes	IIls-1	4,200	A1a
ErC	Evesboro loamy sand, clayey substratum, 5 to 10 percent slopes	IVs-1	550	A1a
EsC	Evesboro and Galestown loamy sands, 6 to 12 percent slopes	VIIs-1	6,600	A1b
EsE	Evesboro and Galestown loamy sands, 12 to 40 percent slopes	VIIs-1	4,710	A1c
EuC	Evesboro-Urban land complex, 0 to 15 percent slopes	------	5,180	A1b
Fa	Fallsington sandy loam	IIIw-6	1,870	F2
GaB	Galestown loamy sand, 0 to 5 percent slopes	IVs-1	4,530	A1a
Gp	Gravel and borrow pits	VIIIs-4	1,760	Bp
Ha	Hatboro silt loam	IIIw-7	1,100	G2
HfB2	Howell fine sandy loam, 2 to 6 percent slopes, moderately eroded	IIe-28	480	B2a
HgB2	Howell fine sandy loam, shaly subsoil, 2 to 6 percent slopes, moderately eroded	IIe-28	120	B2a
HsB2	Howell silt loam, 2 to 6 percent slopes, moderately eroded	IIe-29	290	B2a
HtB2	Howell silt loam, shaly subsoil, 2 to 6 percent slopes, moderately eroded	IIe-29	230	B2a
HyC3	Howell clay loam, 6 to 12 percent slopes, severely eroded	IVe-3	1,020	B2b
HyD3	Howell clay loam, 12 to 20 percent slopes, severely eroded	VIe-2	800	B2c
HyE3	Howell clay loam, 20 to 40 percent slopes, severely eroded	VIIe-2	470	B2c
HzC3	Howell clay loam, shaly subsoil, 6 to 12 percent slopes, severely eroded	IVe-3	270	B2b
KeA	Keyport sandy loam, 0 to 2 percent slopes	IIw-9	420	E2a
KeB	Keyport sandy loam, 2 to 5 percent slopes	IIe-36	1,370	E2a
KpA	Keyport sandy loam,0 to 2 percent slopes	IIw-8	380	E2a
KpB2	Keyport silt loam, 2 to 5 percent slopes, moderately eroded	IIe-13	1,390	E2a
KrB	Keyport-Urban land complex, 0 to 5 percent slopes	------	350	E2a
Ks	Klej loamy sand	IIIw-10	650	E1
LoB	Loamy and clayey land, 0 to 5 percent slopes	IIIe-42	5,830	B3
LoC	Loamy and clayey land, 5 to 10 percent slopes	IVe-3	4,300	B3
LoD	Loamy and clayey land, 10 to 40 percent slopes	VIe-2	2,270	B3
Ma	Made land	------	100	Ma
MfB2	Marr fine sandy loam, 2 to 6 percent slopes, moderately eroded	IIe-5	7,750	B1a
MfC2	Marr fine sandy loam, 6 to 12 percent slopes, moderately eroded	IIIe-5	1,120	B1b
MfC3	Marr fine sandy loam, 6 to 12 percent slopes, severely eroded	IVe-5	7,800	B1b
MfD2	Marr fine sandy loam, 12 to 20 percent slopes, moderately eroded	IVe-5	840	B1c
MfD3	Marr fine sandy loam, 12 to 20 percent slopes, severely eroded	VIe-2	4,250	B1c
MfE3	Marr fine sandy loam, 20 to 35 percent slopes, severely eroded	VIIe-2	1,090	B1c
MkA	Matapeake fine sandy loam, 0 to 2 percent slopes	I-5	100	B1a
MkB2	Matapeake fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-5	200	B1a
MmA	Matapeake silt loam, 0 to 2 percent slopes	I-4	390	B1a
MmB2	Matapeake silt loam, 2 to 5 percent slopes, moderately eroded	IIe-4	830	B1a

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
MmC2	Matapeake silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-4	400	B1a
MmC3	Matapeake silt loam, 5 to 10 percent slopes, severely eroded	IVe-3	230	B1a
MmD3	Matapeake silt loam, 10 to 15 percent slopes, severely eroded	VIe-2	230	B1b
MnA	Matawan loamy fine sand, 0 to 2 percent slopes	IIw-10	230	E2a
MnB	Matawan loamy fine sand, 2 to 5 percent slopes	IIe-36	420	E2a
MpA	Mattapex fine sandy loam, 0 to 2 percent slopes	IIw-5	130	E3a
MpB2	Mattapex fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-36	220	E3a
MrA	Mattapex silt loam, 0 to 2 percent slopes	IIw-1	2,230	E3a
MrB2	Mattapex silt loam, 2 to 5 percent slopes, moderately eroded	IIe-16	1,740	E3a
MrC2	Mattapex silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-16	420	E3a
Mt	Mixed alluvial land	VIw-1	4,350	G2
MuA	Monmouth loamy sand, 0 to 2 percent slopes	IIs-5	340	B2a
MuB2	Monmouth loamy sand, 2 to 5 percent slopes, moderately eroded	IIs-5	4,520	B2a
MuC2	Monmouth loamy sand, 5 to 10 percent slopes, moderately eroded	IIIe-5	990	B2a
MuC3	Monmouth loamy sand, 5 to 10 percent slopes, severely eroded	IVe-5	950	B2a
MuD2	Monmouth loamy sand, 10 to 15 percent slopes, moderately eroded	IVe-5	450	B2b
MuD3	Monmouth loamy sand, 10 to 15 percent slopes, severely eroded	VIe-2	570	B2b
MvA	Monmouth fine sandy loam, 0 to 2 percent slopes	I-23	460	B2a
MvB2	Monmouth fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-28	3,780	B2a
MvC2	Monmouth fine sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-28	870	B2a
MvD2	Monmouth fine sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-5	750	B2b
MvE	Monmouth fine sandy loam, 15 to 40 percent slopes	VIe-2	7,790	B2c
MwC3	Monmouth clay loam, 5 to 10 percent slopes, severely eroded	IVe-3	2,340	B2a
MwD3	Monmouth clay loam, 10 to 15 percent slopes, severely eroded	VIe-2	1,040	B2b
MxB	Monmouth-Urban land complex, 0 to 5 percent slopes	-----	2,020	B2a
MxD	Monmouth-Urban land complex, 5 to 15 percent slopes	-----	830	B2b
MyB	Muirkirk loamy sand, 0 to 5 percent slopes	IIs-5	2,490	B3
MyC	Muirkirk loamy sand, 5 to 10 percent slopes	IIIe-5	330	B3
MyD	Muirkirk loamy sand, 10 to 15 percent slopes	IVe-5	410	B3
MyE	Muirkirk loamy sand, 15 to 30 percent slopes	VIIe-2	260	B3
MzB	Muirkirk-Urban land complex, 0 to 5 percent slopes	-----	870	B3
MzD	Muirkirk-Urban land complex, 5 to 15 percent slopes	-----	280	B3
Os	Osier loamy sand	IVw-6	390	F1
Ot	Othello silt loam	IIIw-7	4,040	F3
RuA	Rumford loamy sand, 0 to 2 percent slopes	IIs-4	1,050	A1a
RuB2	Rumford loamy sand, 2 to 5 percent slopes, moderately eroded	IIs-4	8,500	A1a
RuC2	Rumford loamy sand, 5 to 10 percent slopes, moderately eroded	IIIe-33	1,540	A1a
RuC3	Rumford loamy sand, 5 to 10 percent slopes, severely eroded	IVe-5	1,420	A1a
RuD2	Rumford loamy sand, 10 to 15 percent slopes, moderately eroded	IVe-5	490	A1b
RyB	Rumford-Urban land complex, 0 to 5 percent slopes	-----	1,350	A1a
RyD	Rumford-Urban land complex, 5 to 15 percent slopes	-----	330	A1b
SaA	Sassafras fine sandy loam, 0 to 2 percent slopes	I-5	1,220	B1a
SaB2	Sassafras fine sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-5	7,170	B1a
SaC2	Sassafras fine sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-5	920	B1a
SaC3	Sassafras fine sandy loam, 5 to 10 percent slopes, severely eroded	IVe-5	1,990	B1a
SaD2	Sassafras fine sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-5	460	B1b
SaD3	Sassafras fine sandy loam, 10 to 15 percent slopes, severely eroded	VIe-2	1,590	B1b

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
SaE	Sassafras fine sandy loam, 15 to 40 percent slopes	VIe-2	1,910	Blc
SfA	Sassafras loam, 0 to 2 percent slopes	I-4	240	Bla
SfB2	Sassafras loam, 2 to 5 percent slopes, moderately eroded	IIe-4	1,010	Bla
SnB	Sassafras-Urban land complex, 0 to 5 percent slopes	-----	350	Bla
SnD	Sassafras-Urban land complex, 5 to 15 percent slopes	-----	310	Blb
Sr	Shrewsbury fine sandy loam	IIIw-6	1,310	F2
Ss	Shrewsbury silt loam	IIIw-7	520	F2
Sw	Swamp	VIIw-1	65	G3
Tm	Tidal marsh	VIIIw-1	3,400	G3
Ur	Urban land	-----	690	Ma
WaB2	Westphalia fine sandy loam, 2 to 6 percent slopes, moderately eroded	IIe-5	1,320	Bla
WaC2	Westphalia fine sandy loam, 6 to 12 percent slopes, moderately eroded	IIIe-5	510	Blb
WaC3	Westphalia fine sandy loam, 6 to 12 percent slopes, severely eroded	IVe-5	3,210	Blb
WaD3	Westphalia fine sandy loam, 12 to 20 percent slopes, severely eroded	VIe-2	4,470	Blc
WaE3	Westphalia fine sandy loam, 20 to 50 percent slopes, severely eroded	VIIe-2	5,130	Blc
WdA	Woodstown sandy loam, 0 to 2 percent slopes	IIw-5	830	El
WdB	Woodstown sandy loam, 2 to 5 percent slopes	IIe-36	1,260	El
WoA	Woodstown loam, 0 to 2 percent slopes	IIw-1	250	El
WoB	Woodstown loam, 2 to 5 percent slopes	IIe-16	250	El
		-----	2,640	Ma
		Total -	266,880	

BALTIMORE COUNTY

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
AdA	Aldino silt loam, 0 to 3 percent slopes	IIw-2	380	E2a
AdB2	Aldino silt loam, 3 to 8 percent slopes, moderately eroded	IIe-14	2,170	E2a
AdC2	Aldino silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-14	370	E2b
AsC	Aldino very stony silt loam, 0 to 15 percent slopes	VIs-3	190	H1b
AuB	Aldino-Urban land complex, 0 to 8 percent slopes	----	1,020	E2a
Av	Alluvial land	VIw-1	5,170	G2
BaA	Baile silt loam, 0 to 3 percent slopes	Vw-1	2,030	F3
BaB	Baile silt loam, 3 to 8 percent slopes	VIw-2	1,820	F3
BmA	Baltimore silt loam, 0 to 3 percent slopes	I-1	560	B1a
BmB2	Baltimore silt loam, 3 to 8 percent slopes, moderately eroded	IIe-1	6,590	B1a
BmC2	Baltimore silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-1	1,480	B1b
Bnd	Baltimore-Urban land complex, 0 to 8 percent slopes	----	330	B1a
Br	Barclay silt loam	IIIw-1	1,680	F2
BtA	Beltsville silt loam, 0 to 2 percent slopes	IIw-8	390	E2a
BtB	Beltsville silt loam, 2 to 5 percent slopes	IIe-13	3,350	E2a
BtC2	Beltsville silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-13	1,150	E2a
BuB	Beltsville-Urban land complex, 0 to 5 percent slopes	----	1,670	E2a
BuC	Beltsville-Urban land complex, 5 to 10 percent slopes	----	450	E2a
BwB2	Brandywine loam, 3 to 8 percent slopes, moderately eroded	IIe-10	790	C1a
BwC2	Brandywine loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	1,700	C1b
ByD2	Brandywine gravelly loam, 15 to 25 percent slopes, moderately eroded	IVe-10	1,000	C1c
ByD3	Brandywine gravelly loam, 15 to 25 percent slopes, severely eroded	VIe-3	690	C1c
ByE	Brandywine gravelly loam, 25 to 45 percent slopes	VIe-3	890	C1c
CaA	Captina silt loam, 0 to 3 percent slopes	IIw-1	420	E2a
CaB2	Captina silt loam, 3 to 8 percent slopes, moderately eroded	IIe-16	620	E2a
CcA	Chester silt loam, 0 to 3 percent slopes	I-4	330	B1a
CcB2	Chester silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	18,020	B1a
CcC2	Chester silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	3,490	B1b
CgB2	Chester gravelly silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	3,160	B1a
CgC2	Chester gravelly silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	2,720	B1b
ChB2	Chillum silt loam, 2 to 5 percent slopes, moderately eroded	IIs-7	1,340	B2a
ChC2	Chillum silt loam, 5 to 10 percent slopes, moderately eroded	IIIe-7	610	B2a
ChC3	Chillum silt loam, 5 to 10 percent slopes, severely eroded	IVe-7	190	B2a
CkB2	Chillum-Neshaminy silt loams, 2 to 5 percent slopes, moderately eroded	IIs-7	690	B2a
CkC2	Chillum-Neshaminy silt loams, 5 to 10 percent slopes, moderately eroded	IIIe-7	570	B2a
CkD2	Chillum-Neshaminy silt loams, 10 to 15 percent slopes, moderately eroded	IVe-7	250	B2b
ClB	Chillum-Urban land complex, 0 to 5 percent slopes	----	1,450	B2a
ClD	Chillum-Urban land complex, 5 to 15 percent slopes	----	1,030	B2b

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
CmB	Christiana loam, 2 to 5 percent slopes	IIe-42	740	B3
CmC2	Christiana loam, 5 to 10 percent slopes, moderately eroded	IIIe-42	480	B3
CnB2	Chrome silt loam, 3 to 8 percent slopes, moderately eroded	IIe-10	280	C1a
CoC3	Chrome channery silty clay loam, 3 to 15 percent slopes, severely eroded	VIs-32	1,010	C1b
CoE3	Chrome channery silty clay loam, 15 to 45 percent slopes, severely eroded	VIIs-32	610	C1c
Cp	Clay pits	VIIIs-4	110	---
Ct	Coastal beaches	VIIIs-2	60	A2
Cu	Codorus silt loam	IIw-7	9,200	G1
Cv	Comus silt loam	I-6	810	G1
CwB2	Conestoga loam, 3 to 8 percent slopes, moderately eroded	IIIe-24	4,700	B1a
CwC2	Conestoga loam, 8 to 15 percent slopes, moderately eroded	IIIe-24	2,140	B1b
DcB	Delanco silt loam, 3 to 8 percent slopes	IIe-16	940	E2a
Du	Dunning silt loam	IVw-3	630	G2
EdB2	Edgemont gravelly loam, 3 to 8 percent slopes, moderately eroded	IIe-4	200	B1a
EdC2	Edgemont gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	280	B1b
EgD	Edgemont very stony loam, 8 to 25 percent slopes	VIs-3	360	H1c
EgE	Edgemont very stony loam, 25 to 45 percent slopes	VIIs-3	440	H1c
EhB2	Elioak silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	4,180	B1a
EhC2	Elioak silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	510	B1b
EkE2	Elioak gravelly silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	450	B1a
EkC2	Elioak gravelly silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	250	B1b
ElC3	Elioak silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-3	190	B1b
Em	Elkton loam	IIIw-9	290	F3
En	Elkton silt loam	IIIw-9	640	F3
Eo	Elkton-Urban land complex	---	220	F3
EsB	Elsinboro loam, 3 to 8 percent slopes	IIe-4	1,270	B1a
EsC2	Elsinboro loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	450	B1b
Fa	Fallsington sandy loam	IIIw-6	600	F2
Fs	Fallsington loam	IIIw-7	920	F2
FtB	Fort Mott loamy sand, 0 to 5 percent slopes	IIs-4	570	A1a
GaB	Galestown loamy sand, 0 to 5 percent slopes	IIIs-1	230	A1a
GaC	Galestown loamy sand, 5 to 10 percent slopes	IVs-1	160	A1a
GcB2	Glenelg loam, 3 to 8 percent slopes, moderately eroded	IIe-4	24,400	B1a
GcC2	Glenelg loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	17,850	B1b
GcC3	Glenelg loam, 8 to 15 percent slopes, severely eroded	IVe-3	2,030	B1b
GcD2	Glenelg loam, 15 to 25 percent slopes, moderately eroded	IVe-3	1,440	B1c
GcD3	Glenelg loam, 15 to 25 percent slopes, severely eroded	VIe-3	740	B1c
GgB2	Glenelg channery loam, 3 to 8 percent slopes, moderately eroded	IIe-4	2,070	B1a
GgC2	Glenelg channery loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	5,180	B1b
GgD2	Glenelg channery loam, 15 to 25 percent slopes, moderately eroded	IVe-3	1,740	B1c

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
GgD3	Glenelg channery loam, 15 to 25 percent slopes, severely eroded	VIe-3	1,120	Blc
GlB	Gleneig-Urban land complex, 0 to 8 percent slopes	----	3,210	Bla
GlC	Gleneig-Urban land complex, 8 to 15 percent slopes	----	1,370	Blb
GnA	Glenville silt loam, 0 to 3 percent slopes	IIw-1	1,900	E2a
GnB	Glenville silt loam, 3 to 8 percent slopes	IIe-16	12,030	E2a
GuB	Glenville-Urban land complex, 0 to 8 percent slopes	---	390	E2a
HaA	Hagerstown silt loam, 0 to 3 percent slopes	I-1	280	Bla
HaB2	Hagerstown silt loam, 3 to 8 percent slopes, moderately eroded	IIe-1	1,410	Bla
HaC2	Hagerstown silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-1	430	Blb
Hb	Hatboro silt loam	IIIw-7	4,160	G2
HoB2	Hollinger loam, 3 to 8 percent slopes, moderately eroded	IIe-25	360	Bla
HoC2	Hollinger loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	500	Blb
HrD3	Hollinger and Conestoga loams, 15 to 25 percent slopes, severely eroded	VIe-3	360	Blc
HsC	Hollinger and Conestoga very rocky loams, 3 to 15 percent slopes	VIs-2	550	H2b
lu	luka silt loam	IIw-7	530	Gl
JpB	Joppa gravelly sandy loam, 2 to 5 percent slopes	IIs-4	960	Ala
JpC2	Joppa gravelly sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-33	1,370	Ala
JpD2	Joppa gravelly sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-5	490	Alb
JuD	Joppa-Urban land complex, 5 to 15 percent slopes	----	1,510	Alb
KeB2	Kelly silt loam, 3 to 8 percent slopes, moderately eroded	IVw-3	890	F3
KeC2	Kelly silt loam, 8 to 15 percent slopes, moderately eroded	IVw-3	240	F3
KsC	Kelly very stony silt loam, 0 to 15 percent slopes	VIIs-4	240	Hlb
KuB	Xelly-Urban land complex, 0 to 8 percent slopes	---	300	F3
LeB2	Legore silt loam, 3 to 8 percent slopes, moderately eroded	IIe-10	1,170	Bla
LeC2	Legore silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	1,310	Blb
LeD2	Legore silt loam, 15 to 25 percent slopes, moderately eroded	IVe-10	770	Blc
LeE	Legore silt loam, 25 to 45 percent slopes	VIe-3	430	Blc
LfC	Legore very stony silt loam, 3 to 15 percent slopes	VIs-3	1,650	Hlb
LfD	Legore very stony silt loam, 15 to 25 percent slopes	VIs-33	1,140	Hlc
LfE	Legore very stony silt loam, 25 to 45 percent slopes	VIIs-3	1,290	Hlc
LgC3	Legore silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-10	750	Blb
LgD3	Legore silty clay loam, 15 to 25 percent slopes, severely eroded	VIe-3	690	Blc
LhB	Legore-Urban land complex, 0 to 8 percent slopes	----	3,260	Bla
LhC	Legore-Urban land complex, 8 to 15 percent slopes	----	1,800	Blb
LlB	Lenoir loam, 0 to 5 percent slopes	IIIw-5	940	F3
LmB	Lenoir silt loam, 0 to 5 percent slopes	IIIw-5	2,140	F3
LmC2	Lenoir silt loam, 5 to 12 percent slopes, moderately eroded	IIIe-34	270	F3
LnC3	Lenoir silty clay loam, 5 to 12 percent slopes, severely eroded	IVe-9	280	F3
LoB	Lenoir-Urban land complex, 0 to 5 percent	----	740	F3
Lr	Leonardtown silt loam	IVw-3	560	F3
Ls	Lindside silt loam	IIw-7	510	Gl
LyB	Loamy and clayey land, 0 to 5 percent slopes	IIIe-42	3,460	B3

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
LyD	Loamy and clayey land, 5 to 15 percent slopes	VIe-2	6,570	B3
LyE	Loamy and clayey land, 15 to 40 percent slopes	VIIe-2	590	B3
Ma	Made land	----	3,600	Ma
MbB2	Manor loam, 3 to 8 percent slopes, moderately eroded	IIe-25	8,810	B1a
MbC2	Manor loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	20,090	B1b
MbC3	Manor loam, 8 to 15 percent slopes, severely eroded	IVe-25	3,360	B1b
MbD2	Manor loam, 15 to 25 percent slopes, moderately eroded	IVe-3	6,830	B1c
MbD3	Manor loam, 15 to 25 percent slopes, severely eroded	VIe-3	6,830	B1c
McB2	Manor channery loam, 3 to 8 percent slopes, moderately eroded	IIe-25	3,140	B1a
McC2	Manor channery loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	12,270	B1b
McC3	Manor channery loam, 8 to 15 percent slopes, severely eroded	IVe-25	2,010	B1b
McD2	Manor channery loam, 15 to 25 percent slopes, moderately eroded	IVe-25	11,700	B1c
McD3	Manor channery loam, 15 to 25 percent slopes, severely eroded	VIe-3	8,300	B1c
MdE	Manor soils, 25 to 50 percent slopes	VIe-3	16,310	B1c
MeD	Manor-Urban land complex, 15 to 25 percent slopes	----	350	B1c
MgC	Manor and Glenelg very stony loams, 3 to 15 percent slopes	VIs-3	570	H1b
MhD	Manor and Brandywine very stony loams, 15 to 25 percent slopes	VIs-3	1,000	H1c
MhE	Manor and Brandywine very stony loams, 25 to 65 percent slopes	VIIs-3	8,000	H1c
MkA	Matapeake silt loam, 0 to 2 percent slopes	I-4	240	B1a
MkB	Matapeake silt loam, 2 to 5 percent slopes	IIe-4	670	B1a
MkC2	Matapeake silt loam, 5 to 12 percent slopes, moderately eroded	IIIe-4	260	B1a
MIA	Mattapex silt loam, 0 to 2 percent slopes	IIw-1	1,940	E3a
MIB	Mattapex silt loam, 2 to 5 percent slopes	IIe-16	3,170	E3a
MmB	Mattapex-Urban land complex, 0 to 5 percent slopes	----	3,740	E3a
Mh	Melvin silt loam	IIIw-3	330	G2
Mo	Melvin silt loam, local alluvium	IIIw-3	1,210	G2
Mr	Mine dumps and quarries	VIIIs-4	120	--
MsB2	Montalto silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	1,690	B2a
MsC2	Montalto silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	390	B2b
MtB2	Mt. Airy channery loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	380	C1a
MtC2	Mt. Airy channery loam, 8 to 15 percent slopes, moderately eroded	IVe-10	1,690	C1b
MtD2	Mt. Airy channery loam, 15 to 25 percent slopes, moderately eroded	VIe-3	1,440	C1c
MtD3	Mt. Airy channery loam, 15 to 25 percent slopes, severely eroded	VIIe-3	1,250	C1c
NeB2	Neshaminy silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	2,730	B1a
NeC2	Neshaminy silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	950	B1b
Ot	Othello silt loam	IIIw-7	820	F3
Po	Pocomoke sandy loam	IIIw-6	110	F2
ReC2	Relay silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	330	C1b
ReD2	Relay silt loam, 15 to 25 percent slopes, moderately eroded	IVe-10	150	C1c
RsD	Relay very stony silt loam, 3 to 25 percent slopes	VIs-3	230	H1c

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
RsE	Relay very stony silt loam, 25 to 65 percent slopes ----------	VIIs-3	640	H1c
RyD3	Relay clay loam, 15 to 25 percent slopes, severely eroded ----------	VIe-3	310	C1c
Sg	Sand and gravel pits ----------	VIIIs-4	1,240	---
ShA	Sassafras sandy loam, 0 to 2 percent slopes ----------	I-5	1,060	B1a
ShB	Sassafras sandy loam, 2 to 5 percent slopes ----------	IIe-5	2,970	B1a
ShC2	Sassafras sandy loam, 5 to 10 percent slopes, moderately eroded ----------	IIIe-5	610	B1a
ShC3	Sassafras sandy loam, 5 to 10 percent slopes, severely eroded ----------	IVe-5	210	B1a
ShD2	Sassafras sandy loam, 10 to 15 percent slopes, moderately eroded ----------	IVe-5	310	B1a
SIA	Sassafras loam, 0 to 2 percent slopes ----------	I-4	490	B1a
SIB	Sassafras loam, 2 to 5 percent slopes ----------	IIe-4	1,020	B1a
SIC2	Sassafras loam, 5 to 10 percent slopes, moderately eroded ----	IIIe-4	350	B1a
SnB	Sassafras-Urban land complex, 0 to 5 percent slopes ----------	----	5,170	B1a
SsD3	Sassafras and Joppa soils, 5 to 15 percent slopes, severely eroded ----------	VIe-2	640	B1b
SsE	Sassafras and Joppa soils, 15 to 30 percent slopes ----------	VIe-2	420	B1c
St	Stony land, steep ----------	VIIIs-1	1,670	H1c
SuB2	Sunnyside fine sandy loam, 0 to 5 percent slopes, moderately eroded ----------	IIe-5	250	B1a
Sw	Swamp ----------	VIIw-1	180	G3
Tm	Tidal marsh ----------	VIIIw-1	2,320	G3
WaA	Watchung silt loam, 0 to 3 percent slopes ----------	V-1	750	F3
WaB	Watchung silt loam, 3 to 8 percent slopes ----------	VIw-2	700	F3
WcB	Watchung very stony silt loam, 0 to 8 percent slopes ----------	VIIs-4	530	H1a
WdA	Woodstown sandy loam, 0 to 2 percent slopes ----------	IIw-5	1,810	E1
WdB	Woodstown sandy loam, 2 to 5 percent slopes ----------	IIe-36	1,090	E1
WoA	Woodstown loam, 0 to 2 percent slopes ----------	IIw-1	910	E1
WoB	Woodstown loam, 2 to 5 percent slopes ----------	IIe-16	650	E1
	Paved Areas ----------	----	540	---
	Total		390,400	

CARROLL COUNTY

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
ArA	Abbottstown and Readington silt loams, 0 to 3 percent slopes	IIIw-1	3,302	F3
ArB2	Abbottstown and Readington silt loams, 3 to 8 percent slopes, moderately eroded	IIIw-1	1,812	F3
BaA	Baile silt loam, 0 to 3 percent slopes	Vw-1	3,435	F3
BaB	Baile silt loam, 3 to 8 percent slopes	VIw-2	2,657	F3
Be	Bermudian silt loam	I-6	602	G1
BrA	Birdsboro silt loam, 0 to 3 percent slopes	I-4	325	B1a
BrB2	Birdsboro silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	424	B1a
Bs	Bowmansville silt loam	IIIw-7	544	G2
BuA	Bucks silt loam, 0 to 3 percent slopes	I-4	515	B2a
BuB2	Bucks silt loam, 0 to 8 percent slopes, moderately eroded	IIe-4	2,508	B2a
CaC2	Cardiff channery silt loam, 3 to 15 percent slopes, moderately eroded	IIIe-10	245	C1b
CeA	Chester silt loam, 0 to 3 percent slopes	I-4	500	B1a
CeB2	Chester silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	6,357	B1a
CeC2	Chester silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	759	B1b
CeC3	Chester silt loam, 8 to 15 percent slopes, severely eroded	IVe-3	165	B1b
Ch	Codorus silt loam	IIw-7	4,823	G1
Cm	Comus silt loam	I-6	256	G1
CnA	Comus silt loam, local alluvium, 0 to 3 percent slopes	I-6	231	G1
CnB	Comus silt loam, local alluvium, 3 to 8 percent slopes	IIe-6	1,232	G1
CoA	Conestoga silt loam, 0 to 3 percent slopes	I-1	232	B1a
CoB2	Conestoga silt loam, 3 to 8 percent slopes, moderately eroded	IIe-24	1,630	B1a
CoC2	Conestoga silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-24	793	B1b
CoC3	Conestoga silt loam, 8 to 15 percent slopes, severely eroded	IVe-1	145	B1b
CoD3	Conestoga silt loam, 15 to 25 percent slopes, severely eroded	VIe-1	191	B1c
DeA	Delanco silt loam, 0 to 3 percent slopes	IIw-1	332	E3a
DeB2	Delanco silt loam, 3 to 8 percent slopes, moderately eroded	IIe-16	386	E3a
ElB2	Elioak silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	1,179	B1a
ElC2	Elioak silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	335	B1b
EmD3	Elioak silty clay loam, 15 to 25 percent slopes, severely eroded	VIe-2	95	B1c
EnB2	Elsinboro gravelly loam, 3 to 8 percent slopes, moderately eroded	IIe-4	1,156	B1a
EnC2	Elsinboro gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	691	B1b
EsA	Elsinboro silt loam, 0 to 3 percent slopes	I-4	91	B1a
EsB2	Elsinboro silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	1,006	B1a
EsC2	Elsinboro silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	365	B1b

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
GcB2	Glenelg channery loam, 3 to 8 percent slopes, moderately eroded	IIe-4	11,405	B1a
GcC2	Glenelg channery loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	6,754	B1b
GcC3	Glenelg channery loam, 8 to 15 percent slopes, severely eroded	IVe-3	1,891	B1b
GcD2	Glenelg channery loam, 15 to 25 percent slopes, moderately eroded	IVe-3	1,093	B1c
GcD3	Glenelg channery loam, 15 to 25 percent slopes, severely eroded	VIe-2	1,330	B1c
GlA	Glenelg loam, 0 to 3 percent slopes	I-4	631	B1a
GlB2	Glenelg loam, 3 to 8 percent slopes, moderately eroded	IIe-4	12,991	B1a
GlB3	Glenelg loam, 3 to 8 percent slopes, severely eroded	IIIe-4	706	B1a
GlC2	Glenelg loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	5,299	B1b
GlC3	Glenelg loam, 8 to 15 percent slopes, severely eroded	IVe-3	2,062	B1b
GvA	Glenville silt loam, 0 to 3 percent slopes	IIw-2	2,477	E2a
GvB	Glenville silt loam, 3 to 8 percent slopes	IIe-13	8,015	E2a
HaA	Hagerstown silt loam, 0 to 3 percent slopes	I-1	98	B1a
HaB2	Hagerstown silt loam, 3 to 8 percent slopes, moderately eroded	IIe-1	999	B1a
HaC2	Hagerstown silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-1	131	B1b
Ht	Hatboro silt loam	IIIw-7	6,258	G2
KlB2	Klinesville gravelly loam, 3 to 8 percent slopes, moderately eroded	IVs-32	268	D1a
KsD4	Klinesville soils, 8 to 25 percent slopes, very severely eroded	VIIs-32	698	D1c
KsF3	Klinesville soils, 15 to 65 percent slopes, severely eroded	VIIs-32	2,165	D1c
LbB2	Lewisberry gravelly fine sandy loam, 3 to 8 percent slopes, moderately eroded	IIs-2	453	B1a
LbC2	Lewisberry gravelly fine sandy loam, 8 to 15 percent slopes, moderately eroded	IIIe-5	765	B1b
LbD	Lewisberry gravelly fine sandy loam, 15 to 25 percent slopes	IVe-5	161	B1c
Le	Lindside silt loam	IIw-7	842	G1
LnB2	Linganore channery silt loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	1,439	C1a
LnC2	Linganore channery silt loam, 8 to 15 percent slopes, moderately eroded	IVe-10	2,138	C1b
LnC3	Linganore channery silt loam, 8 to 15 percent slopes, severely eroded	VIe-3	427	C1b
LnD2	Linganore channery silt loam, 15 to 25 percent slopes, moderately eroded	VIe-3	1,168	C1c
LnE	Linganore channery silt loam, 25 to 45 percent slopes	VIIe-3	1,628	C1c
Md	Made land	-----	324	Ma
MgB2	Manor gravelly loam, 3 to 8 percent slopes, moderately eroded	IIe-25	2,473	B1a
MgC2	Manor gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	3,204	B1b
MgC3	Manor gravelly loam, 8 to 15 percent slopes, severely eroded	IVe-25	1,508	B1b
MgD2	Manor gravelly loam, 15 to 25 percent slopes, moderately eroded	IVe-25	983	B1c

Carroll Co.

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
MgD3	Manor gravelly loam, 15 to 25 percent slopes, severely eroded	VIe-3	1,641	Blc
MlB2	Manor loam, 0 to 8 percent slopes, moderately eroded	IIe-25	8,383	Bla
MlB3	Manor loam, 3 to 8 percent slopes, severely eroded	IIIe-25	2,381	Bla
MlC2	Manor loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	5,583	Blb
MlC3	Manor loam, 8 to 15 percent slopes, severely eroded	IVe-25	4,853	Blb
MlD2	Manor loam, 15 to 25 percent slopes, moderately eroded	IVe-25	1,817	Blc
MlD3	Manor loam, 15 to 25 percent slopes, severely eroded	VIe-3	3,874	Blc
MlE	Manor loam, 25 to 45 percent slopes	VIIe-3	3,791	Blc
MnC	Manor very stony loam, 3 to 15 percent slopes	VIs-3	1,418	Hlb
MnD	Manor very stony loam, 15 to 25 percent slopes	VIs-3	1,306	Hlc
MnE	Manor very stony loam, 25 to 45 percent slopes	VIIs-3	2,942	Hlc
MnF	Manor very stony loam, 45 to 75 percent slopes	VIIs-3	933	Hlc
Mo	Melvin silt loam	IIIw-3	270	G2
MtA	Mt. Airy channery loam, 0 to 3 percent slopes	IIIs-1	209	Cla
MtB2	Mt. Airy channery loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	19,291	Cla
MtC2	Mt. Airy channery loam, 8 to 15 percent slopes, moderately eroded	IVe-10	34,489	Clb
MtC3	Mt. Airy channery loam, 8 to 15 percent slopes, severely eroded	VIe-3	5,836	Clb
MtD2	Mt. Airy channery loam, 15 to 25 percent slopes, moderately eroded	VIe-3	13,635	Clc
MtE	Mt. Airy channery loam, 25 to 45 percent slopes	VIIe-3	22,182	Clc
PeB2	Penn loam, 0 to 8 percent slopes, moderately eroded	IIe-10	4,720	Cla
PhB2	Penn shaly silt loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	5,051	Dla
PhC2	Penn shaly silt loam, 8 to 15 percent slopes, moderately eroded	IVe-10	1,770	Dlb
PhC3	Penn shaly silt loam, 8 to 15 percent slopes, severely eroded	VIe-3	1,288	Dlb
PnA2	Penn silt loam, 0 to 3 percent slopes, moderately eroded	IIs-11	1,174	Cla
PnB2	Penn silt loam, 3 to 8 percent slopes, moderately eroded	IIe-10	10,209	Cla
PnC2	Penn silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	2,576	Clb
PnC3	Penn silt loam, 8 to 15 percent slopes, severely eroded	IVe-10	443	Clb
PoD	Penn soils, 15 to 25 percent slopes	VIe-3	860	Clc
PsB2	Penn-Steinsburg loams, 3 to 8 percent slopes, moderately eroded	IIe-10	612	Cla
PsC3	Penn-Steinsburg loams, 8 to 15 percent slopes, severely eroded	IVe-10	220	Clb
RaA	Raritan silt loam, 0 to 3 percent slopes	IIIw-1	417	E2a
RaB	Raritan silt loam, 3 to 8 percent slopes	IIIw-1	302	E2a
Ro	Rowland silt loam	IIw-7	1,359	Cl
StB2	Steinsburg channery loam, 3 to 8 percent slopes, moderately eroded	IIe-10	587	Cla
StD3	Steinsburg channery loam, 8 to 25 percent slopes, severely eroded	VIe-3	411	Clc
UrA	Urbana silt loam, 0 to 3 percent slopes	IIw-2	87	E2a
UrB2	Urbana silt loam, 3 to 8 percent slopes, moderately eroded	IIe-13	215	E2a
Ws	Wiltshire silt loam	IIw-2	122	E2a
			259,920	

HARFORD COUNTY

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
AdA	Aldino silt loam, 0 to 3 percent slopes	IIw-2	440	E2a
AdB	Aldino silt loam, 3 to 8 percent slopes	IIe-14	5,260	E2a
AdC	Aldino silt loam, 8 to 15 percent slopes	IIIe-14	360	E2b
AsB	Aldino very stony silt loam, 0 to 8 percent slopes	VIs-3	1,170	H1a
Av	Alluvial land	VIw-1	2,520	G2
BaA	Baile silt loam, 0 to 3 percent slopes	Vw-1	1,110	F3
BaB	Baile silt loam, 3 to 8 percent slopes	VIw-2	1,080	F3
BeA	Beltsville silt loam, 0 to 2 percent slopes	IIw-8	840	E2a
BeB	Beltsville silt loam, 2 to 5 percent slopes	IIe-13	2,060	E2a
BeC	Beltsville silt loam, 5 to 10 percent slopes	IIIe-13	610	E2a
BrC2	Brandywine gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	500	C1b
BrD3	Brandywine gravelly loam, 15 to 25 percent slopes, severely eroded	VIe-3	570	C1c
BrB3	Brandywine gravelly loam, 25 to 45 percent slopes, severely eroded	VIIe-3	180	C1c
CcA	Chester silt loam, 0 to 3 percent slopes	I-4	320	B1a
CcB2	Chester silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	23,765	B1a
CcC2	Chester silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	5,920	B1b
CgB2	Chester gravelly silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	4,330	B1a
CgC2	Chester gravelly silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	3,220	B1b
CgD2	Chester gravelly silt loam, 15 to 25 percent slopes, moderately eroded	IVe-3	610	B1c
ChB2	Chillum silt loam, 2 to 5 percent slopes, moderately eroded	IIs-7	1,670	B2a
CkC2	Chillum-Neshaminy silt loams, 5 to 10 percent slopes, moderately eroded	IIIe-7	630	B2a
CrE	Chrome shannery silty clay loam, 15 to 45 percent slopes	VIIs-32	340	C1c
Cu	Codorus silt loam	IIw-7	7,170	G1
Cv	Comus silt loam	I-6	890	G1
Cx	Cut and fill land	----	680	Ma
DcA	Delanco silt loam, 0 to 3 percent slopes	IIw-1	480	E3a
DcB	Delanco silt loam, 3 to 8 percent slopes	IIe-16	2,140	E3a
EhB2	Elioak silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	1,840	B1a
EhC2	Elioak silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	570	B1b
En	Elkton silt loam	IIIw-9	740	F3
EsA	Elsinboro loam, 0 to 2 percent slopes	I-4	400	B1a
EsB2	Elsinboro loam, 2 to 5 percent slopes, moderately eroded	IIe-4	1,420	B1a
EsC2	Elsinboro loam, 5 to 10 percent slopes, moderately eroded	IIIe-4	950	B1a
EvC	Evesboro loamy sand, 5 to 15 percent slopes	VIIs-1	100	B1a
Fs	Fallsington loam	IIIw-7	190	F2
GcB2	Glenelg loam, 3 to 8 percent slopes, moderately eroded	IIe-4	13,610	B1a
GcC2	Glenelg loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	14,490	B1b
GcC3	Glenelg loam, 8 to 15 percent slopes, severely eroded	IVe-3	1,220	B1b
GcD2	Glenelg loam, 15 to 25 percent slopes, moderately eroded	IVe-3	2,850	B1c
GcD3	Glenelg loam, 15 to 25 percent slopes, severely eroded	VIe-2	950	B1c
GgB2	Glenelg gravelly loam, 3 to 8 percent slopes, moderately eroded	IIe-4	2,200	B1a
GgC2	Glenelg gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	5,880	B1b
GgC3	Glenelg gravelly loam, 8 to 15 percent slopes, severely eroded	IVe-3	590	B1b

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
GgD2	Glenelg gravelly loam, 15 to 25 percent slopes, moderately eroded	IVe-3	2,960	B1c
GgD3	Glenelg gravelly loam, 15 to 25 percent slopes, severely eroded	VIe-2	1,290	B1c
GnA	Glenville silt loam, 0 to 3 percent slopes	IIw-1	2,200	E2a
GnB	Glenville silt loam, 3 to 8 percent slopes	IIe-16	8,170	E2a
Hb	Hatboro silt loam	IIIw-7	4,000	G2
JpB	Joppa gravelly sandy loam, 2 to 5 percent slopes	IIs-4	450	A1a
JpC	Joppa gravelly sandy loam, 5 to 10 percent slopes	IIIe-33	630	A1a
KeB	Kelly silt loam, 3 to 8 percent slopes	IVw-3	1,110	F3
KeC2	Kelly silt loam, 8 to 15 percent slopes, moderately eroded	IVw-3	350	F3
KfD	Kelly very stony silt loam, 3 to 25 percent slopes	VIIs-4	320	H1c
KpA	Keyport silt loam, 0 to 2 percent slopes	IIw-8	280	E2a
KpB	Keyport silt loam, 2 to 5 percent slopes	IIe-13	1,380	E2a
KrA	Kinkora silt loam, 0 to 3 percent slopes	Vw-1	210	F3
KrB	Kinkora silt loam, 3 to 8 percent slopes	VIw-2	170	F3
LeB2	Legore silt loam, 3 to 8 percent slopes, moderately eroded	IIe-10	1,010	B1a
LeC2	Legore silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	1,110	B1b
LeD2	Legore silt loam, 15 to 25 percent slopes, moderately eroded	IVe-10	1,690	B1c
LeE	Legore silt loam, 25 to 45 percent slopes	VIe-3	690	B1c
LfC	Legore very stony silt loam, 0 to 15 percent slopes	VIs-3	310	H1b
LfD	Legore very stony silt loam, 15 to 25 percent slopes	VIs-3	650	H1c
LfE	Legore very stony silt loam, 25 to 45 percent slopes	VIIs-3	680	H1c
LgC3	Legore silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-10	990	B1b
LgD3	Legore silty clay loam, 15 to 25 percent slopes, severely eroded	VIe-3	1,110	B1c
Lr	Leonardtown silt loam	IVw-3	440	F3
LyB	Loamy and clayey land, 0 to 5 percent slopes	IIIe-42	870	B3
LyD	Loamy and clayey land, 5 to 15 percent slopes	VIe-2	1,660	B3
LyE	Loamy and clayey land, 15 to 30 percent slopes	VIIe-2	220	B3
MbB2	Manor loam, 3 to 8 percent slopes, moderately eroded	IIe-25	4,190	B1a
MbC2	Manor loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	4,820	B1b
MbC3	Manor loam, 8 to 15 percent slopes, severely eroded	IVe-25	1,340	B1b
MbD2	Manor loam, 15 to 25 percent slopes, moderately eroded	IVe-25	5,320	B1c
MbD3	Manor loam, 15 to 25 percent slopes, severely eroded	VIe-3	3,230	B1c
McB2	Manor channery loam, 3 to 8 percent slopes, moderately eroded	IIe-25	1,330	B1a
McC2	Manor channery loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	5,090	B1b
McC3	Manor channery loam, 8 to 15 percent slopes, severely eroded	IVe-25	710	B1b
McD2	Manor channery loam, 15 to 25 percent slopes, moderately eroded	IVe-25	5,310	B1c
McD3	Manor channery loam, 15 to 25 percent slopes, severely eroded	VIe-3	3,550	B1c
MdE	Manor very stony loam, 25 to 45 percent slopes	VIIs-3	750	H1c
MfE	Manor soils, 25 to 45 percent slopes	VIe-3	7,530	B1c
MgC	Manor and Glenelg very stony loams, 3 to 15 percent slopes	VIs-3	1,500	H1b
MgD	Manor and Glenelg very stony loams, 15 to 25 percent slopes	VIs-3	1,600	H1c
MkA	Matapeake silt loam, 0 to 2 percent slopes	I-4	280	B1a
MkB	Matapeake silt loam, 2 to 5 percent slopes	IIe-4	730	B1a
MlA	Mattapex silt loam, 0 to 2 percent slopes	IIw-1	870	E3a
MlB	Mattapex silt loam, 2 to 5 percent slopes	IIe-16	1,250	E3a

Harford Co.

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
MsA	Montalto silt loam, 0 to 3 percent slopes	I-4	300	B2a
MsB2	Montalto silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	6,960	B2a
MsC2	Montalto silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	1,690	B2b
NeA	Neshaminy silt loam, 0 to 3 percent slopes	I-4	370	B1a
NeB2	Neshaminy silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	7,940	B1a
NeC2	Neshaminy silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	3,430	B1b
NsC	Neshaminy and Montalto very stony silt loams, 0 to 15 percent slopes	VIs-3	5,190	H1b
NsD	Neshaminy and Montalto very stony silt loams, 15 to 25 percent slopes	VIs-3	1,280	H1c
NsE	Neshaminy and Montalto very stony silt loams, 25 to 45 percent slopes	VIIs-3	630	H1c
Ot	Othello silt loam	IIIw-7	410	F3
Sa	Sand and gravel pits	VIIIs-4	570	---
ShB2	Sassafras sandy loam, 2 to 5 percent slopes, moderately eroded	IIe-5	360	B1a
ShC2	Sassafras sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-5	350	B1a
SlB2	Sassafras loam, 2 to 5 percent slopes, moderately eroded	IIe-4	440	B1a
SlC2	Sassafras loam, 5 to 10 percent slopes, moderately eroded	IIIe-4	410	B1a
SsD	Sassafras and Joppa soils, 10 to 15 percent slopes	IVe-5	330	B1b
SsE	Sassafras and Joppa soils, 15 to 30 percent slopes	VIe-2	410	B1c
St	Stony land, steep	VIIIs-1	1,020	H1c
Sw	Swamp	VIIw-1	140	G3
Tm	Tidal marsh	VIIIw-1	1,030	G3
WaA	Watchung silt loam, 0 to 3 percent slopes	Vw-1	1,190	F3
WaB	Watchung silt loam, 3 to 8 percent slopes	VIw-2	2,200	F3
WcB	Watchung very stony silt loam, 0 to 8 percent slopes	VIIs-4	2,870	H1a
WhB	Whiteford silt loam, 3 to 8 percent slopes	IIe-4	710	B1a
WhC2	Whiteford silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	500	B1b
WoB	Woodstown loam, 0 to 5 percent slopes	IIe-16	240	E1a
		Total Area Mapped	242,175	

Note: Unmapped area (U. S. Military Res.) 44,545

HOWARD COUNTY

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
AdB2	Aldino silt loam, 3 to 8 percent slopes, moderately eroded-----	IIe-13	213	E2a
AdC2	Aldino silt loam, 8 to 15 percent slopes, moderately eroded----	IIIe-13	98	E2b
AgB2	Aura gravelly loam, 1 to 5 percent slopes, moderately eroded---	IIs-7	170	B2a
AgC2	Aura gravelly loam, 5 to 10 percent slopes, moderately eroded--	IIIe-7	241	B2a
AgE3	Aura gravelly loam, 10 to 30 percent slopes, severely eroded---	VIIe-2	196	B2c
Ba	Baile silt loam---	Vw-1	3,318	F3
BeA	Beltsville silt loam, 0 to 1 percent slopes--------------------	IIw-8	108	E2a
BeB2	Beltsville silt loam, 1 to 5 percent slopes, moderately eroded--	IIe-13	1,383	E2a
BeC2	Beltsville silt loam, 5 to 10 percent slopes, moderately eroded--	IIIe-13	557	E2a
BeC3	Beltsville silt loam, 5 to 10 percent slopes, severely eroded--	IVe-9	465	E2a
BeD2	Beltsville silt loam, 10 to 15 percent slopes, moderately eroded--	IVe-9	327	E2b
BrB2	Brandywine loam, 3 to 8 percent slopes, moderately eroded------	IIe-10	883	C1a
BrC2	Brandywine loam, 8 to 15 percent slopes, moderately eroded-----	IIIe-10	898	C1b
BrC3	Brandywine loam, 8 to 15 percent slopes, severely eroded-------	IVe-10	712	C1b
BrD2	Brandywine loam, 15 to 25 percent slopes, moderately eroded----	IVe-10	420	C1c
BrD3	Brandywine loam, 15 to 25 percent slopes, severely eroded------	VIe-3	799	C1c
BrF	Brandywine loam, 25 to 60 percent slopes----------------------	---	1,052	C1c
	North aspect---	VIIe-3		
	South aspect---	VIIe-3		
BvD	Brandywine very stony loam, 3 to 25 percent slopes------------	VIs-3	142	H1c
CgB2	Chester gravelly silt loam, 3 to 8 percent slopes, moderately eroded--	IIe-4	3,536	B1a
CgC2	Chester gravelly silt loam, 8 to 15 percent slopes, moderately eroded--	IIIe-4	2,530	B1b
ChA	Chester silt loam, 0 to 3 percent slopes----------------------	I-4	2,409	B1a
ChB2	Chester silt loam, 3 to 8 percent slopes, moderately eroded----	IIe-4	14,577	B1a
ChC2	Chester silt loam, 8 to 15 percent slopes, moderately eroded---	IIIe-4	2,875	B1b
ChC3	Chester silt loam, 8 to 15 percent slopes, severely eroded-----	IVe-3	719	B1b
ChD2	Chester silt loam, 15 to 25 percent slopes, moderately eroded--	IVe-3	802	B1c
ClC3	Chillum gravelly loam, 5 to 10 percent slopes, severely eroded--	IVe-7	447	B2a
ClD2	Chillum gravelly loam, 10 to 15 percent slopes, moderately eroded--	IVe-7	304	B2b
ClE2	Chillum gravelly loam, 15 to 30 percent slopes, moderately eroded--	VIe-2	140	B2c
CmB2	Chillum silt loam, 1 to 5 percent slopes, moderately eroded----	IIs-7	882	B2a
CmC2	Chillum silt loam, 5 to 10 percent slopes, moderately eroded---	IIIe-7	265	B2a
CnB2	Chillum-Fairfax loams, 1 to 5 percent slopes, moderately eroded--	IIs-7	323	B2a
CnD3	Chillum-Fairfax loams, 5 to 15 percent slopes, severely eroded--	VIe-2	401	B2b
Co	Codorus silt loam---	IIw-7	3,873	G1
Cs	Comus silt loam---	I-6	697	G1
CuB	Comus silt loam, local alluvium, 3 to 8 percent slopes---------	IIe-6	1,199	G1
DeA	Delanco silt loam, 0 to 3 percent slopes----------------------	IIw-1	138	E3a
DeB2	Delanco silt loam, 3 to 8 percent slopes, moderately eroded----	IIe-16	241	E3a
EkA	Elioak silt loam, 0 to 3 percent slopes-----------------------	I-4	401	B1a
EkB2	Elioak silt loam, 3 to 8 percent slopes, moderately eroded-----	IIe-4	2,779	B1a
EkC2	Elioak silt loam, 8 to 15 percent slopes, moderately eroded----	IIIe-4	987	B1b
EkD2	Elioak silt loam, 15 to 25 percent slopes, moderately eroded---	IVe-3	134	B1c

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
ElC3	Elioak silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-3	411	B1b
ElD3	Elioak silty clay loam, 15 to 25 percent slopes, severely eroded	VIe-2	126	B1c
Em	Elkton silt loam	IIIw-9	94	F3
EnA	Elsinboro loam, 0 to 3 percent slopes	I-4	136	B1a
EnB2	Elsinboro loam, 3 to 8 percent slopes, moderately eroded	IIe-4	356	B1a
EnC2	Elsinboro loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	156	B1b
EvB	Evesboro loamy sand, 1 to 5 percent slopes	IVs-1	146	A1a
EvC	Evesboro loamy sand, 5 to 15 percent slopes	VIIs-1	258	A1b
Fa	Fallsington loam	IIIw-7	356	F2
GlA	Glenelg loam, 0 to 3 percent slopes	I-4	508	B1a
GlB2	Glenelg loam, 3 to 8 percent slopes, moderately eroded	IIe-4	15.616	B1a
GlC2	Glenelg loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	7.835	B1b
GlC3	Glenelg loam, 8 to 15 percent slopes, severely eroded	IVe-3	2.777	B1b
GlD2	Glenelg loam, 15 to 25 percent slopes, moderately eroded	IVe-3	1,290	B1c
GlD3	Glenelg loam, 15 to 25 percent slopes, severely eroded	VIe-2	928	B1c
GnA	Glenville silt loam, 0 to 3 percent slopes	IIw-8	1.724	E2a
GnB2	Glenville silt loam, 3 to 8 percent slopes, moderately eroded	IIe-13	5,266	E2a
GnC2	Glenville silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-13	146	E2b
Gp	Gravel pits and quarries	VIIIs-4	229	Bp
Ha	Hatboro silt loam	IIIw-7	3,381	G2
IuB	Iuka loam, local alluvium, 1 to 5 percent slopes	IIe-16	692	G1
KcE3	Kelly clay loam, 15 to 30 percent slopes, severely eroded	VIIe-2	131	F3
KeB2	Kelly silt loam, 3 to 8 percent slopes, moderately eroded	IVw-3	386	F3
KeC2	Kelly silt loam, 8 to 15 percent slopes, moderately eroded	IVw-3	145	F3
KhC2	Keyport silt loam, 3 to 10 percent slopes, moderately eroded	IIIe-13	124	E2a
Kn	Kinkora silt loam	Vw-1	144	F3
LeB2	Legore silt loam, 3 to 8 percent slopes, moderately eroded	IIe-10	380	B1a
LeC2	Legore silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-10	143	B1b
LgC3	Legore silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-10	150	B1b
Ll	Leonardtown silt loam	IVw-3	480	F3
LnB2	Linganore channery loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	212	C1a
LnC2	Linganore channery loam, 8 to 15 percent slopes, moderately eroded	IVe-10	391	C1b
LnD2	Linganore channery loam, 15 to 25 percent slopes, moderately eroded	VIe-3	148	C1c
LoE	Linganore channery silt loam, 25 to 45 percent slopes	---	142	C1c
	North aspect	VIIe-3		
	South aspect	VIIe-3		
Md	Made land	---	497	Ma
MgB2	Manor gravelly loam, 3 to 8 percent slopes, moderately eroded	IIe-25	1,863	B1a
MgC2	Manor gravelly loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	3,137	B1b
MgC3	Manor gravelly loam, 8 to 15 percent slopes, severely eroded	IVe-25	913	B1b
MlA	Manor loam, 0 to 3 percent slopes	IIs-25	284	B1a
MlB2	Manor loam, 3 to 8 percent slopes, moderately eroded	IIe-25	4,902	B1a
MlC2	Manor loam, 8 to 15 percent slopes, moderately eroded	IIIe-25	4,967	B1b
MlC3	Manor loam, 8 to 15 percent slopes, severely eroded	IVe-25	4,019	B1b
MlD2	Manor loam, 15 to 25 percent slopes, moderately eroded	IVe-25	3,927	B1c
MlD3	Manor loam, 15 to 25 percent slopes, severely eroded	VIe-3	5,005	B1c
MlE	Manor loam, 25 to 45 percent slopes	VIIe-3	3,105	B1c
MnD	Manor very stony loam, 3 to 25 percent slopes	VIs-3	1,239	H1c
MnF	Manor very stony loam, 25 to 60 percent slopes	VIIs-3	1,759	H1c
Mo	Mixed alluvial land	VIw-1	416	G2
MpB2	Montalto silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	628	B2a
MpC2	Montalto silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	193	B2a

Howard Co.

MAP SYMBOL	MAPPING UNIT	CAPABILITY UNIT SYMBOL	ACRES	NATURAL SOIL GROUP
MgC3	Montalto silty clay loam, 8 to 15 percent slopes, severely eroded	IVe-3	123	B2b
MrE	Montalto and Relay soils, 15 to 45 percent slopes	VIe-2	630	B2c
MsD	Montalto and Relay very stony silt loams, 3 to 25 percent slopes	VIs-3	721	H1c
MsF	Montalto and Relay very stony silt loams, 25 to 60 percent slopes	VIIs-3	590	H1c
MtB2	Mt. Airy channery loam, 3 to 8 percent slopes, moderately eroded	IIIe-10	3,084	C1a
MtC2	Mt. Airy channery loam, 8 to 15 percent slopes, moderately eroded	IVe-10	4,590	C1b
MtC3	Mt. Airy channery loam, 8 to 15 percent slopes, severely eroded	VIe-3	1,706	C1b
MtD2	Mt. Airy channery loam, 15 to 25 percent slopes, moderately eroded	VIe-3	3,831	C1c
MtE	Mt. Airy channery loam, 25 to 45 percent slopes	---	1,747	C1c
	North aspect	VIIe-3		
	South aspect	VIIe-3		
NeB2	Neshaminy silt loam, 3 to 8 percent slopes, moderately eroded	IIe-4	957	B1a
NeC2	Neshaminy silt loam, 8 to 15 percent slopes, moderately eroded	IIIe-4	595	B1b
NsD3	Neshaminy silty clay loam, 15 to 25 percent slopes, severely eroded	VIe-2	224	B1c
ReC2	Relay silt loam, 3 to 15 percent slopes, moderately eroded	IIIe-10	209	C1b
RuB2	Rumford loamy sand, 1 to 5 percent slopes, moderately eroded	IIs-4	82	A1a
RuC2	Rumford loamy sand, 5 to 10 percent slopes, moderately eroded	IIIe-33	127	A1a
RuD2	Rumford loamy sand, 10 to 15 percent slopes, moderately eroded	IVe-5	90	A1b
ScB	Sandy and clayey land, gently sloping	IIIe-41	360	B3
ScC	Sandy and clayey land, moderately sloping	VIe-2	795	B3
ScE	Sandy and clayey land, moderately steep	VIIe-2	338	B3
SfB2	Sassafras gravelly sandy loam, 1 to 5 percent slopes, moderately eroded	IIe-5	482	B1a
SfC2	Sassafras gravelly sandy loam, 5 to 10 percent slopes, moderately eroded	IIIe-5	723	B1a
SfD2	Sassafras gravelly sandy loam, 10 to 15 percent slopes, moderately eroded	IVe-5	295	B1b
SlB2	Sassafras loam, 1 to 5 percent slopes, moderately eroded	IIe-4	532	B1a
SlC2	Sassafras loam, 5 to 10 percent slopes, moderately eroded	IIIe-4	432	B1a
SlD2	Sassafras loam, 10 to 15 percent slopes, moderately eroded	IVe-3	222	B1b
SsE	Sassafras soils, 15 to 40 percent slopes	VIe-2	348	B1c
St	Stony land	VIIIs-1	347	H1
SuB2	Sunnyside fine sandy loam, 1 to 5 percent slopes, moderately eroded	IIe-5	62	B1a
SuD2	Sunnyside fine sandy loam, 5 to 15 percent slopes, moderately eroded	IVe-5	111	B1b
WaA	Watchung silt loam, 0 to 3 percent slopes	Vw-1	341	F3
WaB	Watchung silt loam, 3 to 8 percent slopes	VIw-2	214	F3
WoB2	Woodstown sandy loam, 1 to 5 percent slopes, moderately eroded	IIe-36	190	E1

TOTAL 160,640

APPENDIX E

Maps for Detailing Site Conditions

Maps for Detailing Existing Site Conditions in an Urban Retrofit Assessment

Map Type	Use(s)	Scale(s)	Source(s)
Aerial Photography	Land Use Types, Vegetation, Parks & Open Space, Erosion	>= 1" = 2000'	Private Aerial Survey Companies Local Government Contract Surveys Department of State Planning
Flood Plain	Topography, landforms, slopes, Receiving Waters	>= 1" = 2000'	Local Watershed Surveys State Watershed Surveys S.C.S. Mapping Surveys
Geologic	Landforms, Soils, Subsurface Conditions	>= 1" = 1 mile	Maryland Geologic Survey US Geologic Survey
Highway	Land Uses, Boundaries, Potential Problem Areas	>= 1" = 2000'	Maryland State Highway Admin. Local Highway Depts.
Land Use	Land Uses, Parks & Open Space	>= 1" = 2000'	Local Planning & Zoning Depts.
Natural Resources	Vegetation, Parks, Open Space	>= 1" = 1 mile	State Forest & Park Service Maryland Geologic Survey Local Government Depts.
Park & Open Space	Land Uses, Parks, Open Space	>= 1" = 2000'	Department of State Planning Local Parks & Recreation Depts. State Dept. of Natural Resources
Plat	Land Uses	>= 1" = 1000'	Local Public Works Depts.
Recreation	Land Uses, Parks, Open Space	>= 1" = 1000'	Local Parks & Recreation Depts. Department of State Planning
Soils	Soil Physical & Chemical Characteristics, Slope, Hydrologic conditions, Vegetation	>= 1" = 1320'	SCS Soil Surveys of Local Jurisdictions
Storm Drain Systems (Plan & Profile)	Storm Drainage Patterns, Land Uses, Drainage Boundaries	>= 1" = 500'	Subdivision Plans (Public Works) Public Works Dept. Projects Utilities Depts. Projects Local & State Highway Dept. Projects
Tax	Land Uses, Public Lands, Boundaries	>= 1" = 660'	Local Tax Assessors' Offices
Topographic	Topography, Slopes, Drainage Boundaries, Receiving Waters, Land Uses/Covers	>= 1" = 2000'	U.S. Geological Survey Maryland Geological Survey Local Photogrammetric Surveys Site Survey Maps

Maps for Detailing Existing Site Conditions in an Urban Retrofit Assessment (Continued)

Map Type	Use(s)	Scale(s)	Source(s)
Utilities	Land Uses/Covers, Imperviousness Calculations	>= 1" = 2000'	Balto. Gas & Electric Co. Local Public Works Depts.
Vegetation	Land Covers, Imperviousness Calculations, Potential Areas for Management Practices	>= 1" = 2000'	State Forest Service Maryland Geological Survey U.S. Geological Survey Habitat Assessment Studies
Wildlife	Impact Assessment, Natural Areas, Parks, Open Space	>= 1" = 1 mile	State Dept. Natural Resources Local Habitat Assessments U.S. Fish & Wildlife Service

APPENDIX F

Summaries of Urban Retrofit Management Practices

Summaries of Urban Retrofit Management Practices

The following section includes brief summary descriptions of water quality management practices (control measures) that are potential candidates for application in existing urban areas. These summaries should be supported by information about specific management practices in the "Urban Water Quality Management Practice Resource Directory" in Part IV of the **Guide**. Remember that most of these practices have been designed for and used in newly developed areas - not as retrofit controls. Some controls may require modifying prior to use in retrofitting or may not be suitable as retrofit controls.

INFILTRATION

Dry Well

The purpose of a dry well is to capture and store runoff from rooftop areas of less than one acre surface area for infiltration into surrounding soil.

A dry well consists of a small excavated pit backfilled with aggregate. The dry well is similar in design to the infiltration trench but has a smaller surface area but a depth ranging from 3 to 12 feet. Another difference between the dry well and the trench is that the dry well accepts inflow through an inflow pipeand surface infiltration. The trench can only accept inflow through the surface or inlet flow.

The considerations for use of a dry well include: minimum construction depth, maximum allowable storage time, surface area requirements for a specified level of control, and the infiltration rate of the soil textural classes (>= 0.27 in/hr.). All infiltration devices are subject to clogging by sediment, oil, grease, grit, and other debris and should be designed so that runoff entering them is reduced. The bottom of the dry well must be at least 2 to 4 feet above the seasonally high groundwater table as well as bedrock. The dry well must also be located at least 100 feet horizontally form any water supply well.

Dry wells can be used to drain roof runoff from residential, commercial, industrial, and institutional buildings.

Trench

The purpose of an infiltration trench is capture a portion or all of the runoff from relatively small drainage areas for infiltration into the soil.

An infiltration trench consists of a shallow excavated trench, generally 2 to 10 feet in depth, backfilled with a coarse stone aggregate, allowing for temporary storage of storm runoff in the voids between the aggregrate material. The trench is designed to allow slow infiltration of the stored water into the surrounding ground. Unlike the dry well which is covered with soil and vegetation and a subsurface inlet, the surface of the trench consists of stone, gabion, sand, or a grass covered area with a surface inlet.

The trench is designed using the same general reqirements as the dry well. In addition, the trench should be designed to minimize the surface area by making it as deep as possible with three feet a minimum. All infiltration systems are subject to clogging by sediment, grease, oil , grit, and debris. The trench should be designed and constructed to include grass filter strips for filtering the runoff prior to it entering the trench. Three variants of the infiltration trench have been introduced (MWCOG, July 1987). These include: (1) the complete exfiltration system in which all water entering the trench infiltrates into surrounding soil, (2) the partial exfiltration trench in which a perforated underdrain in the trench bottom with a riser to allow only large storms to overflow from the trench, and (3) the water quality exfiltration system in which the trench is designed to receive only the first flush of runoff.

The infiltration trench can be used in residential lots, commercial areas, parking lots, and open space areas. A trench can also be installed under a swale to increase the storage of the infiltration system. The water quality exfiltration trench design, because it captures only small runoff events or portions of larger events, is considerably flexible in its placement within the urban area.

Basin

The purpose of the infiltration basin is to intercept runoff after preliminary concentration and infiltrate the water through the basin bed or sides.

An infiltration basin is a water impoundment made by constructing a dam or an embankment or by excavating a pit or a dugout in or down to relatively permeable soils. A typical basin will range in depth from 3 to 12 feet. Both bedrock and seasonally high groundwater table should be located 2 to 4 feet below the bottom of the basin. The design will be based on the permeability or final infiltration rate of the soil types surrounding the basin, but a basin cannot be built on soils with an infiltration rate < 0.27 inches/hour. All infiltration systems can become clogged and the basin will require placement of runoff filtering devices such as vegetative filters, sediment traps, and grease traps upslope of the basin entrance.

Four design variants have been proposed by MWCOG (July 1987). These include: (1) the full infiltration basin, (2) combined infiltration/detention basin, side-by-side basin, and the (4) the off-line infiltration basin.

An infiltration basin can be used in the same general way as a detention basin. The infiltration basin is suitable for drainage areas of 5 to 50 acres. It can be constructed jointly with a detention basin by raising an outlet pipe.

Porous Pavement

The purpose of porous paving is to capture rainfall at the source, infiltrating and temporarily storing it for later drainage. The use of porous paving increases infiltration, reduces flood peaks, and provides an opportunity for pollutant removal.

Porous paving or porous asphalt refers to a porous asphaltic paving material and a high void aggregate base that allows for rapid infiltration and temporary storage of runoff and rain falling on paved surfaces. This type of paving is an applicable substitute for convential asphalt pavement on parking areas and low-traffic volume roads provided that the grades, subsoil drainage characteristics, and groundwater table conditions are suitable for use. Generally, the grades must be very gentle to flat, the subsoil must be at least moderately permeable ($f >= 0.27$ in/hr), and the depth to the water table or bedrock must be 2 to 4 feet.

Three alternative designs have been proposed for porous pavement (MWCOG, July 1987). The first is a full exfiltration system allowing complete infiltration into the subsoil. The second design is partial exfiltration which only infiltrates a part of the runoff and collects the remaining flow in underdrains. The third alternative design is a water quality exfiltration system which has a stone reservoir sized to handle only the "first flush" of a runoff event.

The application of porous paving includes: parking lots (especially fringe and overflow parking); parking aprons, taxiways, and shoulders at airports; emergency stopping and parking lanes and vehicle cross-overs on divided highways; low-traffic volume roads; rooftop runoff; and runoff from adjacent paved areas.

Some advantages include the need for less land, reduction or elimination of curbs and gutters, downstream conveyance systems, preservation of the natural water balance at the site, and a safer driving surface with better skid resistance.

The major disadvantage of porous paving is that if it becomes clogged, it losses its permeability and is difficult and costly to rehabilitate.

Modular Paving

The purpose of modular paving is to allow infiltration of rainfall-runoff on areas that are normally paved with impermeable materials.

Modular paving consists of precast concrete lattice blocks or bricks placed on soils that are well or moderately well drained to allow partial infiltration while providing a structurally sound surface for support. The modular paving is generally unsuitable for sloping sites unless used to pave level terraces.

Modular paving has at least four advantages. First, lattice concrete blocks permit the establishment of grass, reducing the visual impact of large areas of pavement. Second, because these pavers are all small units laid on a non-rigid base, small sections can be lifted for access to underground utilities or repairs. Third, a variety of patterns can be used. Last, these pavements are flexible and can withstand minor movements without cracking.

Disadvantages include: use of skilled labor required to lay modular paving, possible poor permeability on moderately well drained soils unless deep sub-base is laid, a poor walking surface created by lattice blocks and brick with wide joints, and weed growth in joints of some materials requiring maintenance.

INFILTRATION/FILTRATION/FLOW ATTENUATION

Grassed Swale

The purpose of a vegetated or grassed swale is to serve as natural drainage ways for stormwater runoff. A swale slows down the concentrated runoff velocity and filters out some particulate pollutants.

Grassed swales are typically applied in residential developments and highway medians as an alternative to curb and gutter drainage systems. A swale will remove some particulate pollutants by filtering action but are not generally capable of removing soluble pollutants. A swale can help to control peak discharge in two ways: (1) reducing runoff velocity and increasing time of concentration and (2) infiltrating a portion of the runoff volume.

To improve the effectiveness of a swale, several supplemental devices can be used. On slopes less than 5%, check dams can be installed across swales to further retard the water. Infiltration trenches can also be located under swales to improve infiltration.

Grass Filter Strip

The purpose of a grassed (vegetated filter strip) is to intercept sheet runoff flow to prevent concentration of runoff, lower runoff velocity, slightly reduce both runoff volume and watershed imperviousness, and contribute to groundwater recharge.

Filter strips are similar to grassed swales except rather than collecting concentrated flow, they collect only sheet flow. Since runoff has a strong tendency to concentrate into channels by short circuiting, a grass filter strip must be designed to distribute flow evenly. To work properly, a filter strip must have a level spreading device; dense vegetation with a mix of erosion resistant plant species that bind the soil; a uniform, even, and relatively low slope; and a length as long as the contributing area.

Filter strips have several advantages. They are relatively inexpensive to establish and have low maintenance requirements. A creatively landscaped filter strip provides a community amenity, wildlife habitat, screening, and stream protection. One use in a system of management practices is the application of a grass filter strip to protect surface infiltration trenches from clogging by sediment.

TRAPPING

Water Quality Inlet

The purpose of a water quality inlet (also called an oil/grit separator) is to remove sediment and hydrocarbon loadings (oil and grease) from paved areas before discharging to a storm drain system or infiltration device.

Two designs for water quality inlets have been issued each by Montgomery County and the City of Rockville. The Montgomery County inlet is a long rectangular concrete box connected to a storm drain with three chambers. Runoff flows through each of the three chambers in series with the total design separating out sediment, grit and oil before exiting through the storm drain pipe. The first chamber contains a permanent pool three or four feet deep and is used for gravity settling of grit, sediments, leaves, and floatable debris. It is connected to the second chamber by a pair of well-screened six inch holes. The second chamber holds a permanent pool of water with an inverted pipe elbow leading to a third chamber. The second chamber traps oil and gas films floating on the water surface which eventually settle out into the sediments. The third chamber is a brick cradle forming the transition to the storm drain pipe. It can be designed to also hold a permanent pool for further settling or not.

In the Rockville design is similar to Montgomery County in that it has also a three chamber design. However, the first and second chambers do not have permanent pools. Instead, the flow drains through a series of screened six inch holes in the floor of the chamber into and through a layer of stone aggregate, and eventually exfiltrates into the subsoil. If the weep holes clog, the device would operate in the same way as the Montgomery County design.

Water quality inlets store only a small fraction of the two year design storm volume. Pollutant removal effectiveness of these devices has never been monitored. However, the brief retention time and volume of the devices would probably limit the removal of solids to moderate levels. Fine grained material removals will probably be even more limited. Soluble pollutants will probably pass through the device.

The water quality design will typically serve parking lots one acre or less in size and well suited for areas receiving larger volumes of vehicular traffic or large petroleum inputs (i.e. gasoline service stations, loading areas, etc.). Routine maintenance should be performed at least twice a year.

STORAGE/RELEASE

Parking Lot Storage

The purpose of parking lot storage is to detain stormwater runoff during moderate storms in order to reduce peak runoff discharges to receiving waters and provide initial settling of sediment and particulate pollutants.

The use of parking lots for temporary storage of runoff is most applicable in areas with few opportunities to provide for stormwater detention. The ponding depth should not not exceed six inches to avoid flooding auomobile interiors. The practice is especially appropriate for overflow parking areas and lots which are not in regular use but must not inconvience the customer and car owner.

The practice has several advantages: a reduction of peak discharge, additional flood storage at low cost, will result in larger removal of sediment, and may be used in winter recreation. - ice skating. Disadvantages include inconvience to users of the parking lot. possible damage to unauthorized autos, and frequent sediment and debris removal required.

Dry Basin

A dry basin, also called a detention basin, is designed to control peak stormwater runoff discharges for 2 and 10 year return frequency storms.

As designed, the dry basin does not provide any significant pollutant removal because of the detention time and positive flow of the basin. However, if a dry basin meets certain physical requirements, it can often be modified (retrofitted) to include pollutant removal with the stormwater management objectives. One modification is the conversion of a dry basin to an extended detention basin by providing a means of detaining the water for 24 hours or more. Another modification is the installation of a shallow marsh system in the basin. A third alternative is the conversion of the dry basin to a wet pond.

Extended Detention Basin

The purpose of extending the detention times of dry basins and wet ponds is to provide an effective, low cost means of removing particulate pollutants and controlling increases in downstream bank erosion.

Both dry basins and wet ponds can be adapted to achieve extended detention times. A two stage design is recommended for dry basins in which the top portion of the pond is designed to remain dry most of the time, and a smaller portion near the riser is regularly inundated. Methods to achieve extended detention times in dry basins and wet ponds are:

Perforated Riser Enclosed in a Gravel Jacket	Dry Basin
Perforated Extension of Low Flow Orifice, Inlet Controlled	Dry Basin
Perforated Extension of Low Flow Orifice, Outlet Control	Dry Basin
Slotted Standpipe from Low Flow Orifice, Inlet Control	Dry Basin, Shallow Marsh, Shallow Wet Pond
Negatively Sloped Pipe from Riser	Wet Ponds, Shallow Marshes
Hooded Riser	Wet Ponds

By extending the stormwater detention time by 24 hours or more, as much as 90 % removal of the particulate pollutants can be removed. However, only slight removals of soluble phosphorus and nitrogen are possible. These removals can be enhanced if the area normally inundated is managed as a shallow marsh or a permanent pool.

Construction costs are seldom more than 10% above those reported for dry ponds. Maintenance requirements are moderate to high, depending on the anticipation of future maintenance needs during construction. Routine maintenance includes mowing, inspections, debris and litter removal, erosion control, and nuisance control. Non-routine maintenance can include structural repairs and replacement and sediment removal.

Wet Pond

The purpose of a wet pond (also called a retention pond) is to achieve high removals of pollutants, provide a community aquatic resource, and provide wildlife habitat.

Wet ponds are structural basins of impounded water with a permanent pool. If properly sized and maintained, wet ponds can achieve a high removal rate for pollutants including sediment, BOD, organic nutrients, and trace metals. Biological processes also remove soluble nutrients. Wet ponds must, however, be carefully planned, designed, constructed, and maintained. Because the wet pond is a multi-purpose BMP, competing objectives for use must be resolved to provide stormwater management, pollutant removal, and landscaping/habitat improvement.

The best applications for wet ponds is in residential or commercial developments greater than 20 acres with a reliable source of baseflow. Positive impacts of wet ponds include: creation of local wildlife habitat, higher property values, recreation, and landscape amenities. Negative impacts include: possible upstream ans downstream habitat degradation, potential safety hazards, occassional nuisance problems, and the eventual need for sediment removal (a costly operation).

NATURAL SYSTEMS

Shallow Marsh System

The purpose of the shallow marsh system is to use shallow vegetated marsh land created by detention of water to provide removal and treatment of stormwater runoff by biological activity and extended detention.

The shallow marsh system is a collection of wetland plant species in a multiple depth water environment with sufficient baseflow to maintain a relatively constant water level. Since most wetland plant species thrive in shallow water conditions of one foot or less, most of the surface area will be at this depth. Optimal nutrient removal is achieved when the surface area is maximized - generally the marsh system being 2 - 3 percent of the total area of the contributing watershed. A shallow wetland will be heavily vegetated with only 25 % of the total area in open water of two feet or more in depth. A heavily vegetated basin should provide food and shelter to insects, birds, animals, and fish.

Shallow marsh systems have several variants. A system can be constructed for a single purpose as a shallow marsh with little detention of stormwater. A shallow marsh system can be integrated into the design of a detention basin, extended detention basin, or wet pond by providing shallow benches for aquatic growth or in sediment forebays. Because little or no excavation is needed for the shallow water required in these basins, existing dry stormwater basins (detention basins) can be retrofitted with shallow marsh systems. This is possible if a baseflow passes through the basin.

PHYSICAL TREATMENT

Sand Filter

The purpose of the filtration basin (sand filter) is to remove suspended particulate matter and the associated adsorbed chemical constituents by filtering the runoff through a sand bed.

The City of Austin, Texas has developed water quality design guidelines for filtration basins (1986). The Austin guidelines require the first one-half inch of stormwater runoff to be diverted from the main flow stream by isolation baffles and a diversion weir or by alternative methods. Alternative configurations, listed by priority, are:

- o Separate sand filtration of first one-half inch of runoff and provide stormwater detention in separate basin.
- o Provide stormwater retention/detention followed by sand filtration.
- o Combine detention (sedimentation) and sand filtration in single basin.

The filtration of stormwater runoff is based on design criteria for slow rate filters. The calculation requires the drainage area contributing runoff to the basin and the runoff depth to calculate the necessary surface area of the sand media. The maximum recommended drainage area is 50 acres for each filtration basin system.

Swirl Concentrator/Helical Bend

The purpose of the swirl concentrator/helical bend device is to concentrate suspended material in stormwater runoff into a small volume for removal and disposal.

The swirl concentrator and the helical bend are two devices that depend on the hydraulics of flowing water to concentrate suspended solids from the main stream to a point of further treatment or disposal. The swirl concentrator operates by the swirl action of the flow entering a cylindrical chamber tangentially and travels in a vortex path of decreasing radius. The liquid-solid separation concentrates the solid matter, which leaves the chamber through a foul flow outlet in the chamber floor near the center. the concentrated liquid-solid slurry is either treated directly or stored for later treatment. Treatment occurs by connection to a sanitary sewer system for delivery to the wastewater treatment plant or alternative process. One possible method for stormwater would be use of sand bed filtration following swirl concentration.

The helical bend device operates similarly to sediment depositing along curved sides in streams or rivers. The operating principle is that flow moves into a curved path in a hannel cross section with the deepest part at the inside of the curve. Solids are channeled into the trough by secondary currents and moved to the end of the bend and are removed into a storage device or routed directly to a treatment system. A smooth transition from the circular sewer storm drain pipe to the start of the bend is essential.

Both of these types of units are static - operating without moving parts and require no outside source of power. Both can remove up to 50 percent of the suspended solids. Both are effective for treating separate stormwater discharges. Both devices serve a dual function - physical treatment and regulation of the flow.

Plate/Tube Separator

The plate/tube separator's purpose is to reduce the detention time and fall distance of pollutant particles in a settling basin - removing particles of smaller size in less time.

The process invloves directing the runoff flow through either stacked plates or, more practically, inclined tubes.

The slope of the tube contributes to self cleaning of the settled material on the bottom of the tube. Commercial units are available that consist of a lightweight plastic grid with 2in. X 2 in. passageways in cross section with a length of 24 inches, inclined with a slope of 60° to the horizontal. In use, the module is submerged to a shallow depth below the water surface. The runoff enters from the bottom, passes upward through the tubes, and exits the top. Average flow velocity through the tubes is very slow (< 0.01 fps), and larger particles settle to the tube invert. They eventually drop to the tank bottom and must be removed.

Tube settlers have been used in several applications. The inclined tube concept has had some success in clarication of effluent from waste water treatment plants. It permits a higher rate of flow through the basin while maintaining good efficiency of particle removal. USEPA examined the tube settler for removing sediment from runoff at construction sites by installing the device at the downstream end of a sediment basin (July 1979). Tests revealed that when used in conjunction with the basin, particle removals of 60 - 70 percent were seen, implying that fines in the clay range were also removed.

Screens

The purpose of screens is the removal of floating or suspended solids from runoff.

The process of particle removal for screens ranges in difficulty from little to great. Screens in various shapes and sizes are installed in the runoff flow path and removes materials larger in size than the smallest opening in the screen. Because the material remains on the screen, it must be removed periodically to maintain the efficiency of the screen.

Screens have been used or tested in various runoff and combined sewer- related condtions. Perhaps the most common of these in managing stormwater runoff is the trash rack installed at the riser or spillway of a sediment or stormwater management pond. Debris barriers are commonly used in streams where floating debris is a serious hazard due to stream instability and upstream development. USEPA has tested screens and micro-strainers to remove various sizes of particles from stormwater and combined sewer systems prior to treatment. These screens are made of stainless steel or plastic, in the form of micro-strainers, drums, and discs. Operation of screens in the smaller pore opening ranges have had mixed success and normally high operation and maintenance costs.

As a general rule, the difficulty and cost of removing suspended solids is inversely proportional to their size.

Glossary

Analysis Area
A drainage area within a priority watershed. The analysis area can be a subwatershed, creekshed, subcreekshed, or even as small as a storm drain system.

Analysis Area Information Table
A matrix-type table that lists the characteristics, composition, and magnitude of urban areas in the analysis area.

Analysis Area Urban Retrofit Strategy
The results of Step 5 of the method. Included are a combination of analyses and maps pointing out potential retrofit control measures that can be applied to the selected analysis area.

Candidate Urban Retrofit Management Practice
A proposed water quality management practice. The practice can be a modification to an existing or new practice.

Catchment (urban)
The smallest unit of drainage area in a watershed. A catchment has little or no natural stream channel with the flow patterns governed by storm drain systems.

Concensus Judgment
(See Delphi Technique.)

Creekshed
A drainage area one level smaller in size than the watershed, two or more of which make up the total watershed drainage area.

Developed Areas (Land)
Land on which buildings, roads, parking lots, and other structures have been constructed for long term human habitation and activities.

Delphi Technique
A problem analysis and solution method developed by the Rand Corporation. The procedures require the collection of opinions of experts. The participants are shown the median and range of the individual, independent votes about an issue and asked to reconsider the issues. After several rounds of voting, more often than not, the judgments will converge toward a single answer.

Drainage Area Boundaries
Imaginary lines defined by the topography of the land that divide the drainage areas. Drainage areas can be defined at

several levels - from a watershed down to the many sub-watersheds and many more catchments within a watershed.

Erosion Control
The assessment of problem conditions or sources and the application of one or more control measures to prevent, reduce, or eliminate the problem. Controls are designed to address the runoff source, or sheet, rill, or gully erosion.

Event Mean Pollutant Concentration
The flow-weighted average concentration of a pollutant measured in an urban stormwater runoff event.

Hydrologic Soil Group
The qualitative rating assigned to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. These are Group: A - soils with low runoff potential and high infiltration rates; B - soils with moderate infiltration rates; C - soils with low infiltration rates; and D - soils with high runoff potential.

Intensely Developed Area
A term defined by the Chesapeake BAy Critical Area Critical in which either an area of equal to or greater than 20 contiguous acres or the entire upland portion of a municipality within the Critical Area has predominately residential, commercial, institutional and/or industrial development and relatively little natural habitat. The area must have housing density equal to or greater than 4 dwelling units per acre (DU/Ac.); a concentration of industrial, institutional, or commercial uses; or public sewer and water collection and distribution systems currently serving the area and a housing density of greater than 3 DU/Acre.

InterJurisdictional Watershed
A watershed with drainage boundaries that cross governmental boundaries. An example is the Patapsco River Watershed which includes portions of five local jurisdictions - Carroll, Baltimore, Howard, and Anne Arundel counties and Baltimore City.

IntraJurisdictional Watershed
A watershed with the drainage boundaries within a single governmental jurisdiction's boundaries. An example is the Magothy River watershed in Anne Arundel County.

Limited Development Area
A term defined by the Chesapeake Bay Critical Area Criteria. The term describes any area currently developed in low or moderate intensity uses that contain areas of natural plant and wildlife habitat and the quality of runoff from such areas has not been substantially altered or degraded. The Intensely Developed Area (IDA) must have either a housing

density from 1 to 4 dwelling units per acre; area not dominated by agriculture, forest, barren land, surface water, or open space; areas with characteristics of the IDA but less than 20 acres; or areas with public water or sewer or both.

Management Practices (Controls)
Also known as controls. These water quality control measures include source,erosion, and stormwater runoff controls.

Mitigate
To reduce a water quality or plant and wildlife habitat impact by requiring compensation for or replacing the affected area.

Natural Soil Groups
Soils assembled into groups having similar major properties and features. Natural soil groups are arranged in order of increasing limitations or problems for most uses. Groups are divided on the basis of drainage class, depth, permeability, flooding, and stoniness and rockiness. Subgroups are divided based on slope steepness.

Offset
A structure or actions that compensates for undesirable impacts. It is defined by the Chesapeake Bay Critical Area Criteria, offsets must be provided on or off a proposed development site in the Critical Area for the amount of pollutant loading that cannot be reduced to at least 10 percent of the predevelopment levels. The offsets must provide the equivalent water quality benefits and be obtained within the same watershed.

Priority Watershed
A watershed chosen by the user of this guide.

Resource Conservation Area
A term defined by the Chesapeake Bay Critical Area Criteria. Such areas have mostly wetlands, forests, and forestry activities, abandoned fields, agriculture, fishery activities, aquaculture, or less than one dwelling unit per 5 acres.

Retrofit Control Opportunities
Public open space, existing stormwater drainage structures, or other circumstances - revealed during a field survey of an analysis area - where retrofit control measures could be installed.

Rivershed
Another term for watershed.

Runoff Controls
A collection of management practices applied to stormwater runoff affecting peak discharge, volume, and/or water quality. The major categories include: infiltration, infiltration/ filtration/ flow attenuation, trapping, storage/release, natural systems, and physical treatment.

Slope
The steepness of the land determined by topography. Slope is expressed as a percentage, a gradient ratio, or as the degree of inclination of the land.

Slope Map
A topographic map that shows the steepness of the land. The slope ranges, or zones, vary with the intended use of the map and are represented by different colors or shading patterns.

Soil Erodibility (K Factor)
A measure of the susceptibility of bare surface soil to erosion. The K-factor is a component of an established equation for estimating potential erosion from a field or watershed (the Universal Soil Loss Equation).

Source Control
A class of management practices that are non-structural, and affect human activities and living patterns. These controls prevent, reduce, or eliminate pollutants on the land surface prior to rainfall.

Stormwater Runoff Control
A class of management practices that infiltrate, spread, filter, store, screen, settle, or treat the runoff.

Subcreekshed
A drainage area contributing to the total drainage area of a creekshed (subwatershed).

Subwatershed
A drainage area, two or more of which make up the total drainage area of a watershed. In a river watershed, the tributary creeks normally are called subwatersheds.

Unusual Runoff-Related Pollutant Source
An urban land use or activity that can generate higher pollutant concentrations or unusual pollutant types.

Urban Areas
Areas in which the construction of urban development has been completed and the land stabilized.

Urban Area Field Survey Checklist
A checklist to guide the user in his or her assessment of physical conditions and retrofit opportunities in an urban

area.

Urban Area Retrofit Potential
The potential for application of water quality control measures in an urban area.

Urban Land Use
Development that includes residential, commercial, institutional, industrial, and transportation land uses.

Urban Retrofit
A control measure designed to improve the water quality of urban stormwater runoff in urban areas.

Urban Retrofit Management Practices
Controls to manage or elimate pollutants in urban stormwater runoff.

Urban Retrofit Planning Method
A six step method planning an urban retrofit for stormwater runoff.

Watershed
The largest scale of drainage area used in the Urban Retrofit Planning Method.

Resource Directory

RESOURCE DIRECTORY

Detailed information about specific stormwater-water quality management practices, physical and design characteristics, and application case studies can be found in the information sources in this section. Remember that most of the discussions in these publications address either newly developing urban areas or other water problems (i.e. combined sewer overflows) and do not address directly existing urban areas. However, many of these management practices, if applied creatively and under the proper site conditions, may be used in developed areas.

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