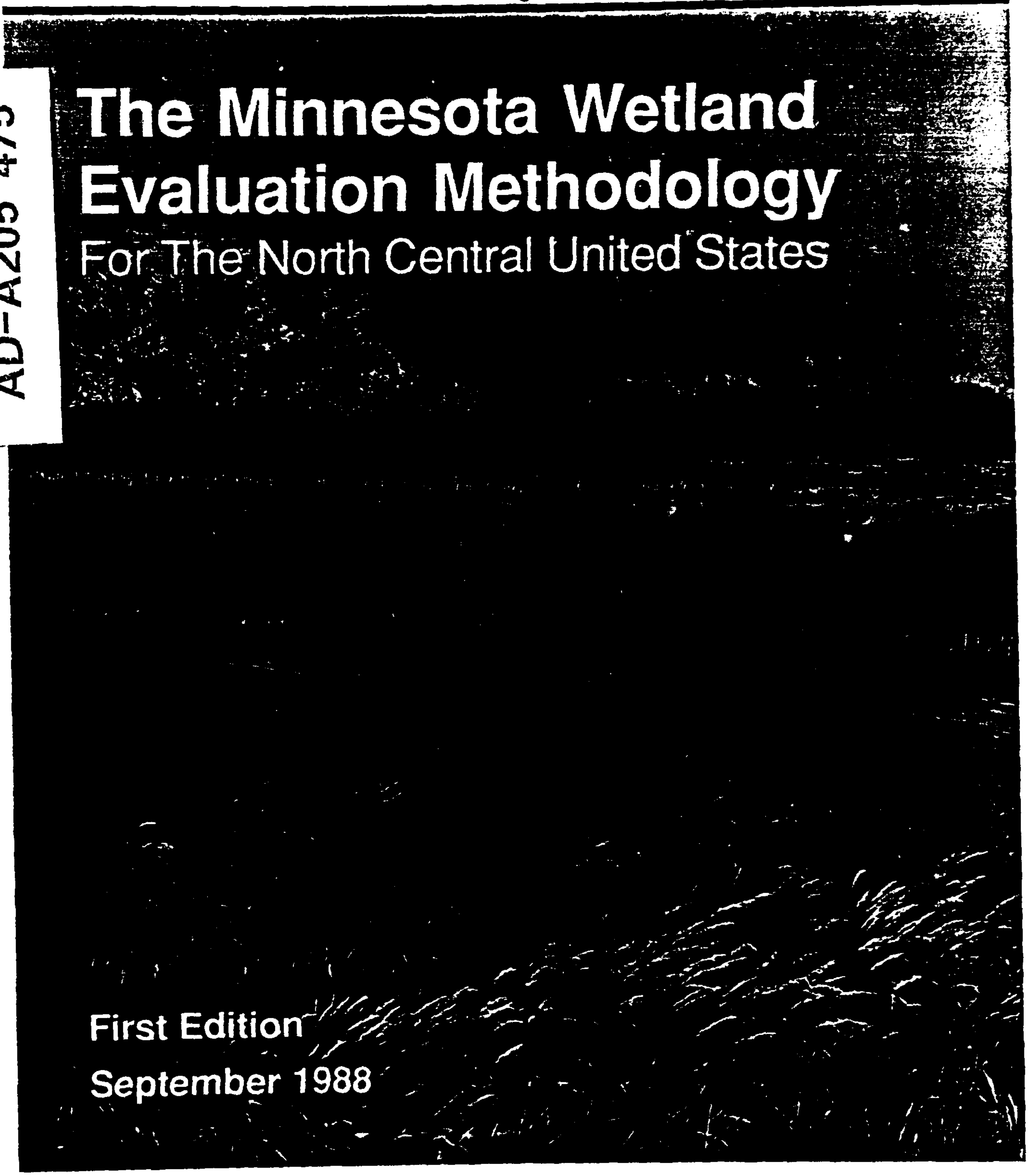
US Army Corps
of Engineers
St. Paul District

The Minnesota Wetland Evaluation Methodology

For The North Central United States



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The art of evaluating the functions and values of wetlands is relatively new. Traditionally wetlands have been recognized for their value as wildlife habitat. However, since the mid-1970's other wetland functions and values (e.g. floodwater storage, water quality improvement) have become increasingly important in the wetland evaulation decision-making process. The purpose of this wetland evaluation methodology is to provide a standard procedure to assist the professional in rapidly evaluating the many functions, values, and characteristics of wetlands.

The computer program which accompanys ~~the~~ this looseleaf manual has been designed as a menu-driven program. It leads the user through each section and performs the more sophisticated mathematical calculations. The program requires as IBM-compatible personal computer and a math-co-processor chip. Some IBM-compatible machines include the Zenith, AT&T, and other PC clones. The math co-processor chip is required to compute the inflow-outflow hydrographs for the flood flows section.

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The Minnesota

WETLAND EVALUATION METHODOLOGY

FOR THE

NORTH CENTRAL UNITED STATES

Prepared by
Corps of Engineers
In Conjunction With
The Minnesota Environmental Quality Board
Wetland Evaluation Methodology Task Force
John R. Wells, Chairman
September 1988

This work was done in response to a request from the
Minnesota Environmental Quality Board
to the
St. Paul District, U.S. Army Corps of Engineers
for planning assistance under Section 22
of the
Water Resources Development Act of 1974 (Public Law 93-251).

PREFACE

This first edition of the Minnesota Wetland Evaluation Methodology represents the efforts of many, many people and organizations.

The original idea for development of a methodology grew out of recommendations developed by the Minnesota Water Planing Board in the 1979 state water plan. In particular, the Board called for the Department of Natural Resources to "determine the specific characteristics of wetlands providing flood control, nutrient and sediment retention, ground water recharge, and other public benefits."

The realization of the enormity of the job led us in the Spring of 1983 to focus these efforts on development of a method for assessing wetland functions, based upon the best information available. The Water Planning Board requested planning assistance from the St. Paul District, under Section 22 of the Water Resources Development Act of 1974 (Public Law 93-251).

With approval of the proposal by the Water Planning Board and the Corps in April 1983, a task force of state, federal, and regional experts was assembled to begin the job of methodology development. At the request of the DNR in order to provide an impartial forum for interagency discussion of issues, staff of the Water Planning Board agreed to chair the task force. The Corps of Engineers staffed, as well as participated as a member of the task force.

The Wetland Evaluation Methodology (WEM) Task Force members, themselves, also deserve much recognition for their important role in guiding the project. Members were collectively responsible for approving the major policy directions and judgments required in development of the method. In addition, in several instances, they introduced new concepts on which portions of the method are based.

Members of the Wisconsin Wetlands Task Force also aided in development of the method, particularly the large watershed flood attenuation and warmwater fishery components. One regret is that different schedules and institutional requirements prevented development of a joint Minnesota-Wisconsin method.

As noted in the Introduction, we refer to the method as a "first edition" because we are intimately aware of its weaknesses, as well as its strengths. For a second edition to improve upon the first, we will need to get feedback on the method's ease of application, its usefulness in local, state, and federal decision-making, and its technical soundness. We call upon the user to give us this feedback for we recognize it is essential to the method's purpose, that of encouraging recognition in land use decision-making of the variety of functions provided by wetlands.

John R. Wells

John R. Wells, Chaiman
Minnesota WEM Task Force

THE MINNESOTA
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WETLAND EVALUATION METHODOLOGY

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INTRODUCTION

INTRODUCTION

The art of evaluating the functions and values of wetlands is relatively new. Traditionally, wetlands have long been recognized for their value as habitat for a variety of wildlife species; however, since the mid-1970's other wetland functions and values (e.g., floodwater storage, water quality improvement) have become increasingly important in the wetland evaluation decision-making process. The many functions and values of wetlands have also become legally recognized in a variety of State and Federal laws and regulations. The increased attention to the multifunctional nature of wetlands has spawned the need to develop procedures to assess these characteristics.

Since 1980, a considerable amount of research effort has been directed at the development of methodologies for evaluating wetland functions. Many States (e.g., Michigan, Wisconsin, Connecticut) have developed formal methodologies, and a national wetland evaluation technique is being developed under the direction of a steering committee comprised of 17 Federal agencies. Recently, major national conferences have focused on wetland functions and values, and significant amounts of research money have been directed at problems related to wetland evaluation.

As with most popular endeavors, there has been a companion development of resistance to the use of methodologies for evaluating wetland functions and values. Critics of the methodologies note that many wetland functions or values are not well understood even by leading experts; hence, standard procedures for evaluating such functions might not be reliable. Methodologies may also be criticized for use of arbitrary scales or cutoff points, qualitative reasoning or ratings, failure to adequately address all wetland types, failure to consider interactions in a wetland complex, and failure to consider cumulative wetland values.

Methodology proponents counter such criticisms by noting that decisions affecting the existence of wetlands are being made with little or no consideration of loss of wetland functions or values. Proponents argue that a methodology is vital to assuring that all wetland functions and values are considered in the decision-making process and that functions and values are determined based on the best available technical information.

Both proponents and critics of wetland evaluation methodologies present valid points, and the debate will doubtlessly continue for many years. Whatever the outcome, it is vital that critics recognize the need for a wetland evaluation methodology and that proponents recognize the role of an evaluator's professional judgment and experience in the use of a methodology. It is only through such recognition that the art of wetland evaluation will become a science, thereby helping to assure that important wetland functions and values are not lost.

With the preceding background, users of this wetland evaluation methodology (or WEM as it will be referred to in this manual) are asked to let the following points guide the evaluation:

Use professional judgment - This methodology is structured and written so that the user will develop an understanding of how and why a wetland provides certain values. This enables the user to use professional judgment and expertise to make modifications to such things as arbitrary cutoff points or rating tables if the concept behind these points or tables seems to indicate they should be changed for the particular wetland being evaluated.

Know the reason for a rating - It is very important that the user understand the system well enough to be able to describe which wetland characteristics were most important in producing a given rating.

"I don't know" may be the best rating - For certain wetland types, the methodology will provide only a general indication of the potential value or function of the wetland. In some situations, it may be best to recommend further study if the methodology does not produce a firm rating.

Use other information sources - If the methodology produces a rating that seems peculiar, a second source of information should be consulted or further study should be recommended.

All wetlands have value - In situations where application of the methodology for determining a particular functional value may not be possible or appropriate, one may still assume that the wetland has value for the given function. This assumption should be made for two reasons: a) other assumptions may result in irreversible losses of wetland functions or values; b) there is enough scientific data and legal mandate (Section 404 of the Clean Water Act; Executive Order 11990; State laws) to make this assumption valid in most situations.

STATEMENT OF PURPOSE

The following statement of purpose is given to provide a context to the wetland evaluation and to define the focus of the methodology:

The purpose of this wetland evaluation methodology is to provide a standard procedure to assist the professional in rapidly evaluating the many functions, values, and characteristics of wetlands.

Five phrases in the statement of purpose require elaboration and emphasis:

...standard procedure... The methodology is intended to remove arbitrariness and add reproducibility to the determination of wetland functions and values.

...to assist... The methodology is intended to enhance the insight and professional expertise of the evaluator, not replace it. It is intended that the methodology will provide guidelines to evaluating those functions outside the user's area of expertise.

...the professional... It is assumed that the user of the methodolgy has a basic understanding of potential wetland functions and values, plant communities, regulations, and issues related to wetland delineation.

...rapidly evaluate... The methodolgy was developed with the intent that an evaluation could be completed in approximately 8 hours (plus one hour of field work at the wetland site) with data that relatively easy to collect.

...many functions, values, and characteristics... One of the key purposes of the methodology is to foster a multi-function focus, thereby enabling wetland management decisions to be based on more than one wetland function.

HOW TO USE THE METHODOLOGY

This section presents an overview of how the methodology is structured and general instructions for its use.

Methodology Structure - The methodology is structured so that the functions to be included in an analysis can be selected by the user. This structure provides the flexibility to restrict the evaluation to those functions that are important to the decision, while providing the opportunity to evaluate all functions if so desired. For a full evaluation of some or all functions, the user should work with the sections included in the portion of the methodology entitled "Detailed Evaluation of Functions."

A "Special Features" section is included to provide a quick overview of unique wetland qualities and qualities of potential legal significance. This section can also be made part of a full evaluation of functions.

General Instructions - A full analysis generally requires four major steps,each of which is summarized and explained below:

a) **Define scope of the analysis** - The user should first decide whether afull or partial analysis should be conducted.

A full analysis of the features listed below requires at least 8 hours of time and a field trip to the wetland. Depending on the sources of information available to the user, many questions can, and should, be answered before going out into the field.

- floodwater characteristics and water quality
- wildlife
- fish
- shoreline anchoring
- visual values

If a partial analysis is conducted, note that the water quality evaluation must be preceded by evaluation of floodwater characteristics. Also, these two sections require approximately two-thirds of the time and effort needed for a full evaluation.

b) **Data collection** - The majority of the data required to use thismethod can be collected in the office, using topographic maps, soil surveys, climatological data, wetland inventory maps, aerial photos, and other similar sources. In addition to this information, the user is encouraged to contact those who might be familiar with the wetland site to help fill data gaps.

For the detailed analysis of functions and values, the user will need to visit the site and take certain measurements (e.g., dimensions of the wetland's outlet). It is recommended that all of the office data be compiled prior to a field visit, since this approach enables the user to better define the critical field data needs.

The data to be collected may be found in the descriptions of the evaluation procedures for each function. The computer program allows the user to print out all of the questions for each section as a planning aid. This must be done individually for each section.

c) **Data analysis** - The instructions for rating wetland functions and values using the data collected in the previous step are contained in the section entitled "Detailed Evaluation of Functions." Most of the analysis can be conducted using the simple flow charts and tables in this section; however, for certain types of wetlands, the WEM computer program must be used for analysis of the floodwater characteristics and water quality functions. For convenience, all functions can be analyzed using the WEM computer program, although continued use of the flow charts and tables is recommended since this provides the user with a better understanding of why a certain functional rating is given.

d) **Reporting and synthesis of ratings** - The section entitled "Synthesis of Functional Ratings" describes the method for summarizing the ratings for the various functions evaluated. The ratings are stored and displayed in the WEM computer program on a "summary of ratings" list. This list can be printed out for comparison with the evaluations of other wetlands.

The "Synthesis of Functional Ratings" section is an optional procedure for obtaining a "bottom line" rating for the wetland by combining the ratings from the various functions. This option is intended to provide a standard way to obtain a single composite estimate of all of the functional values provided by a wetland. It should be most useful for comparison of wetlands that have been evaluated identically or for comparison of the general value of a wetland before and after a proposed project. This procedure will undoubtedly be subject to criticism because it necessarily "adds apples and oranges" to get an overall rating for the wetland. The procedure is provided because, like it or not, it is frequently necessary to obtain some kind of overall rating when making wetland management decisions.

The user must note that in some cases the wetland rating might change drastically as a result of a change in land use. The actual change might be more accurately reflected by a negative number if the wetland no longer performs a function but also reduces the ability of wetlands downstream to perform that function. For instance, a filled wetland, instead of having reduced water retention capacity where none of the inflow is retained, might become part of a contributing watershed and change the functional values of downstream wetlands for water quality and flood flow characteristics.

Further refinement of this methodology cannot be done without the help of a variety of users. We consider this a first edition and welcome your comments, criticisms, and suggestions. Please contact John R. Wells of the Minnesota Environmental Quality Board at 300 Centennial Building, 658 Cedar Street, St. Paul, Minnesota 55155, or Bruce Gerbig of the Minnesota Department of Natural Resources at Division of Waters, 500 Lafayette Road, St. Paul, Minnesota 55155.

WEM COMPUTER PROGRAM USER INFORMATION

WEM Computer Program - User Information

The computer program has been designed as a menu-driven program. It leads the user through each section and performs the more sophisticated mathematical calculations. There are a series of menus that allow the user options such as viewing the summary of ratings of an existing file or entering new data to existing or new files. The user can back out at nearly any point by choosing that menu option. Once the user has begun to answer questions in a particular section they must all be answered before the user is able to move to a different menu. The program does not allow the user to store the responses to every question so this information should be written down. The menu for each section of the methodology has an option allowing the user to print a list of the questions for that section. This list can be used in the field and as a "hard copy" of the responses to each question.

The program requires that the personal computer used be IBM-compatible and have a math co-processor chip. Some IBM-compatible machines include Zenith, AT&T, and other PC "clones". The math co-processor chip is required to compute the inflow-outflow hydrographs for the flood flows section. The program cannot be run without this chip, even if you were not going to evaluate the wetland's flood flow characteristics. If your personal computer does not have a math co-processor chip *floating point not loaded* will appear on the screen.

If the personal computer has a hard disk drive, 300 to 360K of memory is needed to load the program. If you have a two-floppy drive system, you should run the executable from the B drive since output from the program is always written to the A drive. This will keep the executable disk and the data disk, where the results will be stored, separate. It is possible to use only the A drive in which case the output will be written on the executable, or program disk. About 50,000 bytes are presently available to the user on the program disk. The user could probably have 4 to 5 wetland sites on the disk with the executable before it fills up. If you have a one-floppy drive system, you will be limited to using only the A drive and must remember to copy files you wish to save to another disk when you get close to the 4 or 5 wetland limit.

After you have inserted the floppy disk, make sure the *cap lock is on,* and enter WEM to call the program. Directions on the screen will lead you through the program. You will first be asked to enter the name of the wetland area you will be evaluating. This will appear at the top of the screen and at the top of the ratings summary to let you know which wetland is being evaluated. Next the program asks for an 8-letter, or fewer, name for the file. The computer program will use the file name and add an extension to it depending on what file is being written to, or what function you are evaluating. Do not add your own extensions when naming the file. They will interfere with the file extensions added by the program and will prevent your results from being stored properly. The file extensions within the program represent various sections of the methodology as follows:

Section	File Extension
Watershed Characteristics	.WAT
Wetland Characteristics	.WET
Flood Flow Characteristics - Small Watersheds	.RES
Flood Flow Characteristics - Large Watersheds	
Palustrine sites	.LWP
Lacustrine sites	.LWL
Floodplain pool sites	.POL
Floodplain control point sites	.CPS
Other floodplain sites	.OTH
Weir Outlets (one file per weir)	.WR#
Channel Outlets (one file per channel)	.CH#
Culvert Outlets	.CLV
Water Quality	
Small Watersheds,	
Sediment/nutrient input	.SNR
Sediment/nutrient trapping effectiveness	.WAR
Large Watersheds	.WAL
Downstream Sensitivity	.DWQ
Wildlife	
Northern forest region	.WLN
Southern forest region	.WLS
Prairie grassland region	.WLP
Fish	
Northern pike spawning	.NPK
Warmwater fish values	.WFV
Shoreline Anchoring	.SHL
Visual Values	.VV1 (VV#1)
Visual variety	.VI1 (vI#1)
Visual importance	.VI2
Visual integrity	
Special Features	.SPC
Synthesis of Ratings	.SYN

If you need to delete the Wetland Characteristics file in order to make changes you must remember to delete the outlet files that are used with the name.WET file for computing outflow.

For example, assume that you have evaluated a wetland site adjacent to Lake Elmo for all of the above functions. The heading on the summary of ratings screen, or sheet if you print it out, will be LAKE ELMO. The shortened version chosen for the file name is ELMO (remember the caps lock must be on). The files will appear on your disk directory as ELMO.VV1 and ELMO.NPK, etc. If you wish to save only certain files, such as all of the visual importance results or the wildlife results, etc., you will readily be able to identify which files they are from the extension.

The computer must have ANSI.SYS and CONFIG.SYS files as part of its software. Within the CONFIG.SYS file the "device" must equal ANSI.SYS, and "files" must equal 20. This will allow many of the above niceties to be available to the user and will allow the program to open many files at one time. Because these files are specific to the type of personal computer you have, they must be loaded or modified by the user, if they are not already.

Many of the sections can be used without the aid of a personal computer. The flood flows and water quality sections include a lot of mathematical operations and the computer is most useful with these sections. The program has a tendency to go too fast while performing the calculations in the small watershed portions of these two sections. If this occurs, the user will be "dumped" and "system error" will appear on the screen. The user will have to start over after getting out of the WEM program and rebooting the machine, if necessary, then reentering WEM to start the program again.

The best way to en[illegible] all of the glitches are out of a program is to test it, a lot. This program has been tested but we welcome your comments and suggestions to help improve it. Mr. Scott LaChance and Ms. Teri Sardinas, both with the St. Paul District, Corps of Engineers, will be available to answer questions about the computer program. Mr. LaChance can be reached at (612) 220-0686; Ms. Sardinas at (612) 220-0269. Their mailing address is 1421 U.S. Post Office and Custom House, St. Paul, Minnesota 55101-1479.

DETAILED EVALUATION OF FUNCTIONS

Flood Flow Characteristics
Water Quality
Wildlife
Fish
Shoreline Anchoring
Visual Values

FLOOD FLOW CHARACTERISTICS

INTRODUCTION

This section of the methodology focuses on the characteristics of flood flows through the wetland site and on the potential for downstream flood damages. Analyses using this procedure culminate in two ratings; (i) a rating of the magnitude of change in flood peak flows as they pass through the wetland site, and (ii) a qualitative measure of downstream flood damage potential. A description of background and supporting logic for these procedures is given in appendix A.

DEFINITION OF TERMS

Wetland site - the wetland area being evaluated plus adjacent upland areas up to the elevation of the 100-year flood peak. This includes upland areas that control outflow or provide storage of floodwater above the upper boundary of wetland vegetation.

Wet basin - the wetland plus adjoining deep water areas. In some situations (e.g., palustrine wetlands), the entire wet basin will be a wetland and evaluated as such, while in other situations (e.g., lacustrine wetlands), the wetland being evaluated will be a small part of the wet basin.

Effective watershed - the entire watershed upstream of the wetland excluding subwatersheds which only contribute water on low frequency events (e.g. the 50-year or 100-year floods). Hence, the watersheds of upstream lakes or basins with no apparent outlet should not be included in the effective watershed of the wetland being evaluated.

CHARACTERIZATION OF PEAK FLOWS

Methods for describing peak flows through a wetland site are split into two sections: methods for wetlands with small hydrologically uniform upstream watersheds, and methods for those with large or hydrologically diverse watersheds. The distinction between large and small watershed methods is made because the simple hydrologic model used for analysis of wetlands with small watersheds is not appropriate for use on wetlands with larger watersheds. The following steps aid the evaluator in selecting between large and small watershed methods.

Step 1: Categorization of the Wetland Site - Five categories of wetland sites have been identified based on differences between the hydrologic characteristics of different wetland site types. These categories are also described in "Large Watershed Methods." The wetland site should be placed in one of the categories described below:

Palustrine Sites :
Palustrine sites include non-floodplain wetlands that are more than 30-percent vegetated with persistent emergents, trees, shrubs, or emergentmosses. If the wetland is less than 30-percent vegetated, it should beconsidered a palustrine site if the water is less than 7 feet deep. Palustrine sites are basically the same as wetlands classified as palustrine under the USFWS classification scheme (Cowardin, et. al.,1979) except that wetlands that are located entirely in a river floodplain should not be considered palustrine.

Lacustrine Sites :
The typical lacustrine wetland site is a lake with a fringe of wetlandsalong all or some significant portion of the shore. These sites are lessthan 30-percent vegetated and have some areas where water depth is greater than 7 feet. Sites under 20 acres should be considered palustrine(Cowardin, 1979).

Floodplain Sites :
Floodplain sites are located entirely within the floodplain of a river or stream. Major hydrologic influences on their water regime are the flow characteristics in the adjacent river. Typically, a floodplain site will be only a portion of the floodplain area. The following subcategories of floodplain wetlands are used in the evaluation procedures.

Floodplain Control Point Sites - Included in this category are wetlandsthat are part of the channel at a control point in a river or stream.Control points are areas of a river or stream channel where flow is-restricted (e.g. bridges, culverts, a marked constriction in thefloodplain, a natural dam, rock outcrop, etc.). During floods there is atendency for water to form a pond upstream of a control point.

Floodplain Pool Sites - Pool sites are wetland sites that are adjacent toa definite pool in a river or stream. These sites generally become inundated as the pool gets larger during floods.

Other Floodplain Sites - This category includes all other types offloodplain sites. For example: wetlands adjacent to a riffle reach in a stream should be included in this category.

Step 2: Categorization of the Effective Watershed - If the effective watershedfor the wetland being evaluated has either of the following characteristics, it should be categorized as a large watershed and evaluated using the methods shown in that portion of this section of the methodology. Wetland sites classified as "other floodplain sites" in step 1 should be evaluated with large watershed methods regardless of whether or not they meet the following characteristics.

a) Effective is watershed larger than 100 square miles.

b) Effective watershed is hydrologically diverse. Hydrologic diversity isindicated by the presence of two or more prominent subwatersheds (figure 1).

If the wetland being evaluated does not meet the above characteristics, the analysis should be based on the following small watershed methods. (Note: the hydrologic model in the small watershed methods may not work on some wetlands, in which case the evaluator will be directed to use large watershed methods.)

SMALL WATERSHED METHODS

Small watershed methods are based on standard hydrologic modeling techniques that have been adapted for use by persons with a minimal background in hydrology. The techniques, assumptions, and adaptations made are described in appendix A.

The following steps provide instructions for gathering the data necessary to run a computer model which conducts the hydrologic analysis. This model combines rainfall and watershed characteristics (steps 1-5) to construct an inflow hydrograph for the wet basin containing the wetland site. It then uses the volume and outlet capacity of the wet basin (step 6) to route the inflow hydrograph through the basin, producing an outflow hydrograph just downstream of its outlet. Comparison of the inflow and outflow hydrographs yields estimates of change in peak flows and floodwater detention time (used in water quality analysis). The interpretation of these estimates for each site type (step 8) and a description of how to use this method for impact analysis (step 9) are also given.

Step 1: Delineation of Effective Watershed - Delineate and compute the acreage of the effective watershed. (See the definitions on the preceding pages.)

Step 2: Rainfall Data - Using figures 2 through 11 (see end of this chapter), determine rainfall amounts for the following events:

2 year - 5 minutes	100 year - 5 minutes
2 year - 15 minutes	100 year - 15 minutes
2 year - 1 hour	100 year - 1 hour
2 year - 24 hours	100 year - 24 hours
2 year - 96 hours	100 year - 96 hours

Step 3 - Curve Number -The runoff curve number (RCN) is an indicator of the absorptive capacity of the watershed. RCN = 100 implies all rainfall becomes runoff; RCN = 0 implies all rainfall is absorbed (no runoff). Determine the runoff curve number for the effective watershed using the following relationship:

$$RCN = (U \times 80 + W \times 80 + A \times 75 + F \times 60)$$

Where:

U = proportion of the effective watershed which is urban land

W = proportion of the effective watershed which is wetland or lake which is agricultural land including pasture

F = proportion of the effective watershed which is forested or natural vegetation including grassland

A more accurate (and more time consuming) procedure for determining the RCN is available (appendix A). (Note: RCN does not have as much effect on the inflow hydrograph as the time of concentration; hence, efforts to attain greater accuracy should focus on the latter.)

Step 4: Time of Concentration - Determine the time of concentration (t_c) using the following relationship.

$$t_c = 0.0078\ ((L^{3/2})(H^{-1/2}))^{0.77}$$

Where: H = drop in elevation (measured in feet) from the hydrologically most remote point in the effective watershed to the inlet of the wet basin.

L = distance (measured in feet along the major tributary) that water must travel between the hydrologically most remote point and the inlet of the wet basin.

The hydrologically most remote point is found by following the largest tributary in the effective watershed to its headwaters and proceeding up ditches, ravines, or gullies to the drainage divide.

Appendix A contains a more detailed method for estimating t_c and a description of adjustments to t_c for watersheds that are unusually steep at the upstream end or unusually flat at the downstream end.

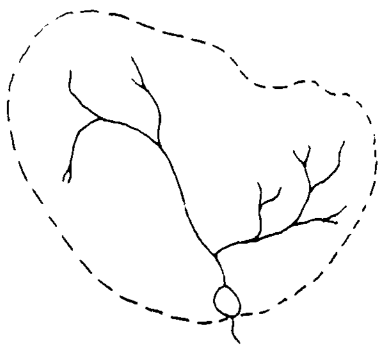
Step 5: Proportion of Impervious Surfaces - Using the following proportions as guidelines determine the proportion of the effective watershed which is impervious to water.

Land Use	*Proportion Impervious*
commercial and business areas	0.85
industrial districts	0.72
residential:	
lots 1/8 acre or smaller	0.65
1/4 acre lots	0.38
1/3 acre lots	0.30
1/2 acre lots	0.25
1.0 acre lots	0.20

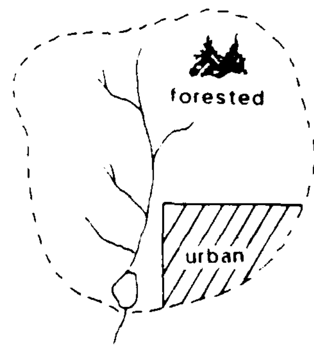
Figure 1. Illustration of hydrologically diverse and non-diverse effective watersheds.

DIVERSE

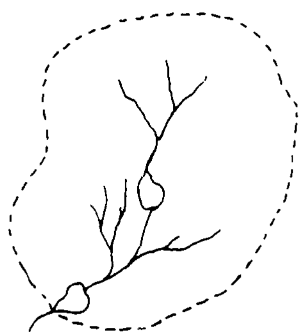
Use large watershed methods



a) Two prominent subwatersheds



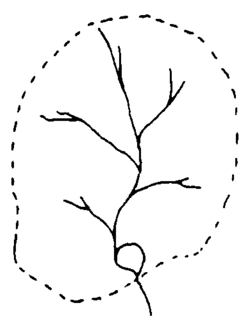
b) Non-uniform distribution of land use



c) Significant upstream storage

NON-DIVERSE

Use small watershed methods



No significant upstream storage, only one predominant tributary, uniform land use.

Step 6: Characterization of Volume and Outlet Capacity of the Wet Basin - Step 6 requires delineation of the boundaries and outlet of the wet basin. Instructions for delineation are given below for each type of wetland site.

— *Palustrine Sites* : In this situation "wet basin" is equivalent to "wetland site"; hence, storage and outlet computations should include the entire depression.

— *Lacustrine sites* : Storage and outlet computations should include the entire lake (wet basin).

— *Floodplain Sites* :
- Pool wetlands : The nearest downstream control point should be used as the outlet of the wet basin; storage should be calculated at elevation increments as if water were ponding behind the control point.

- Control point wetlands : The narrowest part of the control point should be treated as the outlet; storage should be calculated at elevation increments as if water were ponding behind that point.

Step 6a: Volume Computations :
i) At selected elevations, measure (or estimate) the acreage of the wet basin. At a minimum, acreage measurements are required at two elevations within the wet basin (preferably at the elevations described in (ii) and (iii) below).

ii) Estimate the water surface elevation in the wet basin under average flow conditions.

iii) Estimate the highest water surface elevation (e.g., the water level you would expect to observe only once every 100 years). Estimate this elevation using surrounding landforms or structures (for example: most major highways are designed so that they would not be flooded; therefore, a good estimate of maximum water surface may be the elevation of an adjacent highway).

iv) If you already have a storage, elevation, discharge relationship available to you, it can be directly added to the program. That option will be on the menu of the Flood Flows Section of the WEM computer program.

Step 6b: Outlet Characteristics :

i) Determine the number of outlets to be included in the analysis. The model constructed in this method requires an estimate of total discharge at any given elevation. Total discharge at an elevation is the sum of the discharges from each outlet at that elevation. Identification of outlets should not only consider outlets located at different points on the perimeter of the wet basin, but should also consider the possibility of additional outlets at different elevations. For example, a common wetland outlet is a culvert through an embankment. In this situation, the user would readily identify the culvert as an outlet; however, the top of the embankment should also be identified as a weir-type outlet which would begin discharging once water overtopped the embankment. Proper identification of outlets is critical to the model being constructed.

ii) Estimate the elevation of the bottom (lowest point) of each outlet.

iii) Place each outlet in one of the following categories and make the required measurements. If the outlet is a weir or channel, the computer program will use this information to calculate the discharge from the wet basin at several different elevations. If the outlet is a culvert, then the nomographs in figures 12a through 12g should be used to calculate discharges through the outlet at 1-foot elevation increments. This "outlet rating curve" should then be input into the computer program.

Below is a list of outlet common outlet types and the field measurements that are required to obtain data for the hydraulic calculations:

Channel
- Determine the channel width at the top and bottom of the channel.
- Determine the difference in elevation between the channel top and bottom.
- Estimate the average slope of the channel in the vicinity of the outlet.
- Estimate the roughness coefficient of the channel (table 1).

Weir
- Select a weir constant according to the width of the top of the weir (table 2).
- Measure the average length of the weir.

Box culvert
- Measure height and width of the culvert.
- If wing walls are present, estimate their approximate angle of flair.

Concrete pipe (round)
- Measure diameter of the pipe.
- Characterize the entrance type according to figure 12a.

Concrete pipe (oval)
- Measure the diameters of the long axis and the short axis; note if long axis is horizontal or vertical.
- Characterize entrance type according to figure 12a.

Table 1. Manning's roughness coefficients for channelized flow.

NATURAL CHANNELS[1]

Description	n
Excavated or dredged channels	
Ordinary concrete	0.013
Description	**n**
Earth, straight, uniform, and clean	0.022
Same, but with some short grass or weeds	0.027
Earth, winding and sluggish, with no vegetation	0.025
Same, but with some grass or weeds	0.030
Channels not maintained; weeds and some brush	0.080
Natural streams	
Clean and straight; no rifts or deep pools	0.030
Clean and winding; some pools and shoals	0.040
Clean and winding; some weeds, stones and pools	0.048
Sluggish reaches with weeds and deep pools	0.070

CULTIVATED LAND AND WATERWAYS[2]

Cover	Cover density	n
Smooth, bare soil	less than 1 inch deep	0.030
	1-2 in. deep	0.033
	2-4 in. deep	0.038
	4-6 in. deep	0.045
Cornstalks (assumes residue stays in place and is not washed away)	1 ton/acre	0.050
	2 tons/acre	0.075
	3 tons/acre	0.100
	4 tons/acre	0.130
Wheat straw (assumes residue stays in place and is not washed away)	1 ton/acre	0.060
	1.5 tons/acre	0.100
	2 tons/acre	0.150
	4 tons/acre	0.250
Grass (assumes grass is erect and as deep as flow)	Sparse	0.040
	Poor	0.050
	Fair	0.060
	Good	0.080
	Excellent	0.130
	Dense	0.200
	Very Dense	0.300
Small grain (20% to full maturity -- rows with flow)	Poor, 7-in. rows	0.130
	Poor, 14-in. rows	0.130
	Good, 7-in. rows	0.300
	Good, 14-in. rows	0.200
Water or marsh[3]		

1 Source: Chow (1959)
2 Source: Foster, Lane, and Nowlin (1980).
3 Value serves as a flag only to tell the computer that the surface is water.

Corrugated metal (round)
- Measure diameter.
- Characterize entrance type according to figure 12b.

Corrugated metal
- Measure bottom width (at widest point) and height (arched) of arch.
- Characterize entrance type according to figure 12b.

Circular pipe with beveled ring inlet
- Measure diameter of pipe.
- Characterize the beveled ring according to figure 12c.

Step 7: Data Analysis - Data collected and developed in steps 1-6 are used in the computer program (WEM) to develop inflow and outflow hydrographs for the wet basin. Data collected in steps 1-5 are used in constructing the watershed characteristics file, and data from step 6 are used to construct the wetland characteristics file.

Table 2: Weir Constants

Breadth of Weir crest (feet)	***Weir Constant***
0.50	3.32
0.75	3.14
1.00	2.98
1.50	2.75
2.00	2.66
2.50	2.64
3.00	2.65
4.00	2.67
5.00	2.68
10.00	2.68
15.00	2.63

from: Brater, E.F., H.W. King, 1976. Handbook of Hydraulics for the Solution of Hydraulic Engineering Problem, 6th ed. McGraw Hill, New York.

Step 8: Interpretation of Results - The computer program computes average annual peak inflow and average annual peak outflow from the wet basin. Average annual peak inflow is an approximation of what flow characteristics would be like without the basin; hence, average annual peak outflow represents the effect of the basin. A good summary of the importance of the wet basin to peak flow reduction is:

$$S = (1 - Q_o/Q_I) \times 100$$

Where: Q_o = average annual peak outflow
Q_I = average annual peak inflow

This score "S" can range from 0 to 100 where 0 represents no effect on peak flow and 100 represents storage of all inflow in the wet basin.

The score computed above is based on the effect of the wet basin on peak flows. The following computations should be used to determine what portion of the basin's effect on peak flow should be attributed to the wetland site.

a) *Palustrine Sites* -The wetland site usually encompasses the entire basin, in which case the score ("S" in above equation) should be used as the effect of the wetland site on peak flows. If this is not the case,"S" should be decreased as follows:

$$S' = (A_w / A_b) \times S$$

Where: S' = rating of the importance of the wetland site to peak flows
A_w = acreage of the wetland site (flooded conditions)
A_b = acreage of the wet basin (flooded conditions)
S = score from previous equation

b) *Floodplain, Control-Point Sites* - The score "S" is a good description of the hydrologic importance of the entire control point. Since the wetland site is an integral part of that control point, "S" reflects the value of the site.

c) *Lacustrine and Floodplain-Pool Sites* - Since the wetland site is only a portion of the total lake or pool area, site importance should be some portion of basin importance. The following relationship should be used to compute site importance from basin importance:

$$S' = (A_w / A_b) \times S$$

(all variables are as defined above)

Step 9: Impact Assessment - The model constructed in steps 1 through 6 can be used to determine the alteration of peak flows which might result from a proposed action. Postproject peak flows can be computed by redoing steps 6, 7, and 8 using postproject site acreages (step 6a) and postproject outlet characteristics (step 6b). The result will be a new value for site importance (step 8) which can be compared with preproject conditions to determine project impacts:

Project impact = $V_b - V_a$

Where: V_b = site importance before the project
V_a = site importance after the project

LARGE WATERSHED METHODS

The hydrology of wetlands that have a large or hydrologically diverse upstream watershed is not easily modeled. Hydrologic models of large watersheds consider such things as adding hydrographs from subwatersheds, routing flows through upstream detention basins, and channel hydraulics. This type of analysis requires the expertise of a hydraulic engineer and is beyond the scope of this methodology.

The following procedures for analysis of wetlands with large effective watersheds are primarily qualitative and are based on an assumption that different wetland sites can be categorized according to their hydrologic characteristics. The procedures are organized according to site type (step 1, in Characterization of Peak Flows) and include a description of typical hydrologic characteristics, methods for assessing the importance of each site type, and guidelines for determining the hydrologic impacts of a specific project.

a) ***Palustrine Wetland Sites*** :

Hydrologic Characteristics - These wetland sites are hydrologically characterized as storage sites. The degree to which they affect downstream flow is primarily a function of storage volume within the site and runoff volume in a rainfall event. The parameters that affect storage within the site include size and depth of the site, outlet capacity, and outlet elevation. Parameters affecting runoff volume include size of the upstream watershed, amount of upstream storage, and rainfall amount.

Site Importance - Three conditions are described below. If the wetland site meets any one of these conditions, it should be considered hydrologically important and should be flagged for more detailed hydrologic analysis. Note that a site that does not meet any of these conditions may still have important hydrologic functions within the watershed; however, these functions cannot be described in a rapid assessment technique.

Condition 1: Size of Wetland Site — A wetland site that is larger than 1-percent of its upstream watershed should be considered hydrologically important.

Condition 2: Volume of Wetland Site — A wetland site that can store more than 1-percent of the volume of water coming from the watershed should be considered hydrologically important.

Volume Calculations:
Wetland Site:

a) Estimate the acreage of the site at normal water surface elevation (A_b).

b) Estimate the acreage of the site during floods (A_t). This elvation should be determined by looking for drift lines or pollen ringsaround trees along the wetland's banks.

c) Storage Volume = $1/3\,(A_t + A_b + \sqrt{A_t A_b})(T-B)$
where:
A_t = area estimated in step b.
A_b = area estimated in step a.
T = elevation described in step b.
B = elevation described in step a.

Runoff Volume:

a) Compute the Runoff Curve Number (RCN) for the the watershed (see step 3, small watershed section).

b) Determine the acreage of the effective watershed (A).

c) Determine the rainfall amount for the 2-year, 24-hour rainfall event from figure 5.

d) Determine runoff depth (R) using table 3 and values from steps a, b, and c.

e) Runoff volume = A x R

Condition 3: Indications of Flow Moderation — Wetlands that have a moderating effect on downstream flow will exhibit a great deal of volume fluctuation within the wetland and little fluctuation immediately downstream.

a) Using the following scale, rate volume fluctuations at two locations: (1) within the wetland site, and (2) immediately downstream of the site outlet. Volume fluctuations are indicated by changes in water surface area, water elevation, or both.

1 = little or no volume fluctuation
2 = moderate volume fluctuation
3 = marked volume fluctuation

b) Rate the hydrologic function of the wetland site using the box following table three.

Table 3. Runoff Depth in Inches for Selected CN's and Rainfall Amounts

Rainfall (inches)	Curve Number (CN 1/)								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0	0	0	0	.56	.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	.74	.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

1/ To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use a linear interpolation.

Wetland Site Rating

		1	2	3
Down-stream Rating	1	M	H	H
	2	L	M	H
	3	L	L	M

H - High probability that the wetland site has a significant effect on downstream hydrology.

M - Moderate probability that the wetland site has a significant effect on downstream hydrology.

L - Low probability that the wetland site has a significant effect on downstream hydrology.

Impact Assessment - The two parameters of major importance to the hydrologic characteristics of a palustrine site are site storage volume and outlet capacity. Any activity that would significantly alter these parameters has the potential for significant effects on site hydrologic characteristics. The following procedures could be used to assess the hydrologic significance of an activity.

a) *Significance of Volume Alterations* — Compare the preactivity and postactivity site volumes (see condition 2, above) to assess the significance of volume changes.

b) *Significance of Outlet Alterations* — Determine preactivity and postactivity activity outlet capacities using step 6b (small watershed methods). A ratio between the pre and post conditions provides an indication of significance.

To obtain numeric estimates of significance, it is necessary to construct a hydrologic model of the site. Therefore, if the hydrologic effects of a proposed activity are a major issue, the expertise of a hydrologic engineer should be sought.

b) ***Lacustrine Sites*** :

Hydrologic Characteristics - Lacustrine sites border lakes and provide an area for water storage when lake levels rise. The lake itself has hydrologic characteristics that are very similar to palustrine sites in that the degree to which the lake affects downstream flows is a function of storage volume within the lake and the volume of runoff from the watershed. Since the wetland site is only a portion of the total lake, the hydrologic importance attributable to the site is only a portion of total lake importance.

Site Importance - Assessing the importance of a lacustrine wetland site is a two-step procedure which first assesses the importance of the entire lake and then determines the portion of the lake's importance that may be attributed to the wetland site.

Step 1: Lake Importance - The three conditions used to determine the importance of a palustrine site should also be used to assess the importance of the lake. If the lake meets any one of these conditions, it should be considered important and noted as such on the rating summary sheet.

Step 2: Site Importance - The importance of the wetland site should only be assessed if the lake is considered important. To determine site importance, the following procedure should be used to compare the volume of storage available at the site to the total volume of storage in the entire lake. A site that has more than 10 percent of total storage volume within the lake should be considered important.

a) Determine the acreage of the entire lake and the acreage of the wetland site under normal water surface levels.

b) Determine the acreage of the entire lake and the acreage of the wetland site under flooded conditions. This will require estimating the water surface level during floods which should be done using field observations such as debris lines or pollen rings on trees adjacent to the site.

c) Calculate the ratio between site storage volume and storage volume in the entire lake using the following relationship:

$$\text{ratio} = \frac{A_{sf} + A_{sn} + \sqrt{A_{sf}A_{sn}}}{A_{lf} + A_{ln} + \sqrt{A_{lf}A_{ln}}}$$

Where:

A_{sf} = site area, flooded conditions
A_{sn} = site area, normal water levels
A_{lf} = lake area, flooded conditions
A_{ln} = lake area, normal water levels

Impact Assessment - Since lacustrine sites are primarily water storage sites, most hydrologic concerns are raised when a proposed activity calls for placement of fill which results in loss of storage in the lake. To assess significance, the volume of fill material to be placed should be compared to the total storage volume available in the lake (computations would be similar to those in step 2c. above).

c) ***Floodplain Sites :***

Floodplain wetlands (especially floodplain forests) have a significant cumulative influence on the hydrologic characteristics of rivers. The soil holding capabilities of dense floodplain vegetation do not allow the river channel to meander in the floodplain as much as it would without this vegetation. Frictional drag offered by floodplain vegetation retards floodwaters and restricts most of the flow to the main channel.

Although the cumulative effects may be significant, individual floodplain wetland sites rarely exert a significant hydrologic influence on the river. Most rivers are simply too large for a single site to have a significant influence on flows. The exceptions to this include those wetland sites which directly influence a control point on the river, and those sites which are large enough that they account for a significant portion of the river's floodplain storage.

Three categories of floodplain wetlands are identified in this methodology: pool sites, control point sites, and other floodplain sites (table 1). Their hydrologic characteristics, methods for assessing their importance, and methods for impact assessment are given below.

Floodplain, Pool Sites :

Hydrologic Characteristics - Floodplain wetlands adjacent to pools in a river act as storage areas for floodwaters. These pool sites are very similar to lacustrine wetland sites in that the site accounts for only a portion of the storage available within the floodplain.

Site Importance - The analysis of lacustrine sites first focused on the importance of the lake within the watershed. This step is omitted in the analysis of floodplain pool sites because all pools are assumed to be important to the river's hydrology.

The following method for assessing the importance of floodplain pool sites focuses on the ratio between storage volume at the site and storage volume within the entire pool. If the ratio is greater than 0.1, the site should be considered important.

a) Delineate pool boundaries at 1) normal water levels, and 2) during flood flows. Pool boundaries should follow topographic contours and end at the downstream control point which forms the pool.

b) Determine the acreage of the wetland site at normal water levels (A_{sn}) and during flood flows (A_{sf}).

c) Determine the acreage of the entire pool at normal water levels (A_{pn}) and during flood flows (A_{pf}).

d) Use the acreages from steps "b" and "c" to compute the ratio between storage volume at the site and total storage volume within the pool.

$$\text{ratio} = \frac{A_{sf} + A_{sn} + \sqrt{A_{sf}\ A_{sn}}}{A_{pf} + A_{pn} + \sqrt{A_{pf}\ A_{pn}}}$$

where A_{sf} = site area, flood conditions
A_{sn} = site area, normal water levels
A_{pf} = pool area, flood conditions
A_{pn} = pool area, normal water levels

Impact Assessment - As with lacustrine sites, one concern with activities in floodplain-pool sites is loss of storage within the pool resulting from fill activities. To assess the significance of loss of storage volume, a ratio between volume of fill and total pool volume can be calculated as described for lacustrine sites.

Of greater concern with any activity in a floodplain is constriction of the floodplain so that water flow is significantly restricted in the vicinity of the proposed activity. As a general indication of the significance, the amount of constriction due to the project should be compared to the floodplain constriction at the closest upstream and downstream control points. The proposed action may significantly affect the hydraulic characteristics of the river if the postproject floodplain cross-sectional area at the evaluation site would be smaller than the cross -sectional area at either the upstream or downstream control point. For quantitative description of project effects, the expertise of a hydraulic engineer is required.

Floodplain, Control Point Sites :

Hydrologic Characteristics - Water flow is restricted past a hydrologic control point; hence, a pool is formed upstream of that point, and downstream flows are limited by the capacity of the channel at the control point. A wetland located at the control point can affect flows in two ways: (i) wetland vegetation may increase channel roughness, thereby restricting flows past the control point, and (ii) the wetland provides surface area for the conveyance of flows, thereby increasing capacity of the control point.

Site Importance - The importance of a wetland site located at a control point can be assessed by determining the proportion of total flows conveyed across the wetland site. This proportion is defined as Q_w/Q_t where Q_t is the total discharge through the control point and Q_w is the portion of Q_t which occurs over the wetland site.

Manning's equation can be used to calculate Q_w/Q_t.

$$\frac{1.49/n \ S^{1/2}(A_w)^{5/3}(W_w)^{-2/3}}{1.49/n \ S^{1/2}(A_t)^{5/3}(W_t)^{-2/3}}$$

If the value of n (roughness coefficient) is assumed to be constant, the expression for Q_w/Q_t reduces to:

$$(A_w/A_t)^{5/3}(W_w/W_t)^{-2/3} \quad \text{(equation 1)}$$

Where: A_t = total cross -sectional area
A_w = cross -sectional area above wetland site
W_t = total wetted perimeter
W_w = wetted perimeter underlying wetland site

Derivation of this expression is explained in appendix A. This expression forms the basis of the method for assessing site importance. The method is explained below and is illustrated with an example in figure 13.

a) Construct a cross section of the control point at its narrowest point. Show the estimated flood peak elevation and the limits of the evaluation site on the cross section.

b) Calculate the total cross -sectional area (A_t) and the total wetted perimeter (W_t) below the flood peak elevation.

c) Calculate the cross -sectional area above the wetland site (A_w) and the wetted perimeter which underlies the wetland site (W_w).

d) Compute Q_w/Q_t using equation 1, and assign an *importance rating* to this value as follows:

$Q_w/Q_t < 0.1$ — the probability the site significantly affects flows is low.

$0.1 < Q_w/Q_t < 0.2$ — the probability the site significantly affects flows is moderate.

$0.2 < Q_w/Q_t$ — the probability the site significantly affects flows is high.

Impact Assessment - If the wetland site is not important (as determined by the preceding calculations), a proposed activity which is restricted to that site would probably have no significant effect on flows. However, if the preceding calculations indicate a moderate or high probability of significance, the following types of activities would be likely to affect flows.

a) *Alteration of Cross-sectional Area* - Any excavation or fill activities that significantly change the cross-sectional area or wetted perimeter of the site are likely to result in changes in upstream and downstream water levels. If the cross—sectional area is decreased, control capacity will also decrease and upstream water levels will generally go up.

b) *Alteration of Roughness* - Removal of thick, woody vegetation will decrease the roughness of the control point, thereby increasing flow velocity at the point. The result would be a tendency toward lower water levels upstream of the site and increased downstream flows.

In some situations, it is possible to get an indication of the magnitude of effects using Manning's equation. Descriptions of these situations, assumptions required, and how Manning's equation should be used are given in appendix A. Wetland sites or proposed activities not meeting the assumptions should be analyzed by a hydraulic engineer.

Other Floodplain Sites :

Hydrologic Characteristics - Floodplain wetland sites, other than sites located at a control point or adjacent to a pool, have very little effect on flows in a river. Wetland vegetation may retard overbank flows during floods, but in most situations, the major portion of total discharge is concentrated in the main channel. The only situation in which these types of sites may cause hydrologic concern is if a proposed action would significantly decrease floodplain area, thereby creating a *control point*. This is more a consequence of a proposed action than a hydrologic characteristic of the wetland site.

Site Importance - The probability of other floodplain sites having a significant effect on stream hydrology is generally low. This includes other floodplain sites with either large or small effective watersheds.

Impact Assessment - The only activities of concern at other types of floodplain sites are activities that would significantly constrict the floodplain, thereby creating a control point. To determine if an activity might create a control point, the amount of constriction due to the proposed action should be compared to floodplain constriction at the closest upstream or downstream control point. The proposed action may significantly affect hydrologic characteristics if the postproject floodplain cross—sectional area at the evaluation site would be the same size or smaller than the cross--sectional area at a nearby control point. If a significant effect is indicated, a hydraulic engineer should be contacted for quantitative analysis.

DOWNSTREAM DAMAGE POTENTIAL

The following procedures should be used for analysis of downstream damage potential regardless of wetland site type or size of the effective watershed. The downstream damage potential rating is an indicator of the relative magnitude of flood damages that might occur if an area downstream of the wetland were to flood. The method utilizes the principle that a wetland's effect on flows decreases with distance downstream due to attenuation caused by the channel (and/or other wetlands) and addition of runoff from other watersheds. It considers differences in flood damage potential related to land use and assumes that the wetland will have no appreciable effect on floodwaters below a point 5 miles downstream of the outlet. The rating does not consider whether or not the downstream area is prone to flooding or the frequency of flooding. It does not incorporate any consideration of the effect of the wetland site on peak flows and is therefore meant to stand as an independent measure.

Step 1: Identify Downstream Area of Influence - The downstream area of influence of the wetland site ends at the closer of the following points:

a. 5 miles downstream of the wet basin.

b. The confluence of a tributary that has a channel capacity equal to or larger than as the channel from the wet basin.

c. (Palustrine and lacustrine sites only) A downstream lake or wetland of approximately the same size as the wet basin under evaluation.

Step 2: Identification of Downstream Reaches - Beginning at the outlet of the wet basin, divide the downstream area of influence into 1-mile reaches.

Step 3: Characterization of Land Use Value - Up to the endpoint of the area of influence, determine the average land use near the channel in each reach, and obtain a land use score from the following table.

	Land Use				
Reach/Mile	Urban	Mixed Urban/Ag	Row Crops/ Small Grains	Other Ag	Other
Reach 1: 0-1 mile*	45	35	25	15	5
Reach 2: 1-2 miles	25	20	15	10	4
Reach 3: 2-3 miles	15	12	9	6	3
Reach 4: 3-4 miles	10	8	6	4	2
Reach 5: 4-5 miles	5	4	3	2	1

*Distances are the distance below the wet basin's outlet.

Step 4: Determination of Downstream Damage Potential - The sum of the values from step 3 should be used in the following table to get a qualitative rating of downstream damage potential.

Sum of Land Use Values	Damage Potential Rating
>50	High
49 - 25	Medium
<25	Low

The above procedure is applicable to both isolated and non-isolated wetlands. Applying the procedure to non-isolated wetlands is straightforward. For isolated wetlands, the downstream area of influence should begin at the outlet of the wet basin, take the shortest route to the nearest stream channel, and follow that channel until one of the conditions in step 1 is met.

Directions for use of the nomographs

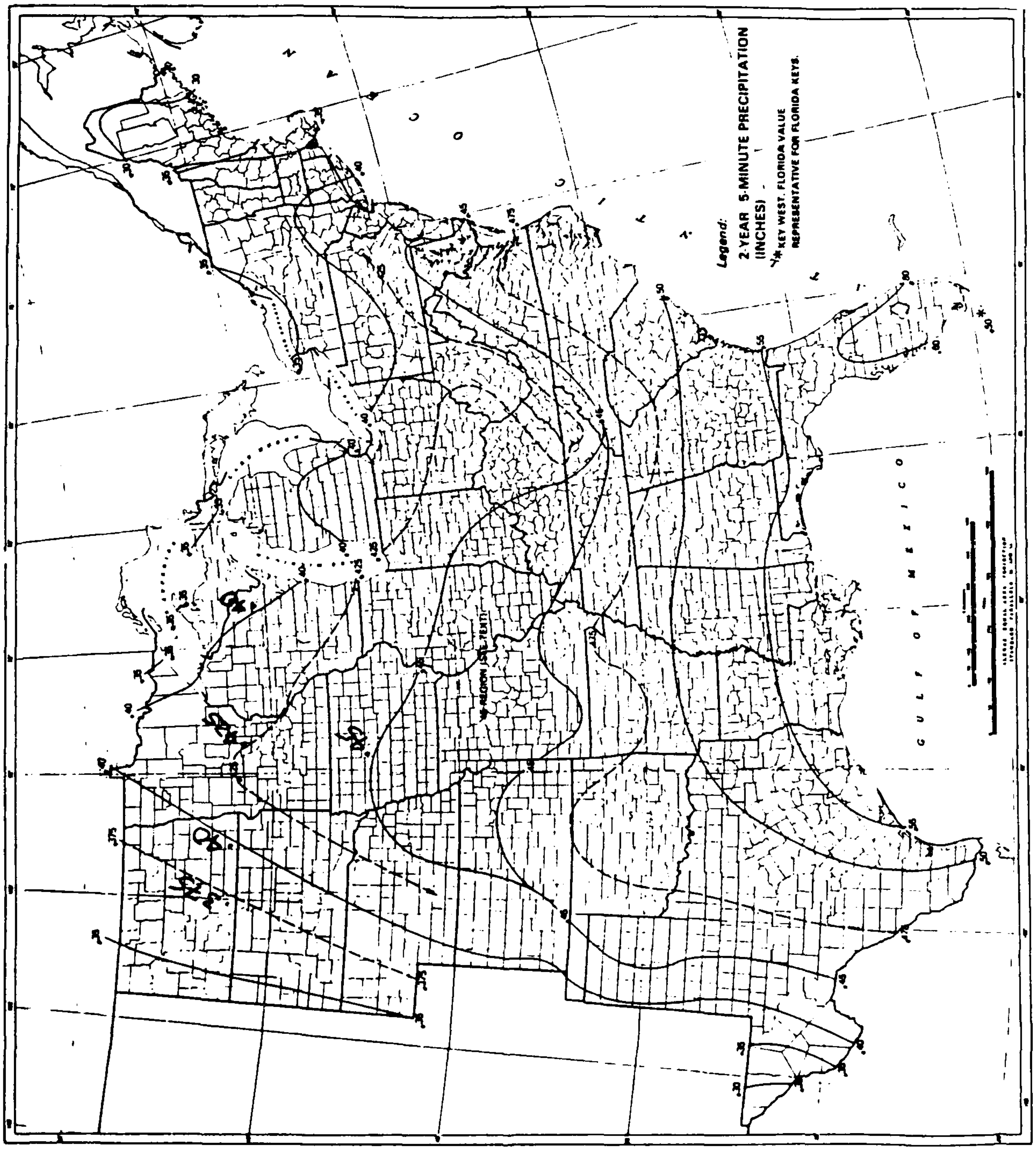
Figures 12a through 12g are used to determine the discharge values required for step 6b of the Flood Flow Characteristics section. The computer uses these values to construct an outlet rating curve to develop outflow hydrographs for the basin. The outflow and inflow hydrographs are compared to determine the effects of the basin on peak flow reduction.

The nomographs must be used to determine discharge values for outlet types other than channels or weirs. The discharge values must be entered by the user when the program asks for them. If more detailed discharge information is available, it can be used in place of the nomographs.

To use the nomograph, you must know the diameter or height of the culvert, the headwater depth in diameters (height of water above the bottom of the culvert divided by the culvert diameter), and the type of entrance the culvert has. These entrance types are illustrated in figure 12. You must select the nomograph that corresponds to the type of outlet under consideration, then select the headwater depth scale that corresponds to the entrance type found on the outlet in question. Two or three entrance types are described on each nomograph.

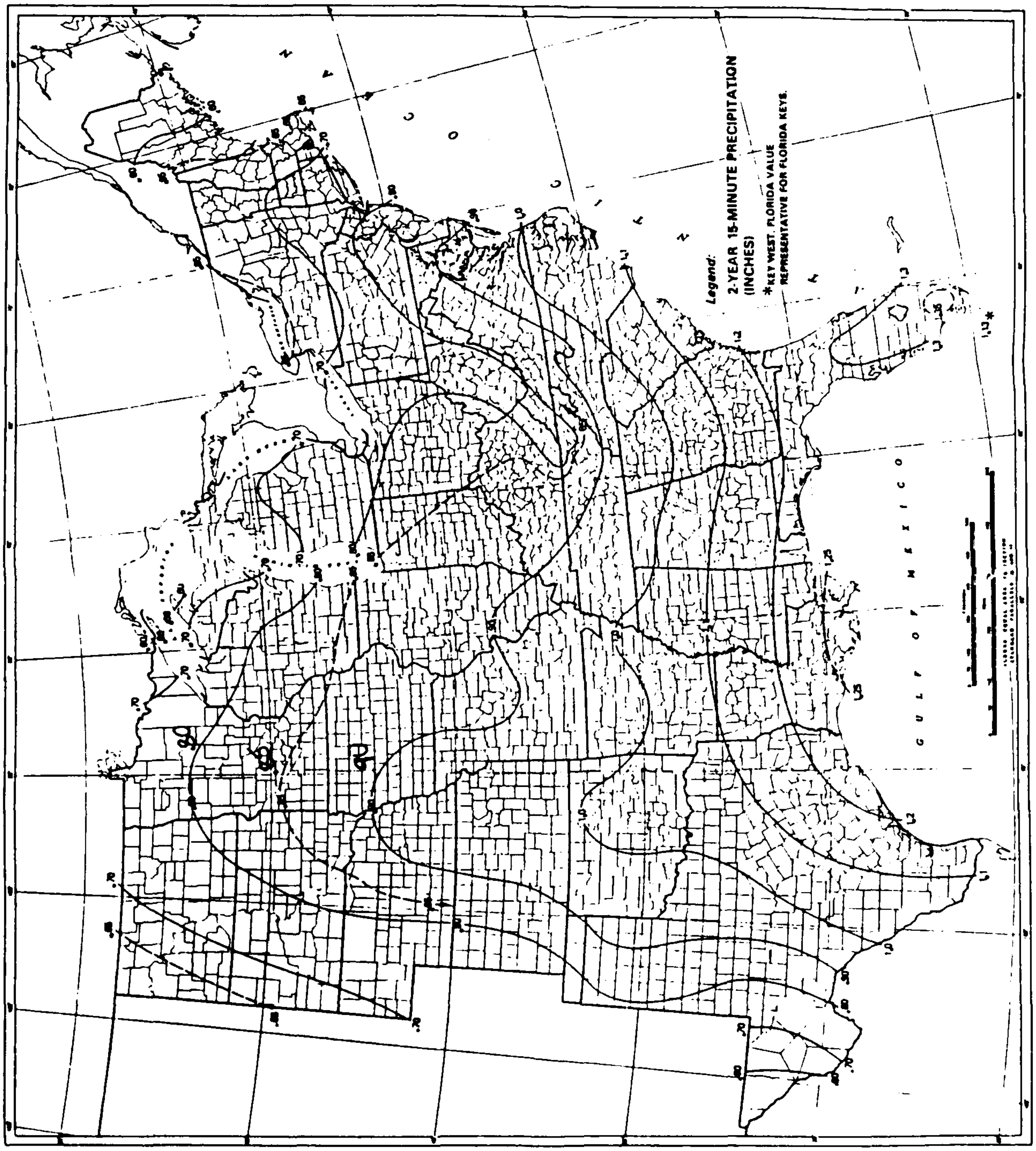
To read the discharge value, connect the culvert diameter with the headwater depth-in-diameters with a straightedge. The discharge value can be read at the point where the straightedge crosses the discharge scale. Note that only the depth-in-diameter scale nearest the discharge scale can be used. If the culvert entrance type corresponds with the middle or right-hand depth-in-diameters scale, the user must bring that value over to the left scale, then connect that point to the correct value on the diameter scale with a straightedge. Again the discharge value is the point where the straightedge crosses the discharge scale and are given in cubic feet per second or cfs. Examples are found on each nomograph.

FIGURE 2: 2-YEAR, 5-MINUTE RAINFALL



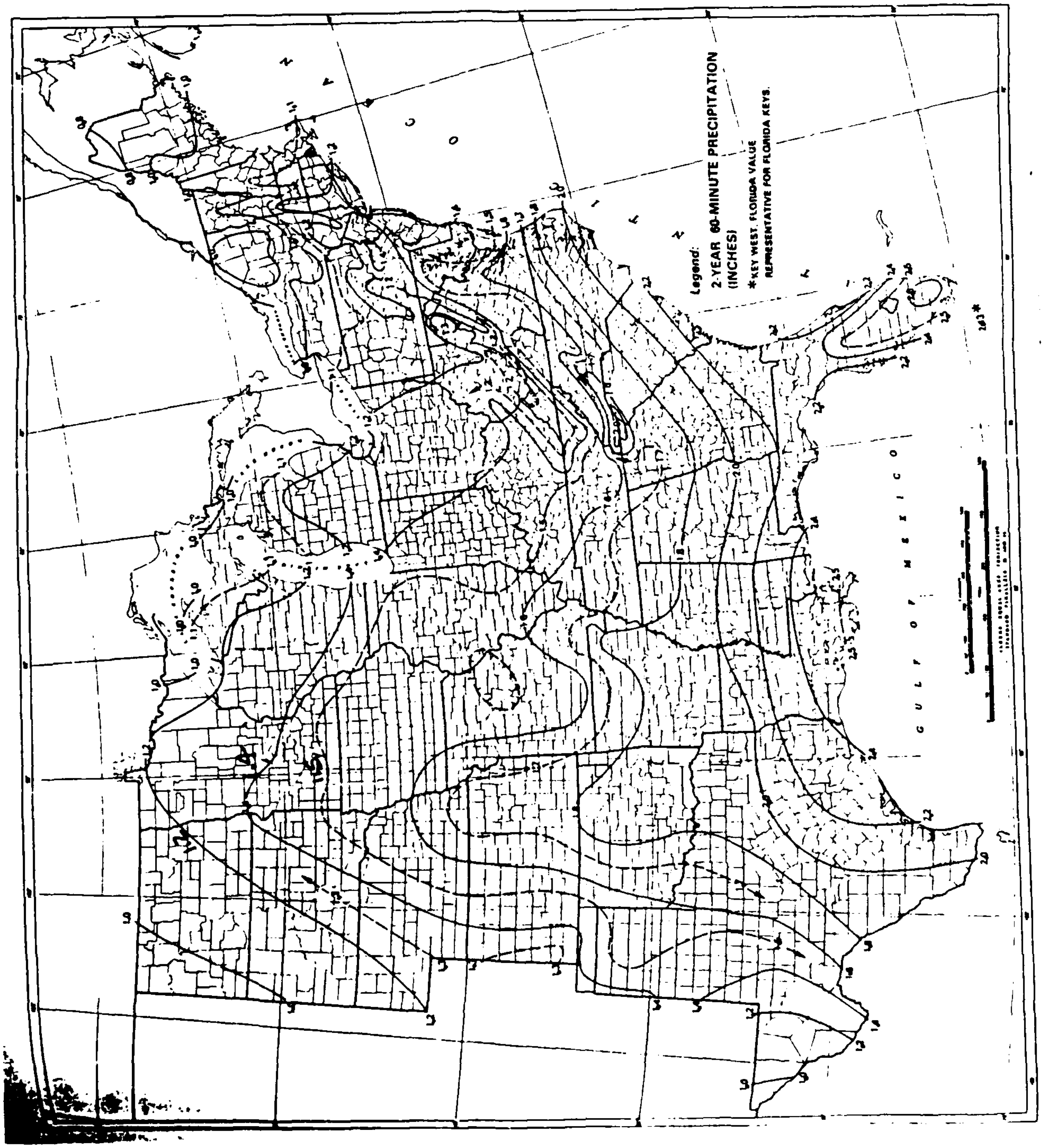
SOURCE: NWS HYDRO-35

FIGURE 3: 2-YEAR, 15-MINUTE RAINFALL



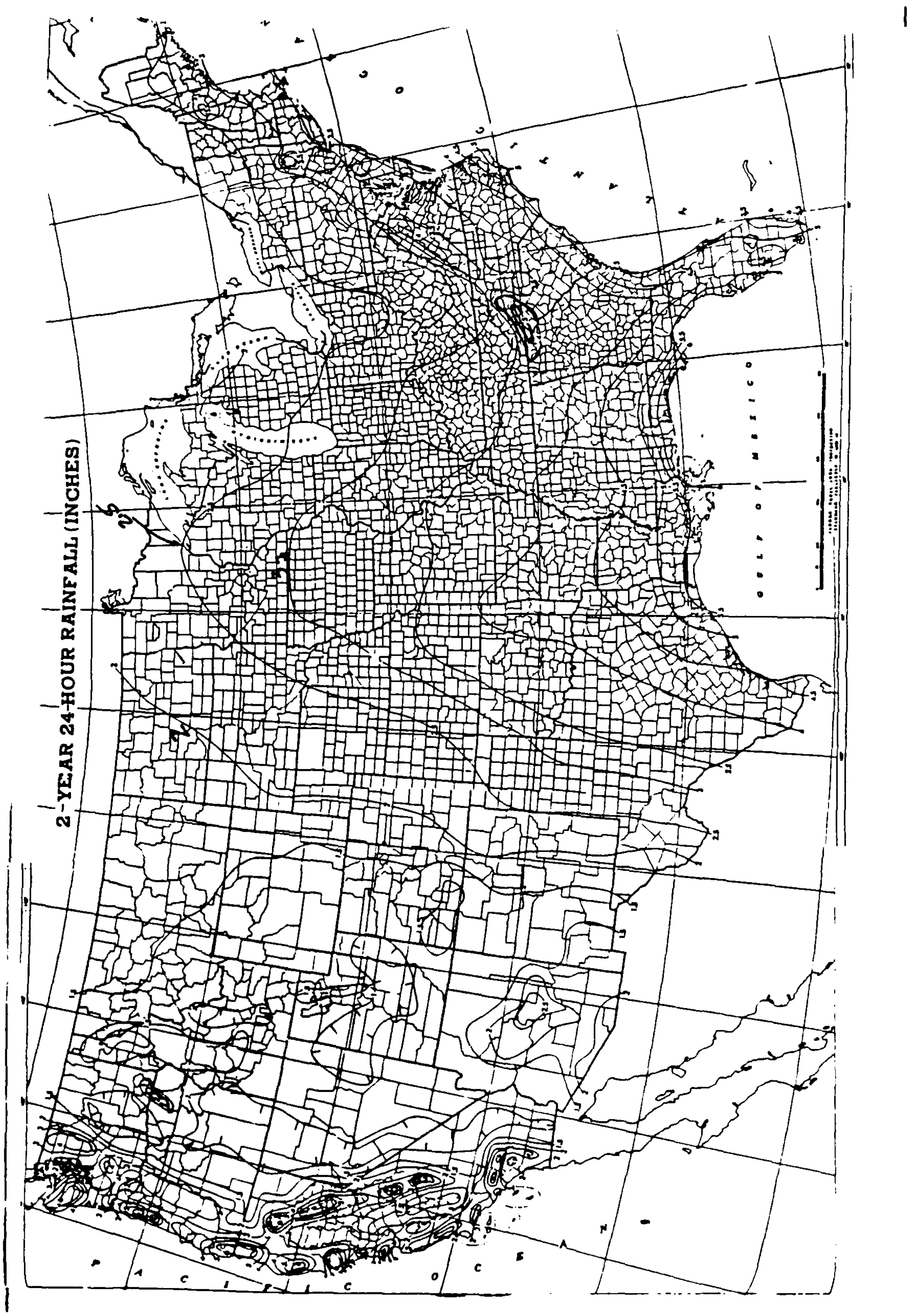
SOURCE: NWS HYDRO-35

FIGURE 4: 2-YEAR, 1-HOUR RAINFALL



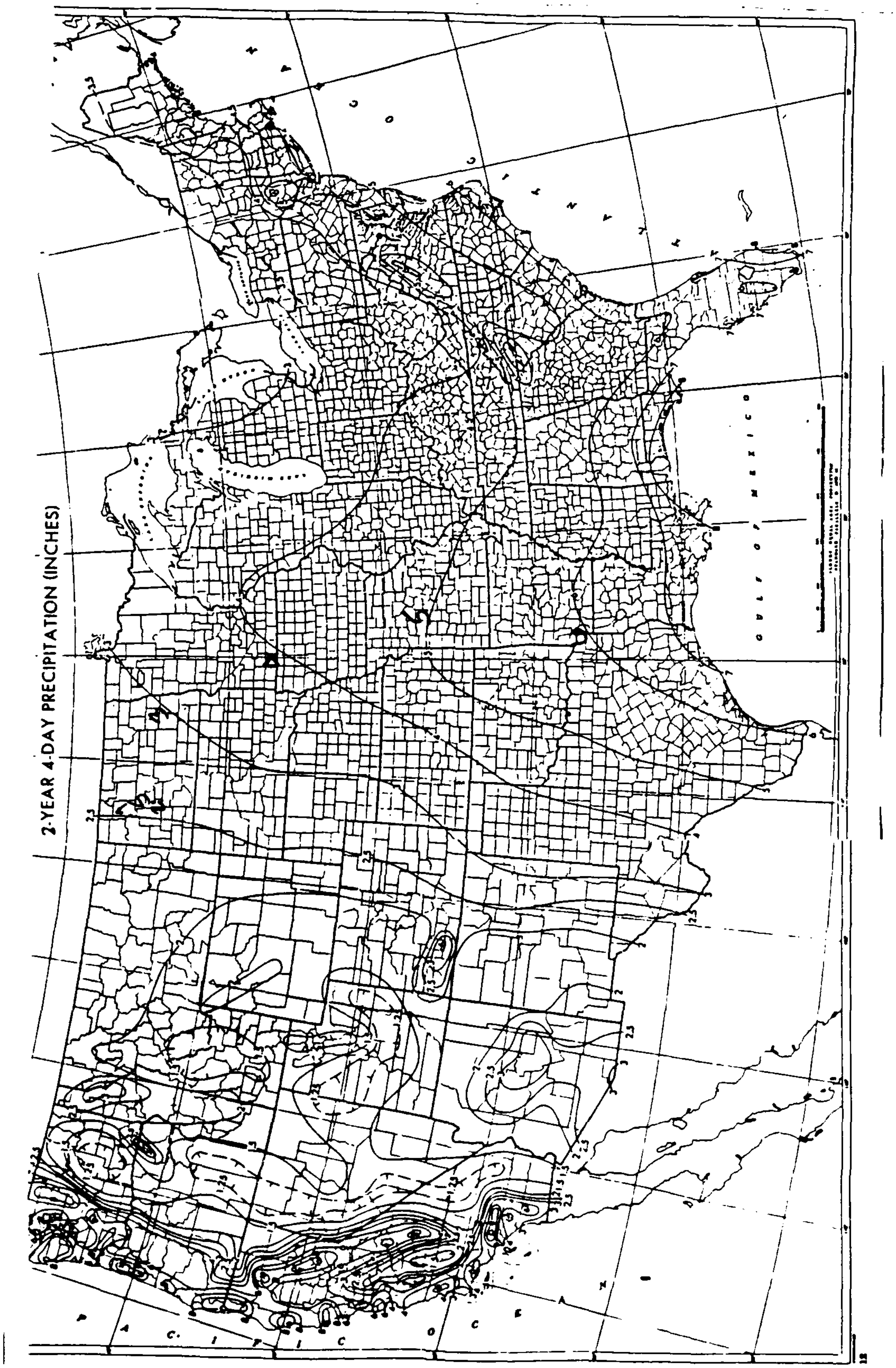
SOURCE: NWS HYDRO-35

FIGURE 5: 2-YEAR, 24-HOUR RAINFALL



SOURCE: USWB TP-40

FIGURE 6: 2-YEAR, 96-HOUR RAINFALL

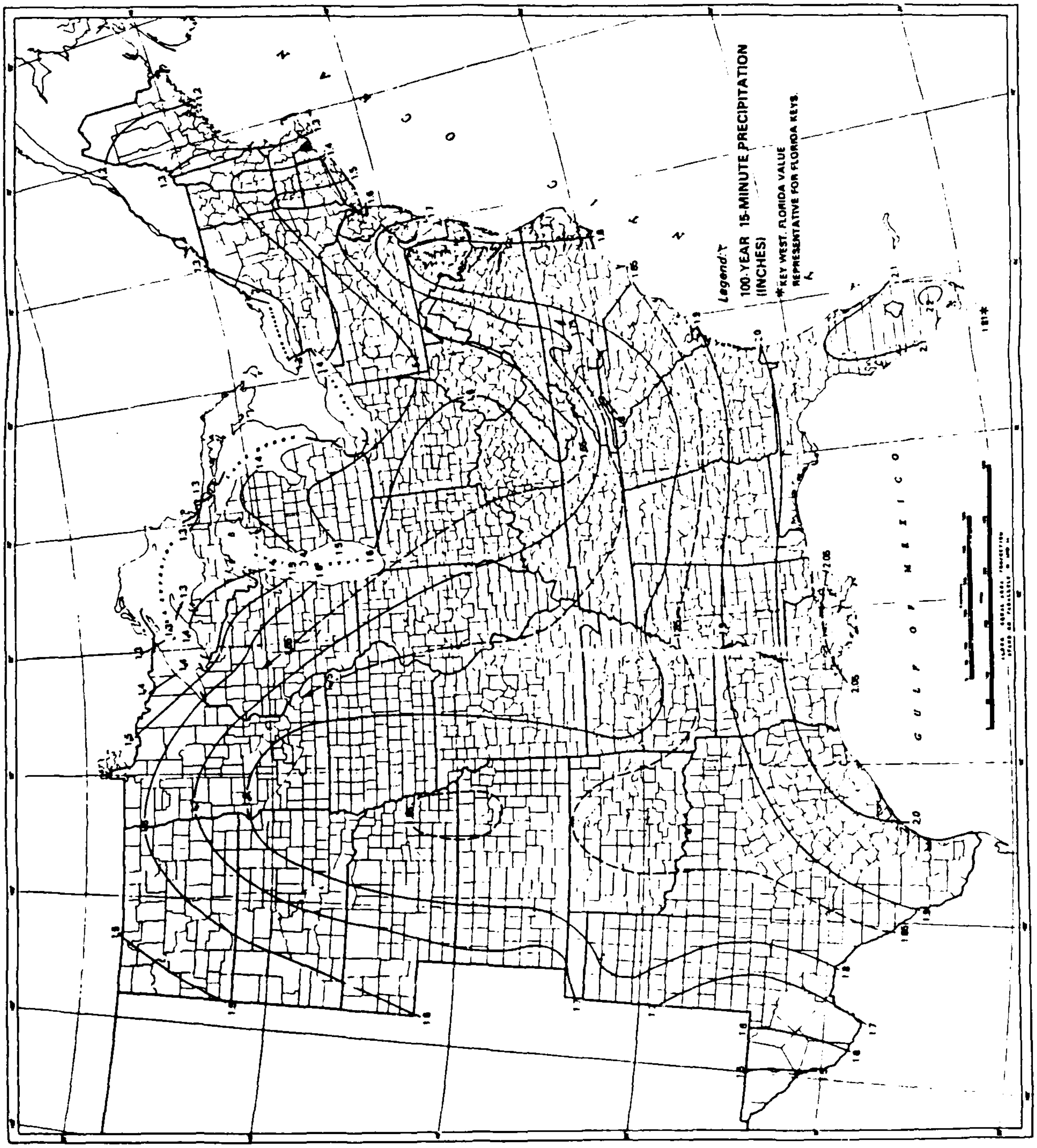


SOURCE: USWB TP-40

FIGURE 7: 100-YEAR, 5-MINUTE RAINFALL

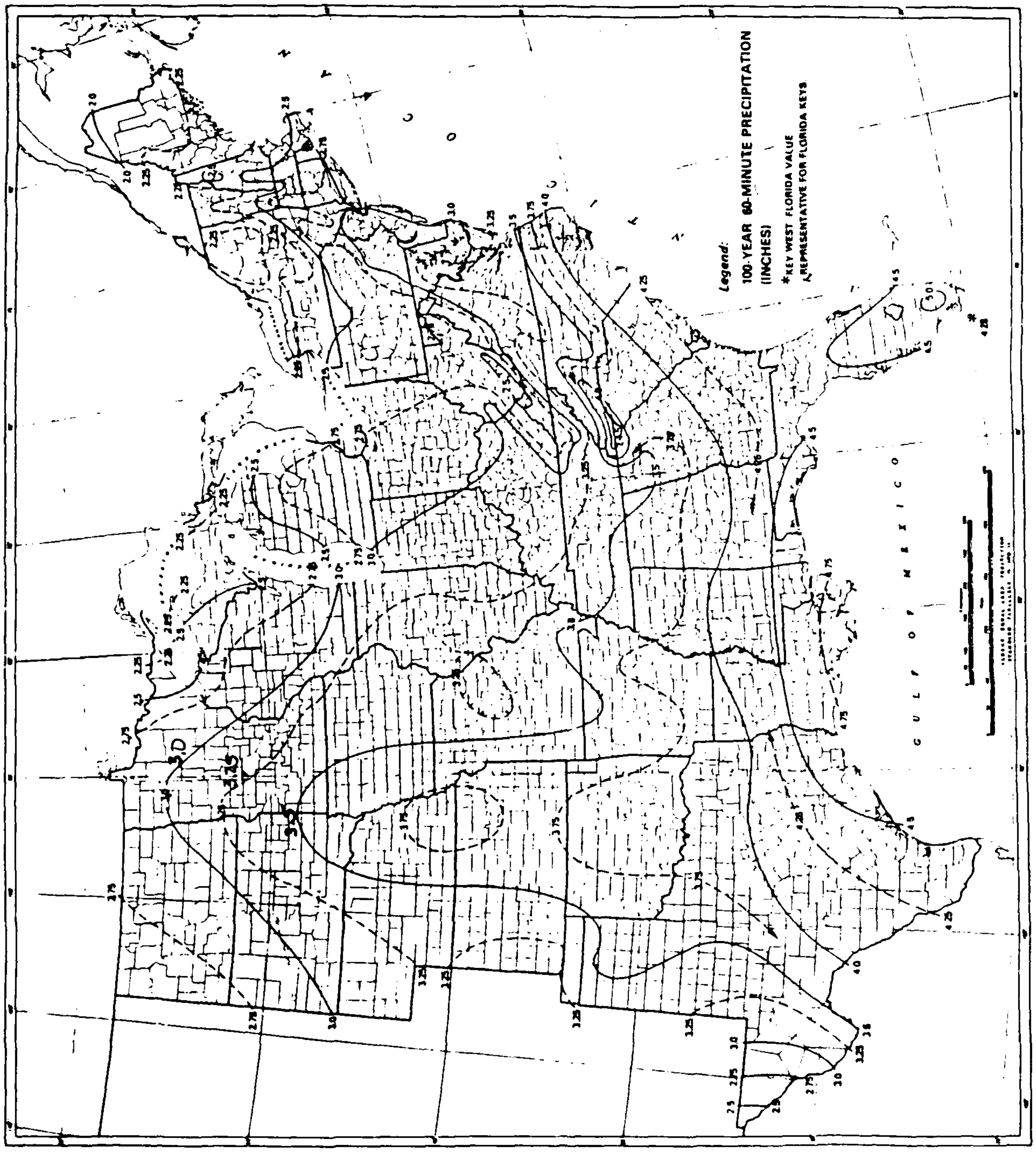
SOURCE: NWS HYDRO-35

FIGURE 8: 100-YEAR, 15-MINUTE RAINFALL



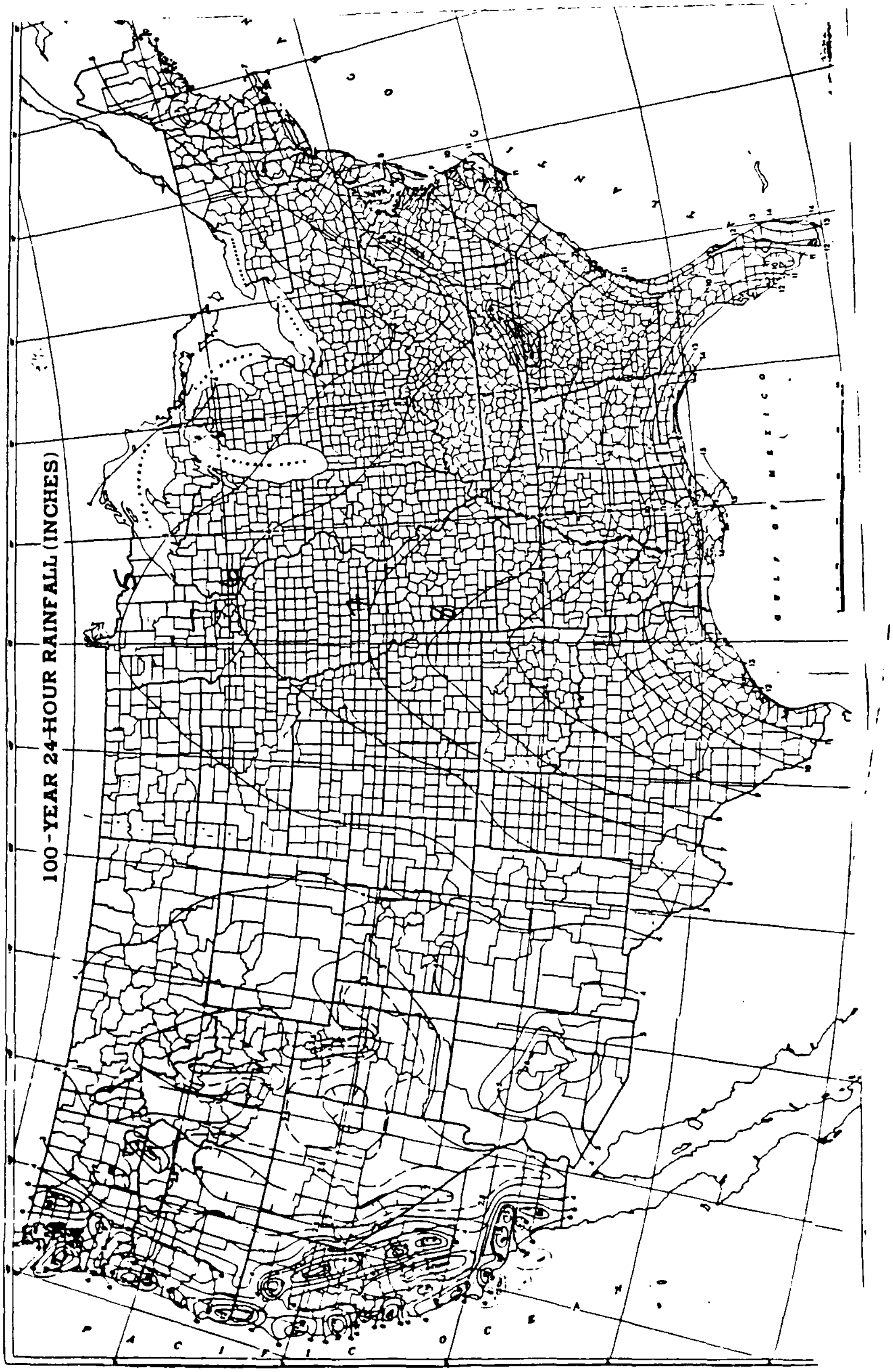
SOURCE: NWS HYDRO-35

FIGURE 9: 100-YEAR, 1-HOUR RAINFALL



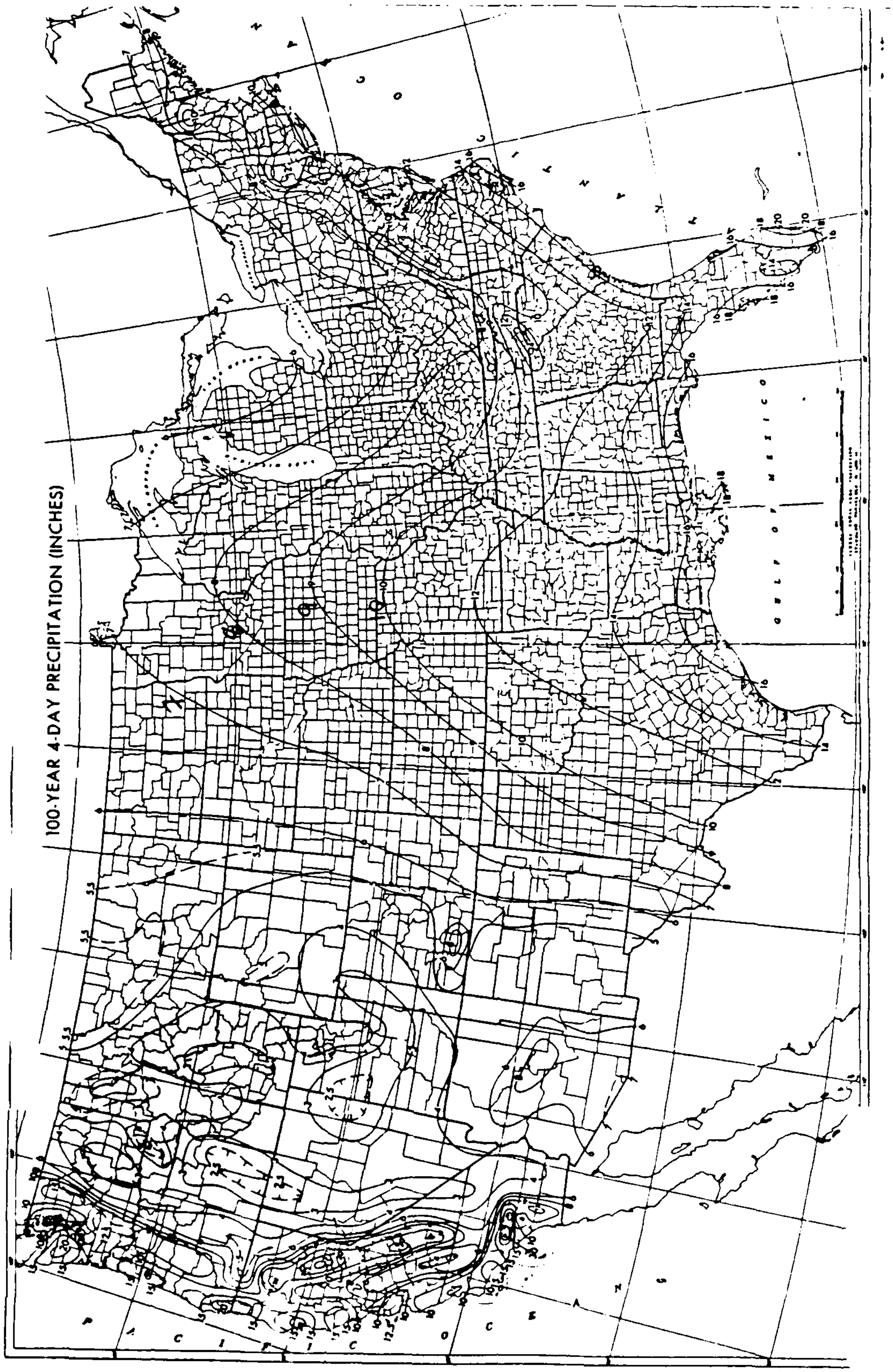
SOURCE: NWS HYDRO-35

FIGURE 10: 100-YEAR, 24-HOUR RAINFALL



SOURCE: USWB TP-40

FIGURE 11: 100-YEAR, 96-HOUR RAINFALL

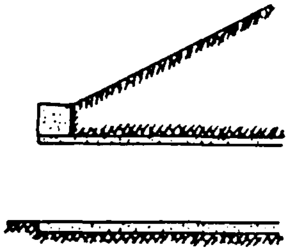


SOURCE: USWB TP-40

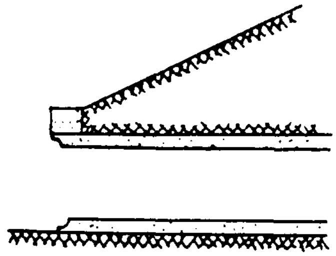
FIGURE 12: Culvert Entrance Types

(a) Concrete Culverts:

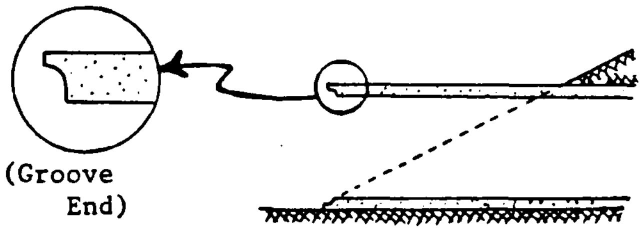
(i) Square edge with headwall:



(ii) Groove end with headwall:

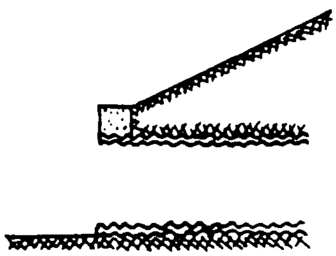


(iii) Groove end projecting:

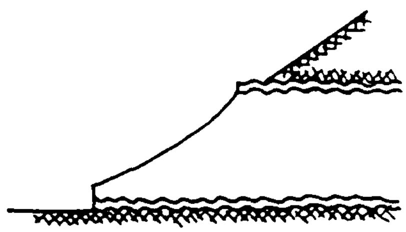


(b) Corrugated Metal Culverts:

(i) Headwall:



(ii) Mitered to conform to slope:



(iii) Projecting:

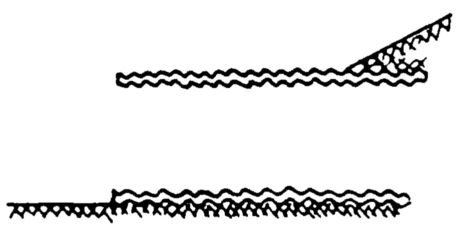


FIGURE 12: Culvert Entrance Types (con't.):

(c) Beveled Ring Inlet Control:

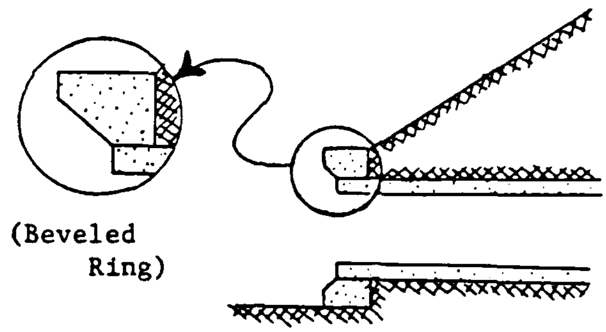


FIGURE 12a Nomograph For

CORRUGATED METAL PIPE CULVERTS

(Inlet Control)

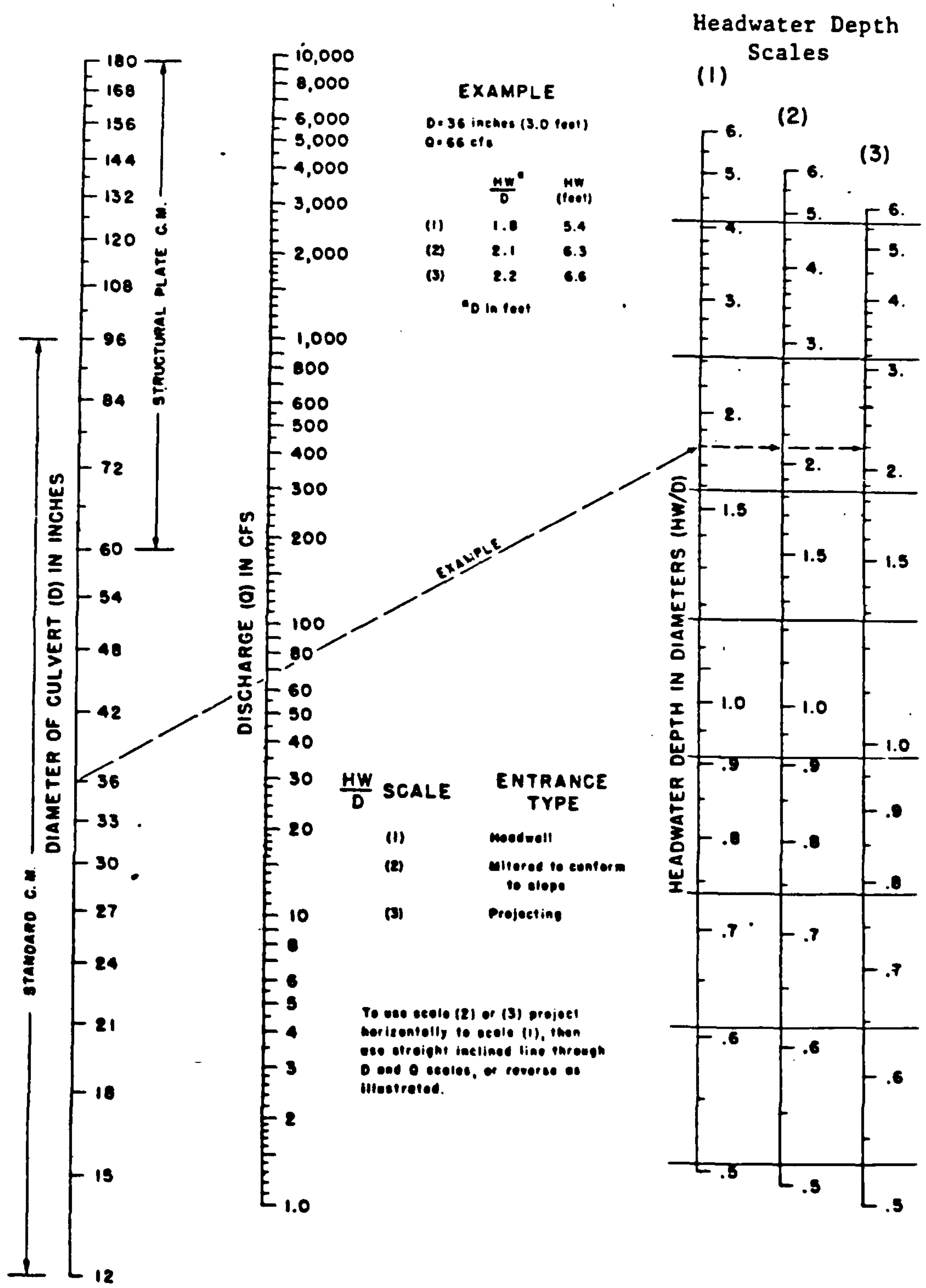


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FIGURE 12b

Nomograph For

BOX CULVERTS

(Inlet Control)

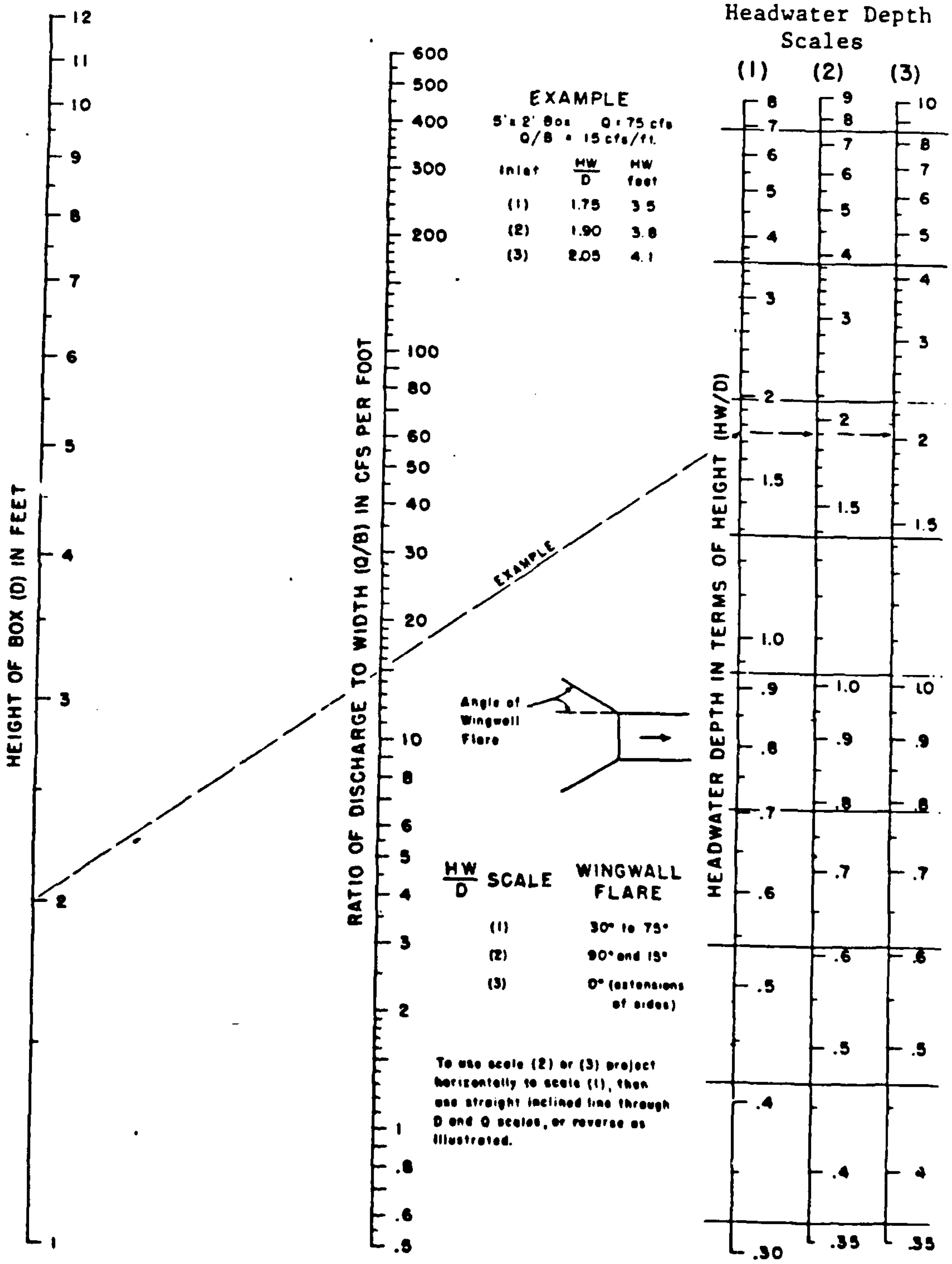

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FIGURE 12c

Nomograph For

CONCRETE PIPE CULVERTS

(Inlet Control)

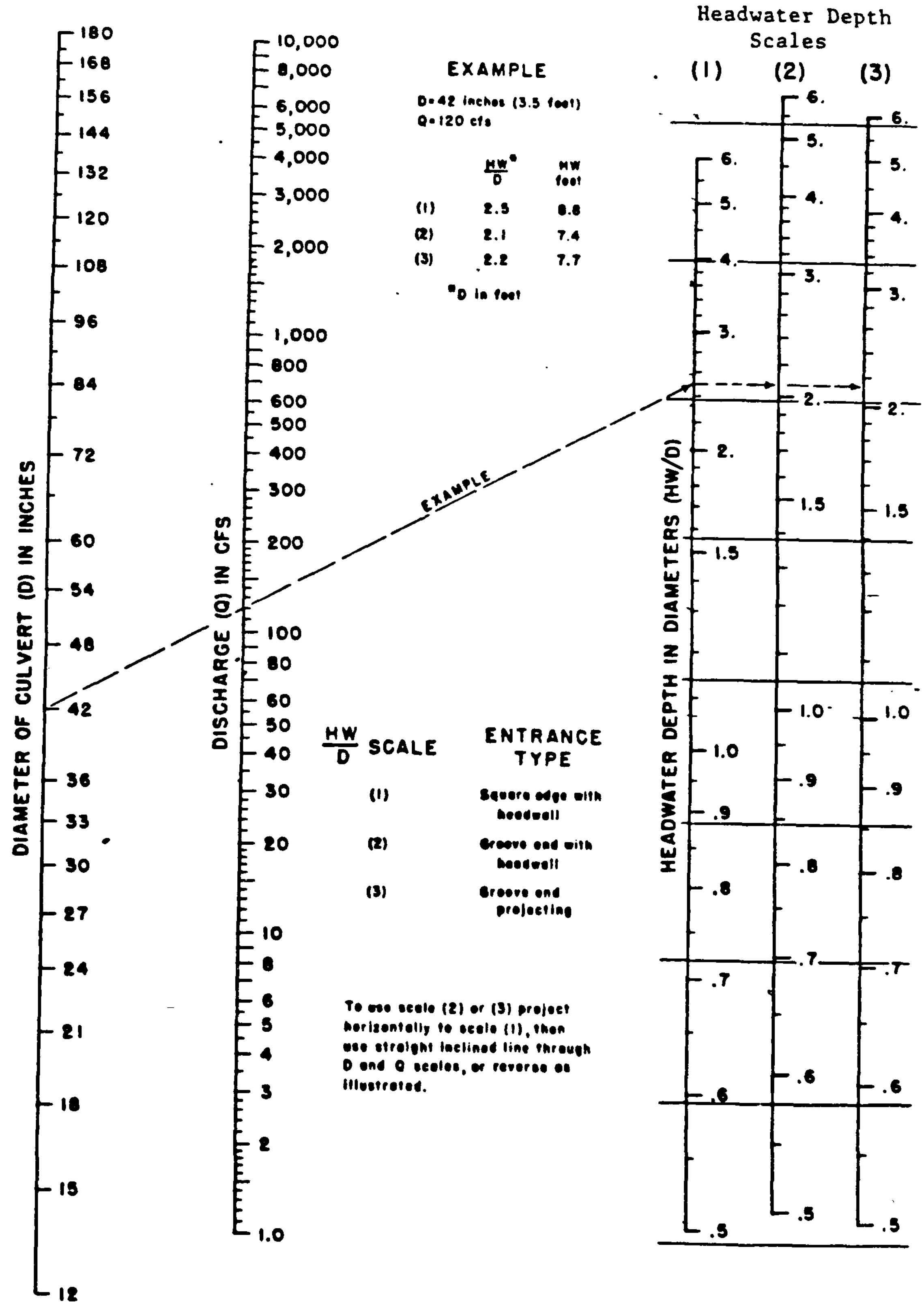

FIGURE 12d

Nomograph For

OVAL CONCRETE PIPE CULVERTS--LONG AXIS HORIZONTAL

(Inlet Control)

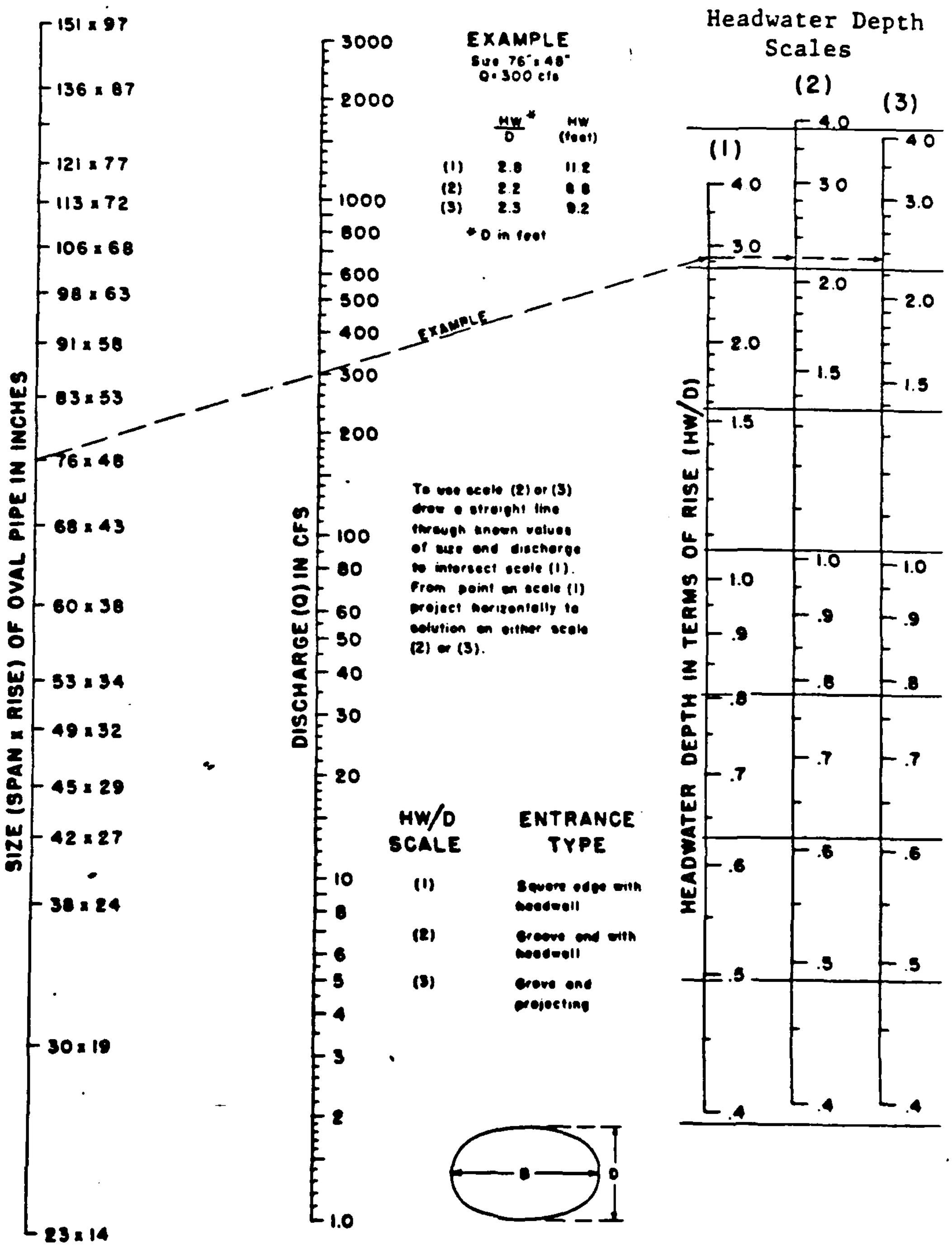

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FIGURE 12e

Nomograph For

OVAL CONCRETE PIPE CULVERTS--LONG AXIS VERTICAL

(inlet Control)

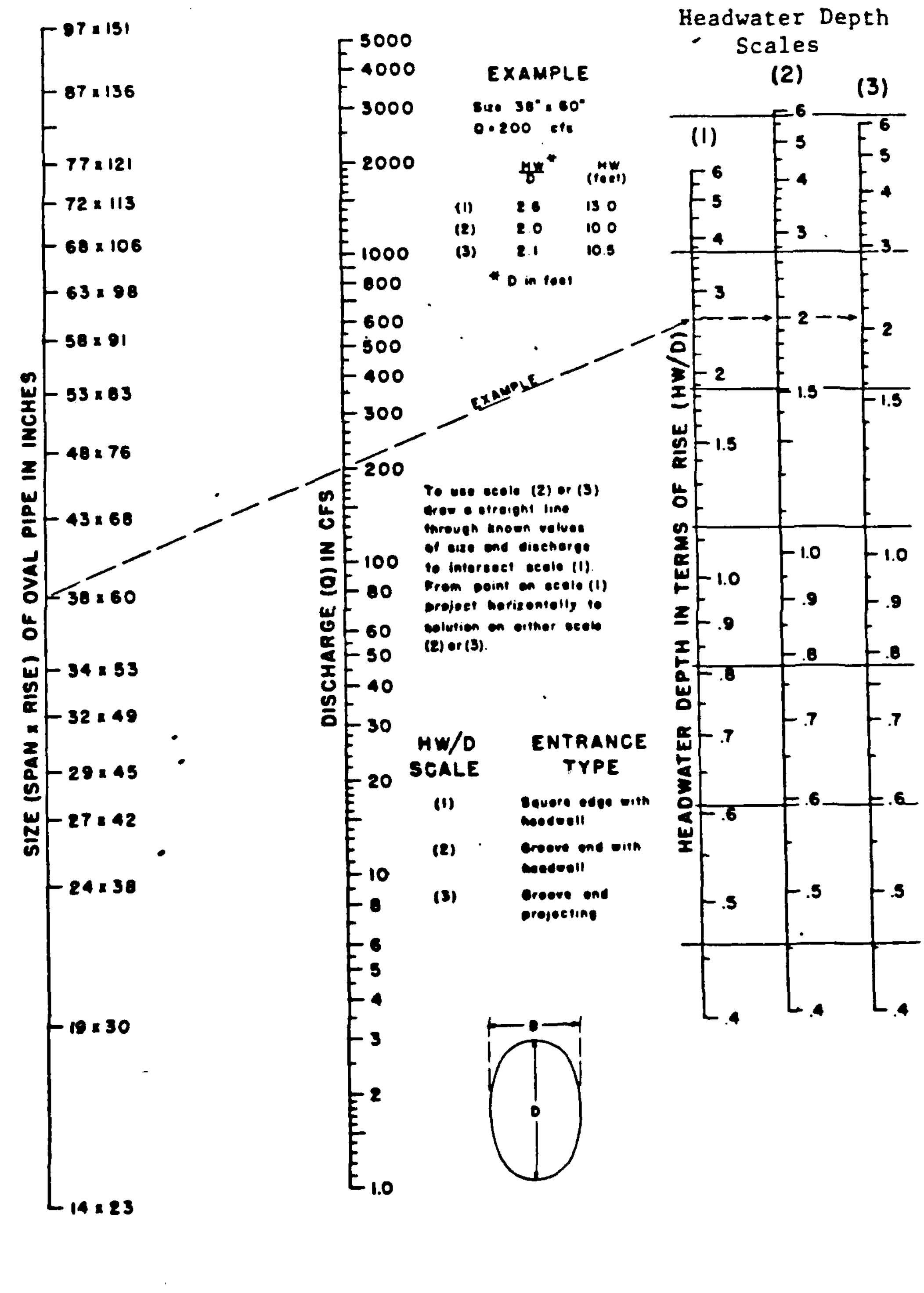

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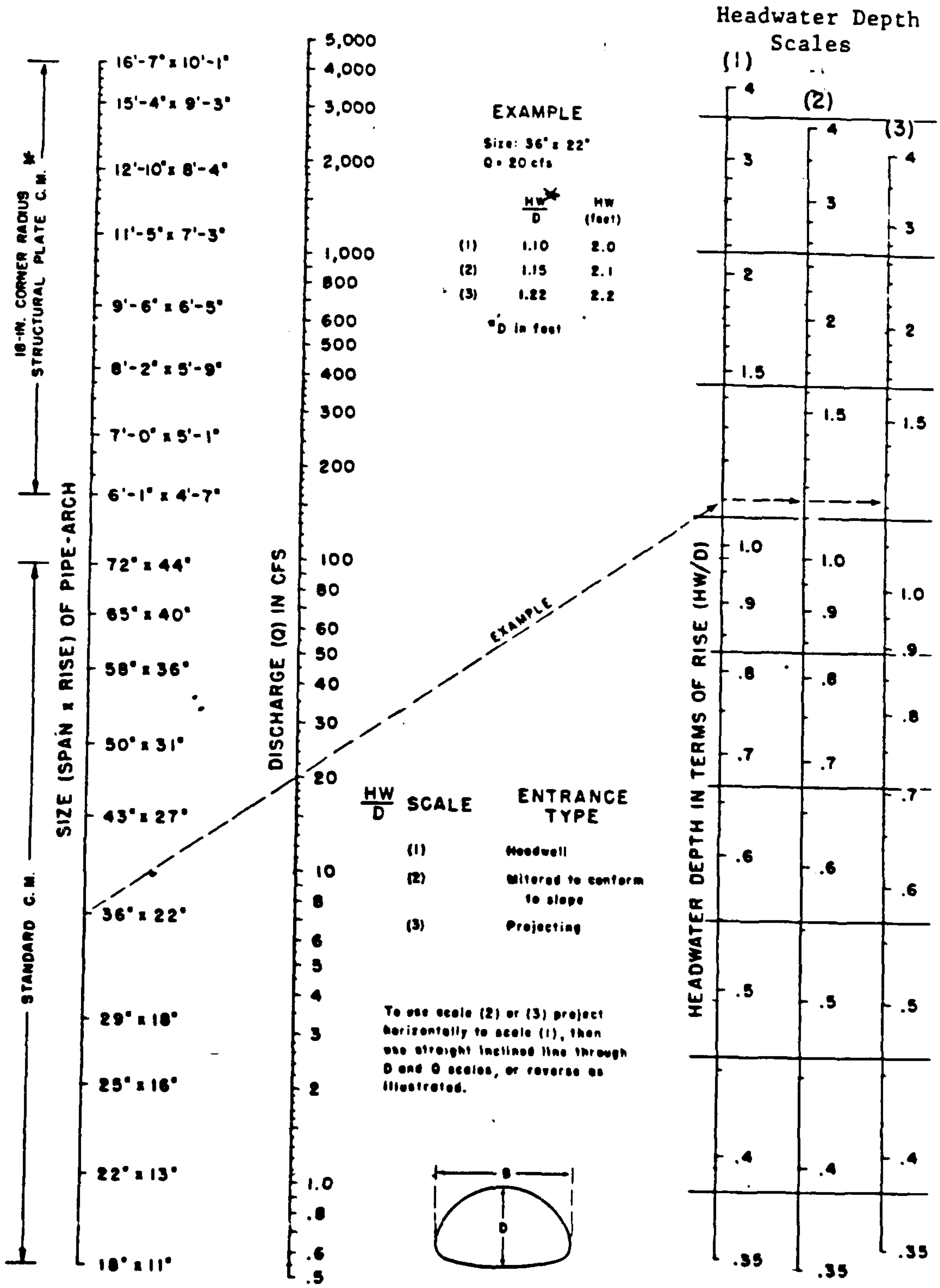
FIGURE 12f

Nomograph For

CORRUGATED METAL PIPE-ARCH CULVERTS

(Inlet Control)



*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

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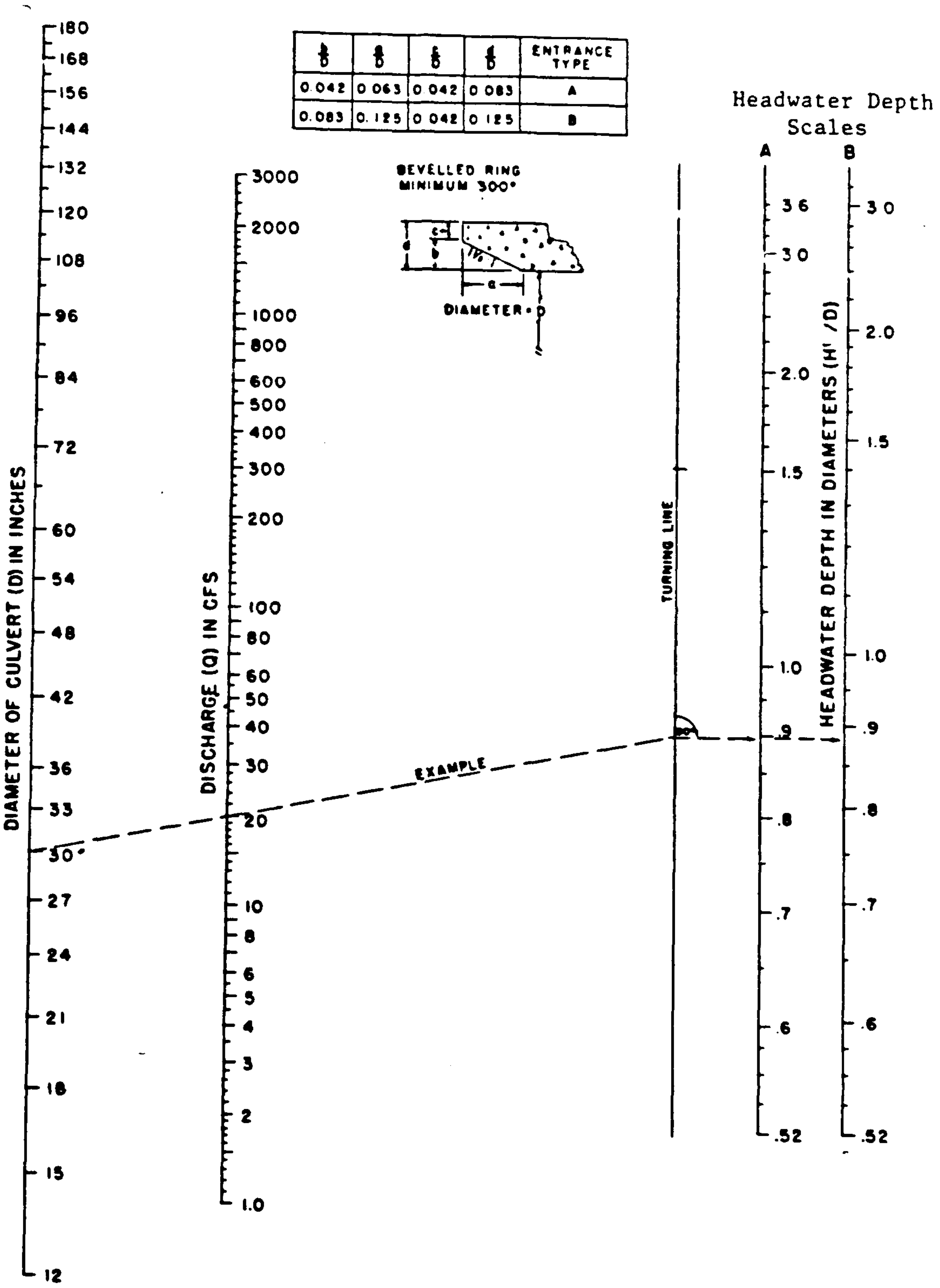
FIGURE 12g

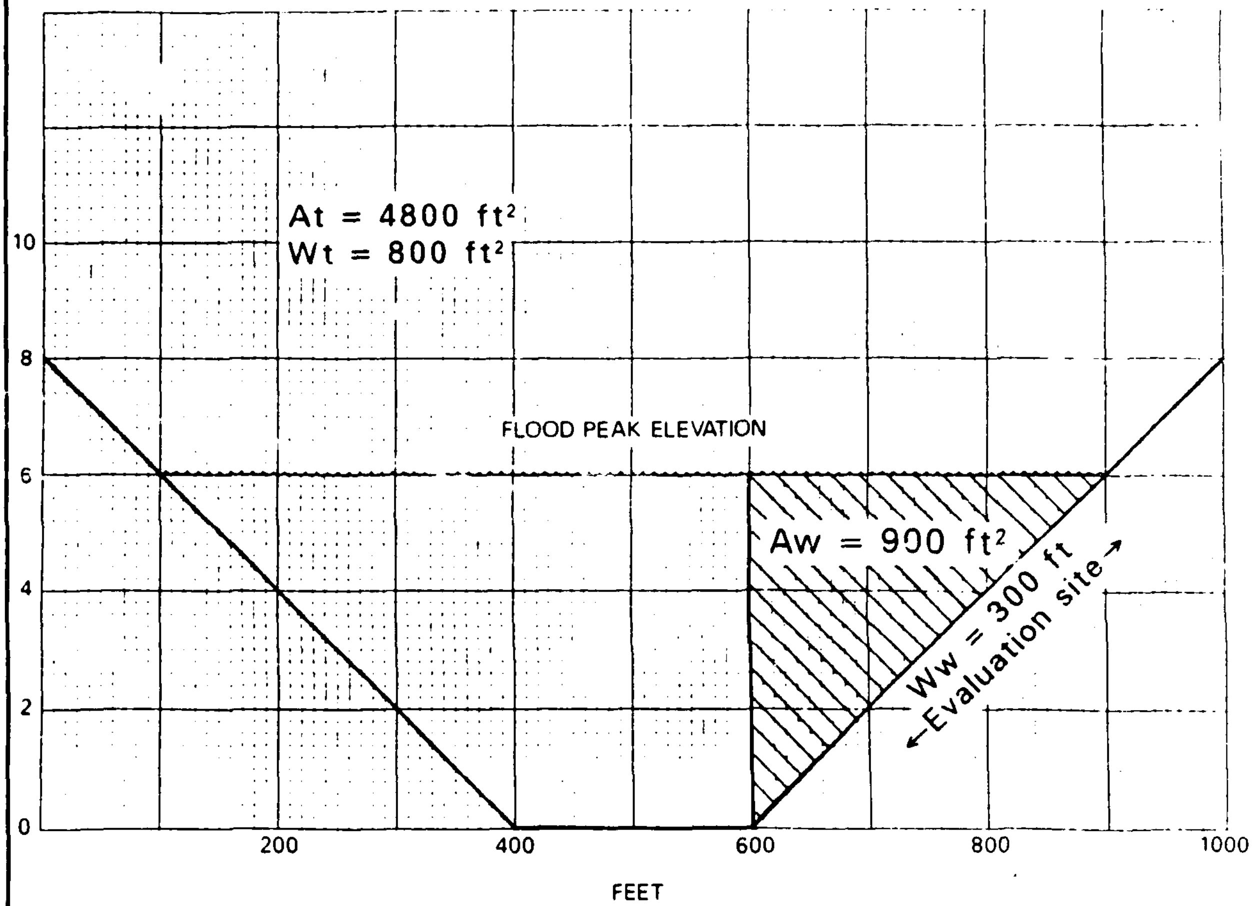
Nomograph For CIRCULAR PIPE CULVERTS WITH BEVELED RING (Inlet Control)

b/D	a/D	c/D	d/D	ENTRANCE TYPE
0.042	0 063	0.042	0 083	A
0.083	0.125	0 042	0 125	B



FEDERAL HIGHWAY ADMINISTRATION
MAY 1973

Figure 13. Sample computation of site importance floodplain-control point site.



$$Qw/Qt = (Aw/At)^{5/3}(Ww/Wt)^{-2/3} = (900/4800)^{5/3}(300/800)^{-2/3} = 0.118$$

The probability the site significantly affects flows is <u>moderate.</u>

WATER QUALITY

INTRODUCTION

A function commonly ascribed to wetland areas is the improvement of water quality through removal of sediment and nutrients from water flowing through the wetland. The water quality function is quite closely tied to flood flow characteristics in this methodology since water velocity during high flows is considered the primary physical process controlling the degree to which a wetland affects water quality. The relationship between flood flow characteristics and water quality functions is maintained in the following procedures by using a detention time estimate from the preceding section in the analysis of wetland effectiveness as a sediment and nutrient trap.

In this method, no distinction is made between the sediment and nutrient aspects of water quality except when wetland trapping efficiency is being analyzed. In computing trap efficiency, phosphorus is used as an indicator of the levels of all nutrients. It is assumed that phosphorus is present in proportion to the surface area of sediment particles coming into the wetland (see appendix B).

Procedures for analyzing the water quality function of a wetland site are broken into three components: (i) sediment and nutrient input, (ii) wetland trap efficiency, and (iii) downstream sensitivity. The remainder of this section describes the methods for rating each of these components.

SEDIMENT AND NUTRIENT INPUT

The following procedure rates the relative amount of sediment/nutrient input to the wetland on a qualitative scale (high, moderate, low). It utilizes general watershed characteristics and examines potential sediment and nutrient sources.

Step 1: Sediment/Nutrient Contribution Area - Delineate the sediment/ nutrient contribution area, which is defined as that portion of the watershed that lies between the wetland's outlet and the closer of the following points:

a) the upstream boundary of the watershed

b) a point 5 miles upstream of the inlet to the wet basin ("Wet basin" is the topographic depression that contains the wetland site and adjacent deep water areas. Refer to definition on the first page of the Flood Flow Characteristics section.)

Step 2: Characterization of the Contribution Area - Characterize the sediment/nutrient contribution area using the following categories and rank this characterization using the criteria in table 4.

a) *Average Slope* - The average slope of the sediment contribution areashould be computed using several measurements of slope from a topographic map.The ranking in table 4 reflects the fact that steeper slopes result in greater sediment discharge from the watershed.

b) *Land Use* - The amount of sediment and nutrient discharged from a watershed is very dependent on the land use practices in the watershed. Examples of high and moderate sediment/nutrient generating activities are given in table 5.

c) *Soil Erodibility Factor* - Determine the average soil erodibility factor ("K-factor") for land immediately surrounding the wetland. "K-factors" are listed by soil type in table 7.

d) *Predominant Flow Patterns* - Channelized flow (channelized streams, drainage ditches, tile drains, urban storm sewers, etc.) generally has higher velocity and greater capability for nutrient and sediment transport. Contribution areas with drainage patterns that are primarily channelized or otherwise artificially enhanced are ranked higher in table 4.

e) *Tributary Characteristics* - The sediment transport capability of the wetland's primary tributary is a key component in determining the potential for significant sediment discharge into the wetland. Steep or channelized tributaries with few pools transport more sediment and nutrient than low gradient tributaries or tributaries with numerous pools. The presence of an effective sediment trap immediately upstream of the wetland will also decrease the amount of sediment discharged into the wetland.

Step 3: Sediment/Nutrient Input Rating - To rate the sediment/nutrient export potential of the contribution area, sum the ranks assigned in table 4 and use the following scale to determine the potential for significant sediment or nutrient discharge into the wetland.

Sum of Ranks	Rating
4-6	Low
7-9	Moderate
10-12	High

WETLAND TRAP EFFICIENCY

This section focuses on the efficiency of the wetland as a nutrient and sediment trap. It utilizes ratings and computer output from the flood flow characteristics section, which means the following methods must be preceded by analysis of flow characteristics. The

Table 4: Criteria for ranking sediment and nutrient discharge into the basin.

Characteristic	Condition	Rank
a) Average slope of sed. contribution area.	i) Steep – greater than 8%	3
	ii) Moderate – from 3% to 8%	2
	iii) Flat – less than 3%	1
b) Land use (see examples – table 5)	i) High generation conditions exist in the contribution area	3
	ii) No high generation conditions but land use in the contributing area consists primarily of moderate generating activities	2
	iii) Other than above	1
c) Soil erodibility factor (see table 7)	i) <0.15	3
	ii) 0.15 to 0.32	2
	iii) >0.32	1
d) Predominant patterns of flow in the watershed	i) Principally channelized surface flows with artificial enhancement common (e.g., drainage ditches, tiles, urban storm sewers, etc.)	3
	ii) Mixture of channelized and diffuse water flows with natural stream patterns predominant	2
	iii) Very diffuse surface water flow and few drainage ditches or artificial enhancement measures	1
e) Tributary characteristics	i) Basin tributaries generally have a lot of energy (few pools, no impoundments or large ponds within 2 miles upstream of the basin, steep gradient)	3
	ii) Some pools, but some flow; no impoundments immediately upstream of the basin	2
	iii) Low gradient, sluggish inflow with little energy or a sediment trapping pool or impoundment located immediately upstream of the basin	1

Table 5: Examples of high and moderate sediment generation conditions within the sediment contribution area

High Generation Conditions

- Evidence of marked erosion along most of the basin's perimeter.
- Evidence of substantial streambank erosion along a tributary draining into the wetland.
- Tilled ground (plowed fields) within 50 feet of the basin or a channel which drains into the basin.
- Feedlots or barns which drain directly into the basin or one of its tributaries.
- Discharge of a municipal sewage system into the basin or one of its tributaries.
- Construction areas or excavations within 50 feet of the basin or one of its tributaries.
- The sediment contribution area is primarily intense agriculture (row crops).
- Numerous on-site septic systems within 10 feet of the wetland or one of its tributaries.

Moderate Generation Conditions

- Sediment contribution area is a mixture of cropland, pasture land and other land uses.
- The basin and its tributaries are buffered from high generation activities by natural vegetation.

distinction between large and small watersheds set forth in the analysis of flow characteristics must also be observed in the following procedures.

Small Watershed Methods

The following methods compute wetland efficiency as the percent reduction in total sediment and nutrient discharge resulting from detention and retention of floodwater within the wetland. The methods first compute the trap efficiency of the wet basin containing the wetland and then determine what portion of basin effectiveness can be attributed to the wetland. The efficiency computations are based on Stokes' law relating particle size to fall velocity through the water (appendix B). If these procedures are being used for assessing the water quality impacts of a project, the analyses should be conducted twice, once using existing conditions in the wet basin and once using conditions that would result from project construction. The effect of the project is then apparent in the difference between these two scenarios.

Step 1: Sediment Input - Determine the average particle size distribution (% sand, % silt, % clay) of soils at the closest upstream source of sediment (examples of sources are listed in table 5 under "high generation conditions"). If no obvious source exists within 5 miles upstream of the wet basin, use the average particle size distribution of the land surrounding the wet basin. Particle size breakdowns for common soil types are given in figure 14.

Step 2: Water Volume Retention - The percent of total runoff volume retained in the basin (2-year event) is computed under the "flood flow characterization" option in the WEM computer program.

Step 3: Effective Detention Time - The amount of time water is detained in the wet basin during the 2-year flood event (t_2) is computed under the "Flood Flow Characterization" option in the WEM computer program. The time should be modified by a turbulence factor (W) to give effective detention time (T):

Condition	Turbulence Factor (W)
Turbulence * limited to upper third of basin	1.0
Turbulence extends through middle third of basin	0.5
Turbulence present throughout basin	0.1

Effective Detention Time (T) = Wt_2

* For the purposes of this methodology, turbulence should be assumed to be present if water in the basin is visibly flowing.

Step 4: Effective Depth - The depth below which particles should be considered trapped is the lesser of the following.

a) average water depth in the wet basin
b) difference in elevation between the bottom of the inlet and the bottom of the outlet.

Depth should be modified by a vegetative trapping factor to yield effective depth. This modification is described in the following steps and is included so that the presence of vegetation types that have good nutrient-trapping ability will result in shallower effective depth, thereby increasing the trapping efficiency.

a) categorize and score the pattern of flow through the basin:

Flow Pattern	Score (S_f)
- At least 50 percent of flow entering the wet basin is intercepted by vegetation in the basin (sheet flow).	0.5
- Between 10 and 50 percent of flow is sheet flow, or channel flow is extensively braided.	0.25
- Less than above characteristics (flow through the wet basin is primarily in a channel)	0.0

b) categorize and score the predominant vegetation type within the wetland. (types are as defined by Cowardin, 1979)

Vegetation Type	Score (S_v)
- Emergent persistent	0.20
- Emergent non-persistent	0.15
- Scrub-shrub	0.10
- Rooted vascular submergent plants	0.05

c) compute effective depth as follows:

$$\text{If } S_f > 0.0:\quad \text{Effective Depth} = (1-S_f)(1-S_v)d$$

$$\text{If } S_f = 0.0:\quad \text{Effective Depth} = d$$

Where d is the lesser of the average depth or the difference between inlet and outlet elevation.

Step 5: Compute Basin Trap Efficiency - The previous four steps have provided instructions for gathering the input values for the water quality option in the WEM computer program. This program will compute the efficiency of the basin as a sediment and nutrient trap.

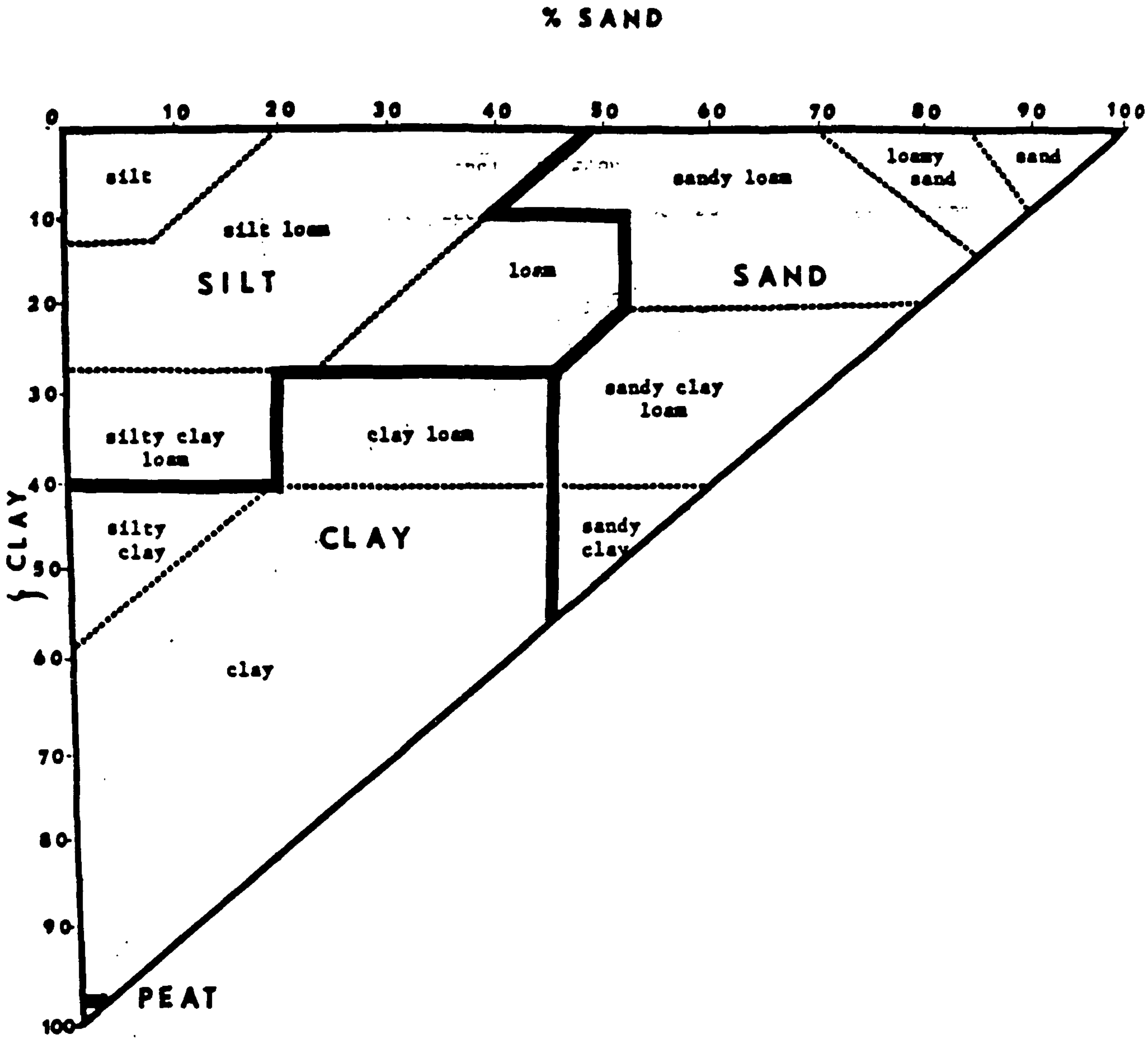


Figure 14. Division of the soil texture triangle into the major texture classes.

Step 6: Interpretation of Result - The computer program rates the basin's trap efficiency based on computations of percent of total nutrient discharge and total sediment discharge that is retained in the basin. The ratings range from 0 (nothing trapped) to 100 (everything trapped) for both nutrient and sediment trap efficiency.

As was the case in the analysis of flood flow characteristics, the water quality rating for the wet basin cannot be applied to the wetland evaluation site unless that site covers the entire basin. The following computations should be used to determine what portion of the basin's water quality rating (W) can be attributed to the wetland site. (NOTE: these procedures are the same as those used in a similar situation during analysis of flood flow characteristics.)

a) *Palustrine Sites* - In palustrine areas the wetland site will commonly encompass the entire wet basin, in which case the basin's ratings for both nutrient and sediment trapping should also be used as the ratings of wetland
sediment and nutrient trap efficiency. If this is not the case, W should be decreased as follows:

$$W' = (A_w / A_B)\, W$$

- W = either the nutrient trap rating or the sediment trap rating for the wet basin.
- A_w = area of the wetland evaluation site
- A_B = area of the wet basin
- W' = nutrient or sediment trap rating for the wetland evaluation site.

b) *Floodplain - Control Point Sites* - Ratings assigned to the wet basin (W) should be taken as ratings for the wetland site because the wetland site is an integral part of the control point and therefore controls much of the water quality function of the basin.

c) *Lacustrine and Floodplain-Pool Sites* - Since the wetland site is only a portion of the total lake or pool area, its water quality function is only a portion of the basin's function. The following relationship should be used to compute site ratings from the wet basin ratings:

$$W' = (A_w / A_B)\, W$$

(variables are as defined in (a) above).

Large Watershed Methods

As in methods for describing flow characteristics, the following procedures for analysis of the water quality function of wetlands are strictly qualitative. The procedures are structured around the qualitative description of flood flow characteristics found in the previous section because of the importance of the relationship between flow characteristics and the water quality function. No specific methods for determining the water quality impacts of a proposed action have been included. If impact assessment is the purpose of the analysis, then water quality impacts should be assumed to be approximately equal to flood flow impacts determined earlier. This assumption is generally valid due to the strong dependence of the water quality function on flow characteristics.

Rating Wetland Efficiency - If the wetland site was rated as not important to flood flow characteristics using large watershed procedures, then its effectiveness as a sediment and nutrient trap should also be rated low. For sites that are important to flood flows, the following water quality characteristics should be analyzed and ranked using conditions in table 6.

a) *Wetland Vegetation Type* - Vegetation types are rated according to their ability to absorb nutrients and to anchor the substrate in the wetland. Vegetation types are as defined by Cowardin, 1979.

b) *Turbulent Flow* - Turbulence within the wetland does not allow as much settling of sediments as if the water is ponded. Turbulence should be assumed to be present if water in the wetland is visibly flowing.

c) *Flow Patterns* - Channel flow through the wetland is much less likely to result in water quality improvement than will sheet flow since channel flow has much less contact with vegetation and tends to result in higher flow velocity through the wetland.

To obtain a rating for the wetland's water quality function from the rankings in table W-3, sum the ranks and use the following rating table:

Sum of Ranks	***Rating***
3	*Low* probability that the wetland site has an effect on water quality.
4 - 6	*Moderate* probability that the wetland site has an effect on water quality.
7 - 9	*High* probability that the wetland site has an effect on water quality.

DOWNSTREAM SENSITIVITY

The following procedure provides an indication of the sensitivity of downstream resources to the water quality functions provided by the wetland site. This section is included as a means of identifying potential water quality impacts that could result from alteration of a wetland that performs significant water purification functions.

Table 6: Criteria for ranking wetland trap efficiency – large watershed methods.

Characteristic	Condition	Rank
a) Vegetation type	i) Emergent persistent	3
	ii) Scrub-shrub or emergent non-persistent	2
	iii) Other (rooted aquatic plants)	1
b) Turbulence	i) Limited to upper third of basin	3
	ii) Extends through middle third of basin	2
	iii) Throughout wetland	1
c) Flow patterns of flow in the watershed	i) At least 50% of flow entering the basin is intercepted by vegetation in the basin (sheet flow)	3
	ii) Between 10 and 50% of flow is sheet flow, or channel flow is extensively braided	2
	iii) Less than above characteristics (flow through basin is primarily in a channel)	1

Step 1: Area of Influence - The closer of the following points should be considered the downstream end of the area that is likely to be affected by the wetland's water quality function.

a) 5 miles downstream of the site outlet
b) the confluence of a tributary of the same or larger capacity than the channel from the wetland site
c) (Palustrine and lacustrine sites only) A lake or wetland of approximately the same size as the wetland being evaluated.

Step 2: Downstream Resources - Identify any resources within the area of influence that would be damaged by increases in sediment or nutrient discharge. Examples of potentially sensitive resources include spawning areas, lakes, water supply intakes, and significant fish populations (e.g., a good trout fishery).

Step 3: Sensitivity Rating - If no potentially sensitive resources were identified in step 1, downstream sensitivity should be rated as low. If a sensitive resource was identified, the following table should be used to rate its sensitivity to water quality functions provided by the wetland site.

	Channel Condition		
Distance	*Channelized*	*Natural Stream*	*Sluggish Stream*
0 mi to 0.5 mi	VH	VH	VH
0.5+ mi to 1 mi	VH	H	H
1+ mi to 2 mi	H	H	H
more than 2 mi	H	M	M

where: VH = very high sensitivity
H = high sensitivity
M = moderate sensitivity

"Distance" is the distance between the basin outlet and the sensitive resource.

"Channel condition" refers to the characteristics of the channel between the basin outlet and the sensitive resource ("channelized" refers to artificial channels that convey floodwaters quickly; "natural streams" refers to those streams with moderate gradient and few pools; "sluggish streams" refers to low gradient, low velocity streams that have little visible flow).

TABLE 7:

EROSION FACTORS AND HYDROLOGICAL GROUPS FOR MINNESOTA SOIL SERIES

SERIES	DEPTH	K	HYD. GROUP
Aastad	0-19	.24	B
	19-60	.32	
Aazdahl	0-14	.24	B
	14-60	.37	
Adolph	0-60	.28	B/D
Adrian	0-60	—	A/D
Afton	0-65	.28	C/D
Ahmeek	0-16	.32	C
	16-75	.28	
Alcester	0-34	.28	B
	34-60	.43	
Allendale	0-28	.15	B
	28-60	.32	
Almena	0-41	.37	C
	41-65	.28	
Alstad	0-60	.32	B
Alvin	0-68	.24	B
Amery	0-35	.24	B
	35-77	.17	
Ames	0-60	.24	C/D
Ankeny	0-60	.20	B
Anoka	0-70	.17	B
Antigo	0-33	.37	B
	33-60	.10	
Arcola	0-60	.32	C
Aredale	0-55	.28	B
	55-70	.37	
Arenzville	0-60	.37	B
Arland	0-16	.24	B
	16-29	.32	
	29-37	.17	
Arveson	0-60	.24	A/D
Arvilla	0-16	.20	B
	16-60	.10	
Athelwold	0-60	.28	B
Atkinson	0-42	.28	B
Auburndale	0-60	.28	C/D
Augsburg	0-62	.28	B/D
Automba	0-60	.28	B
Badger	0-60	.28	C/D
Barbert	0-60	.28	D
Barnes	0-20	.28	B
	20-60		
Baroda	0-60	.28	D
Barrington	0-12	.28	B
	12-84	.43	
Barronett	0-60	.28	B/D
Barrows	0-60	.24	B/D
Barto	0-15	.24	B/D
Baudette	0-60	.37	B
Bearden	0-60	.28	C
Beauford	0-60	.28	D
Becker	0-41	.20	B
	41-60	.15	
Bellechester	0-42	.15	A
Beltrami	0-11	.24	B
	11-60	.32	
Bena	0-60	.15	A
Benoit	0-18	.28	B/D
	18-60	.10	
Beotia	0-20	.28	B
	20-60	.43	
Bergland	0-60	.28	D
Bertrand	0-55	.37	B
	55-60	.15	
Beseman	0-60	—	A/D

SERIES	DEPTH	K	HYD. GROUP
Billett	0-60	.20	B
	60-65	.10	
Biscay	0-48	.28	B/D
Bixby	0-36	.32	B
	36-60	.10	
Blackhoof	0-60	—	C/D
Blomford	0-24	.20	B/D
	24-60	.37	
Blooming	0-60	.32	B
Blue Earth	0-60	—	B/D
Bluffton	0-60	.28	C/D
Bold	0-60	.43	B
Boone	0-36	.15	A
Boots	0-60	—	A/D
Borup	0-60	.28	B/D
Braham	0-24	.17	B
	24-60	.32	
Brainerd	0-76	.24	C
Bremer	0-60	.28	C
Brickton	0-63	.28	C
Brill	0-10	.32	B
	10-36	.43	
	36-60	.10	
Brodale	0-50	.20	C
Brookings	0-23	.28	B
	23-60	.43	
Brophy	0-80	—	A/D
Brownton	0-60	.28	C/D
Burkhardt	0-19	.20	B
	19-60	.10	
Burnsville	0-20	.20	B
	20-60	.10	
Buse	0-7	.28	B
	7-60	.37	
Calamine	0-46	.28	C/D
Calco	0-60	.28	C/D
Campia	0-60	.37	B
Canisteo	0-60	.28	C/D
Carlos	0-60	—	A/D
Caron	0-80	—	A/D
Cashel	0-60	.32	C
Cathro	0-60	—	A/D
Channahon	0-17	.37	D
Chaseburg	0-60	.37	B
Chaska	0-60	.28	B/D
Chelsea	0-70	.17	A
Chetek	0-18	.20	B
	18-60	.10	
Chilgren	0-60	.28	C
Clarion	0-32	.28	B
	32-60	.37	
Clontarf	0-25	.20	B
	25-60	.15	
Cloquet	0-8	.37	B
	8-14	.24	
	14-60	.10	
Clyde	0-66	.28	B/D
Collinwood	0-60	.32	C
Colo	0-60	.28	B/D
Colvin	0-60	.28	C/D
Comfrey	0-60	.28	B/D
Conic	0-30	.15	C
Copaston	0-18	.28	D
Cordova	0-60	.28	C/D
Cormant	0-60	.17	A/D
Crippin	0-35	.28	B

SERIES	DEPTH	K	HYD. GROUP
	35-60	.37	
Crocker	0-18	.20	A
	18-60	.32	
Crofton	0-60	.43	B
Cromwell	0-15	.20	A
	15-69	.15	
Curran	0-21	.32	C
	21-48	.43	
	48-60	.15	
Cushing	0-42	.28	B
	42-60	.37	
Cutfoot	0-70	.17	A
Cylinder	0-60	.28	B
Dakota	0-35	.28	B
	35-60	.17	
Dalbo	0-14	.43	B
	14-60	.32	
Darfur	0-60	.28	B/D
Darnen	0-34	.28	B
	34-60	.37	
Dassel	0-60	.20	B/D
Dawson	0-60	—	A/D
Deerwood	0-60	.17	B/D
Derinda	0-7	.43	C
	7-60	.32	
Dickey	0-31	.17	A
	31-60	.37	
Dickinson	0-30	.20	B
	30-60	.15	
Dickman	0-18	.20	A
	18-60	.15	
Dinsdale	0-73	.32	B
Divide	0-25	.28	B
	25-60	.10	
Dodgeville	0-13	.32	B
	13-36	.43	
Doland	0-60	.32	B
Donaldson	0-60	.28	B
Donnan	0-60	.28	C
Doran	0-60	.28	C
Dorchester	0-60	.28	B
Dorset	0-16	.20	B
	16-60	.10	
Dovray	0-60	.28	C/D
Downs	0-17	.32	B
	17-60	.43	
Dubuque	0-27	.37	B
Duelm	0-60	.28	A
Duluth	0-72	.37	C
Dunbarton	0-18	.37	D
Dundas	0-60	.28	B/D
Dunnville	0-32	.28	B
	32-60	.15	
Dusler	0-60	.37	C
Eckman	0-8	.28	B
	8-60	.43	
Edison	0-38	.32	B
	38-60	.20	
Edwards	0-60	—	B/D
Egeland	0-48	.20	B
	48-60	.37	
Elderon	0-26	.24	B
	26-46	.17	
Eleva	0-30	.24	B
	30-36	.15	
Ely	0-32	.32	B

TABLE 7 (continued)

SERIES	DEPTH	K	HYD. GROUP
	32-60	.43	
Embden	0-60	.20	B
Emmert	0-72	.15	A
Enloe	0-60	.28	D
Enstrom	0-33	.15	B
	33-60	.37	
Erin	0-71	.37	B
Estelline	0-37	.32	B
	37-60	.10	
Estherville	0-18	.20	B
	18-60	.10	
Etter	0-32	.20	B
Everly	0-12	.24	B
	12-60	.32	
Fairhaven	0-14	.32	B
	14-27	.43	
	27-60	.10	
Fargo	0-60	.32	C
Farrar	0-22	.20	B
	22-60	.37	
Faxon	0-34	.28	B/D
Fayette	0-73	.37	B
Fedji	0-24	.17	A
	24-60	.32	
Fieldon	0-60	.28	B/D
Finchford	0-60	.17	A
Flak	0-60	.24	C
Flaming	0-60	.17	A
Flandreau	0-39	.28	B
	39-60	.10	
Flom	0-60	.28	B/D
Floyd	0-24	.24	B
	24-60	.32	
Foldahl	0-28	.20	B
	28-60	.37	
Forada	0-60	.28	B/D
Fordville	0-24	.24	B
	24-66	.10	
Forman	0-17	.28	B
	17-60	.37	
Formdale	0-9	.24	B
	9-60	.32	
Fossum	0-60	.15	A/D
Foxhome	0-14	.20	B
	14-24	.10	
	24-60	.37	
Fram	0-18	.28	B
	18-60	.37	
Freeon	0-35	.37	B
	35-60	.28	
Freer	0-60	.37	C
Frontenac	0-30	.32	B
	30-80	.24	
Fulda	0-60	.28	C/D
Gale	0-31	.37	B
	31-39	.15	
Galva	0-11	.32	B
	11-60	.43	
Garnes	0-60	.32	B
Garwin	0-60	.28	C/D
Glencoe	0-60	.28	B/D
Glyndon	0-60	.28	B
Gonvick	0-10	.24	B
	10-60	.32	
Gotham	0-60	.17	A
Granby	0-60	.15	A/D
Grays	0-11	.32	B
	11-60	.43	
Greenwood	0-60	—	A/D
Grimstad	0-28	.20	B
	28-60	.37	
Grogan	0-13	.32	B
	13-60	.43	
Growton	0-60	.20	B
Grygla	0-60	.15	B/D
Guckeen	0-24	.28	C
	24-60	.37	
Halder	0-60	.28	C
Hamar	0-60	.15	A/D
Hamel	0-60	.28	C
Hamerly	0-8	.28	C
	8-60	.37	
Hangaard	0-60	.20	A/D
Hanska	0-54	.28	C
Hantho	0-24	.28	B
	24-60	.43	
Harps	0-60	.28	B/D
Harpster	0-60	.28	B/D
Hatfield	0-60	.28	B/D
Hattie	0-60	.28	C
Haug	0-60	.20	B/D
Havana	0-66	.32	B
Hayden	0-60	.32	B
Hayfield	0-80	.32	B
Hecla	0-72	.17	A
Hegne	0-60	.32	C/D
Hesch	0-32	.20	B
	32-38	.15	
Heyder	0-53	.20	B
	53-60	.28	
Hibbing	0-60	.37	C
Hidewood	0-60	.28	C
Hillet	0-60	.32	C/D
Hiwood	0-60	.15	A
Hixton	0-25	.32	B
	25-35	.15	
Holdingford	0-68	.28	C
Houghton	0-66	—	A/D
Hubbard	0-72	.15	A
Huntsville	0-60	.32	B
Ihlen	0-15	.32	B
	15-31	.43	
Indus	0-60	.28	D
Insula	0-15	.17	D
Isan	0-60	.15	A/D
Isanti	0-60	.17	A/D
Jackson	0-56	.37	B
	56-60	.15	
Joliet	0-19	.28	D
Joy	0-19	.32	B
	19-74	.43	
Judson	0-28	.28	B
	28-60	.43	
Kamrar	0-36	.28	B
	36-72	.37	
Kanaranzi	0-20	.28	B
	20-60	.10	
Karlstad	0-60	.15	A
Kasota	0-28	.28	C
	28-60	.15	
Kasson	0-70	.32	C
Kato	0-60	.28	C
Kegonsa	0-12	.32	B
	12-33	.43	
	33-60	.10	
Kennebec	0-41	.32	B
	41-60	.43	
Kenyon	0-54	.28	B
	54-76	.37	
Kilkenny	0-48	.28	B
	48-60	.37	
Kingsley	0-34	.20	B
	34-60	.28	
Kingston	0-60	.28	B
Kittson	0-11	.24	C
	11-60	.32	
Klinger	0-19	.32	B
	19-64	.43	
Kranzburg	0-60	.32	B
Kratka	0-60	.17	B/D
LaPrairie	0-44	.24	B
	44-60	.32	
Lamont	0-50	.24	B
	50-60	.17	
Lamoure	0-60	.28	C
Langhei	0-60	.32	B
Langola	0-31	.17	B
	31-60	.24	
Lasa	0-60	.15	A
Lawler	0-37	.28	B
	37-60	.10	
Lawson	0-60	.28	B
LeSueur	0-10	.24	B
	10-60	.32	
Lemond	0-60	.28	B/D
Lerdal	0-60	.37	C
Lester	0-36	.28	B
	36-60	.37	
Letri	0-60	.28	B/D
Lilah	0-80	.20	A
Linder	0-24	.28	B
Lindstrom	0-33	.32	B
	33-70	.43	
Lino	0-66	.17	B
Lismore	0-24	.28	B
	24-60	.37	
Litchfield	0-60	.17	A
Lobo	0-78	.17	D
Lohnes	0-60	.15	A
Lomax	0-42	.28	B
	42-60	.15	
Loxley	0-60	—	A/D
Lupton	0-65	—	A/D
Lura	0-72	.28	C/D
Maddock	0-60	.17	A
Madelia	0-60	.28	B/D
Mahtowa	0-60	.32	C/D
Malachy	0-60	.20	B
Marcus	0-62	.28	B/D
Markey	0-60	—	A/D
Marlean	0-12	.24	B
Marna	0-60	.28	D
Marquette	0-9	.17	A
	9-60	.10	
Marshan	0-50	.28	B/D
Marysland	0-60	.28	B/D
Mavie	0-60	.28	B/D
Maxcreek	0-63	.28	B/D
Maxfield	0-66	.28	B/D
Mayer	0-60	.28	B/D
Mazaska	0-62	.28	C/D
McDonaldsville	0-60	.28	C/D
McIntosh	0-60	.28	B
McPaul	0-60	.28	B
Medary	0-14	.43	C
	14-60	.32	
Meehan	0-60	.15	A/D
Menagha	0-60	.15	A
Meridian	0-35	.28	B
	35-60	.15	
Merton	0-60	.32	B
Merwin	0-60	—	A/D
Mesaba	0-28	.17	C
Metogga	0-80	—	A/D
Milaca	0-60	.28	C
Millerville	0-78	—	A/D

TABLE 7: (continued)

SERIES	DEPTH	K	HYD. GROUP
Millington	0-60	.28	B
Minneiska	0-60	.28	C
Minneopa	0-60	.20	B
Minnetonka	0-60	.28	D
Moland	0-60	.32	B
Moody	0-5	.32	B
	5-60	.43	
Mooselake	0-78	—	A/D
Mora	0-75	.28	C
Mosomo	0-66	.15	A
Mt. Carroll	0-13	.32	B
	13-80	.43	
Muscatine	0-16	.28	B
	16-64	.43	
Muskego	0-60	—	A/D
Nebish	0-60	.32	B
Nemadji	0-69	.17	B
Nereson	0-60	.20	B
Nessel	0-60	.32	B
Newfound	0-60	.15	C
Newglarus	0-35	.37	B
Newry	0-66	.32	B
Newson	0-60	—	A/D
Nicollet	0-17	.24	B
	17-60	.32	
Nokasippi	0-60	.17	D
Nokay	0-64	.28	C
Nordness	0-12	.43	B
Normania	0-36	.24	B
	36-60	.37	
Northcote	0-60	.28	C/D
Nowen	0-60	.28	B/D
Noyes	0-60	.28	C/D
Nutley	0-60	.28	C
Nymore	0-60	.17	A
Oak Lake	0-60	.28	B
Ocheyedan	0-21	.24	B
	21-60	.32	
Ogilvie	0-60	.37	B/D
Okoboji	0-60	.28	B/D
Oldham	0-62	.28	C/D
Omega	0-60	.17	A
Onamia	0-28	.28	B
	28-64	.10	
Ontonagon	0-60	.28	D
Opole	0-60	.24	B
Orion	0-60	.37	B
Oronoco	0-60	.28	B
Osakis	0-14	.28	B
	14-60	.10	
Oshawa	0-60	.28	C/D
Ossian	0-60	.28	B/D
Ostrander	0-50	.28	B
	50-60	.37	
Otter	0-70	.28	B/D
Otterholt	0-40	.37	B
	40-60	.28	
Paget	0-17	.43	C
	17-64	.24	
Palms	0-60	—	A/D
Palsgrove	0-8	.32	B
	8-37	.43	
	37-42	.32	
Parent	0-60	.28	B/D
Parnell	0-60	.28	C/D
Pelan	0-60	.17	B
Percy	0-60	.28	B/D
Perella	0-60	.28	B/D
Plainfield	0-60	.17	A
Poinsett	0-8	.32	B
	8-65	.43	
Pomroy	0-28	.15	B

SERIES	DEPTH	K	HYD. GROUP
	28-60	.28	
Poppleton	0-60	.15	A
Port Byron	0-22	.32	B
	22-60	.43	
Prebish	0-60	.28	C/D
Primghar	0-60	.28	B
Protivin	0-23	.28	C
	23-60	.37	
Quam	0-60	.28	B/D
Quetico	0-5	.32	D
Racine	0-65	.32	B
Radford	0-60	.28	B
Ransom	0-19	.32	B
	19-60	.43	
Rasset	0-60	.17	B
Rauville	0-60	.28	C/D
Readlyn	0-17	.24	B
	17-60	.32	
Redby	0-60	.17	B
Renova	0-60	.37	B
Renshaw	0-15	.28	B
	15-60	.10	
Rib	0-60	.28	C
Richwood	0-13	.32	B
	13-55	.43	
	55-60	.15	
Rifle	0-60	—	A/D
Rockton	0-31	.28	B
Rockwell	0-66	.24	B/D
Rockwood	0-18	.24	C
	18-60	.32	
Rolfe	0-60	.28	C/D
Roliss	0-60	.28	B/D
Rondeau	0-66	—	A/D
Ronneby	0-61	.28	C
Rosemount	0-17	.20	B
	17-44	.32	
	44-66	.10	
Rosendale	0-60	.28	B
Roseville	0-44	.37	B
Rosholt	0-22	.20	B
	22-60	.10	
Rothsay	0-22	.32	B
	22-60	.43	
Rushmore	0-62	.28	B/D
Ryan	0-60	.32	D
Sac	0-11	.32	B
	11-60	.43	
Salida	0-60	.10	A
Santiago	0-28	.37	B
	28-60	.28	
Sargeant	0-60	.37	D
Sartell	0-65	.15	A
Sattre	0-32	.28	B
	32-75	.15	
Sawmill	0-70	.28	B/D
Schapville	0-25	.32	C
Schley	0-63	.32	B
Seaforth	0-60	.28	B
Seaton	0-80	.37	B
Seelyeville	0-60	—	A/D
Shakopee	0-60	.28	C/D
Shawano	0-60	.15	A
Shible	0-42	.20	B
	42-60	.15	
Shields	0-60	.37	C
Shooker	0-60	.32	C
Shorewood	0-60	.37	C
Shullsburg	0-30	.32	C
Sinai	0-35	.28	C
	35-60	.43	
Singsaas	0-30	.28	B

SERIES	DEPTH	K	HYD. GROUP
	30-60	.37	
Sioux	0-5	.24	A
	5-60	.10	
Skyberg	0-66	.37	C
Sletten	0-60	.28	B/D
Soderville	0-60	.15	A
Sogn	0-9	.28	D
Sparta	0-60	.17	A
Spencer	0-40	.37	C
	40-60	.28	
Spicer	0-60	.28	B/D
Spillville	0-60	.28	B
Spooner	0-60	.37	C/D
Spottswood	0-60	.28	B
Storden	0-8	.28	B
	8-60	.37	
Strandquist	0-60	.20	B/D
Stronghurst	0-60	.37	B
Stuntz	0-60	.37	C
Suamico	0-60	—	A/D
Svea	0-21	.28	B
	21-60	.37	
Sverdrup	0-24	.20	B
	24-60	.15	
Swenoda	0-29	.20	B
	29-60	.37	
Syrene	0-60	.28	B/D
Talcot	0-60	.28	B/D
Tallula	0-15	.32	B
	15-60	.43	
Tama	0-14	.32	B
	14-60	.43	
Taopi	0-60	.32	C
Tara	0-24	.28	B
	24-60	.37	
Tawas	0-60	—	A/D
Taylor	0-10	.43	C
	10-60	.32	
Tell	0-32	.37	B
	32-60	.15	
Terril	0-31	.24	B
	31-60	.32	
Tilfer	0-35	.28	B/D
Timula	0-60	.37	B
Toddville	0-20	.32	B
	20-50	.43	
	50-60	.10	
Toivola	0-60	.17	A
Tonka	0-60	.28	C/D
Torning	0-60	.24	B
Towner	0-33	.17	B
	33-60	.37	
Trent	0-60	.32	B
Tripoli	0-66	.28	B/D
Trosky	0-60	.28	B/D
Truman	0-14	.32	B
	14-60	.43	
Twig	0-72	—	A/D
Udolpho	0-60	.37	B/D
Ulen	0-60	.17	B
Upsala	0-60	.28	C
Urness	0-60	—	B/D
Vallers	0-60	.28	C
Vasa	0-9	.32	B
	9-70	.43	
Ves	0-60	.24	B
Vienna	0-9	.32	B
	9-60	.43	
Viking	0-60	.32	D
Vlasaty	0-60	.37	C
Wacousta	0-60	.28	B/D
Wadena	0-13	.24	B

TABLE 7: (continued)

SERIES	DEPTH	K	HYD. GROUP
	13-30	.32	
	30-50	.10	
Wahpeton	0-60	.28	C
Waldorf	0-60	.28	C/D
Warba	0-60	.32	B
Warman	0-60	.24	B/D
Waskish	0-84	.17	A/D
Watab	0-15	.17	C
	15-60	.24	
Watseka	0-60	.17	A
Waubay	0-62	.28	B
Waubeek	0-13	.32	B
	13-67	.43	
Waucoma	0-41	.28	B
Waukee	0-16	.24	B
	16-35	.32	
	35-60	.10	
Waukegan	0-15	.32	B
	15-33	.43	
	33-60	.10	
Waukon	0-9	.24	B
	9-60	.32	
Webster	0-67	.24	B/D
Whalan	0-24	.32	B
Wheatville	0-60	.28	B
Whitewood	0-60	.28	C/D
Wildwood	0-60	.17	C/D
Wilmonton	0-25	.28	B
	25-60	.37	
Winger	0-60	.28	B/D
Wyndmere	0-60	.20	B
Zell	0-11	.32	B
	11-60	.43	
Zimmerman	0-60	.17	A
Zumbro	0-65	.17	A
Zwingle	0-60	.43	D

Urban Runoff, Erosion, and Sediment Control Handbook, Soil Conservation Service, St. Paul, Minnesota.

WILDLIFE

INTRODUCTION

This section describes a step-by-step procedure for measuring the wildlife value of wetlands in the north central region of the United States. It is anticipated that most applications of the method will focus on general wildlife diversity/productivity and that values for any given waterfowl group will be assessed at the option of the user. The procedures for evaluating major waterfowl groups follow in Appendix D.

The general wildlife diversity/productivity section is an adaptation of procedures developed by Golet (1978) while the waterfowl section is based on methods proposed by Adamus (1983). Both the Golet and Adamus procedures had to be modified to make them applicable to the north central region of the country. Descriptions of the modifications made to the Golet and Adamus procedures, including waterfowl, are presented in Appendix C.

PROCEDURE FOR EVALUATING GENERAL WILDLIFE DIVERSITY AND PRODUCTIVITY

Step 1: Select Appropriate Region - The north central portion of the country has been broken into three ecoregions. Select the appropriate ecoregion for the wetland being evaluated using figures 15a and 15b and the descriptions of the ecoregions given in Appendix C. The maps in figures 15a and 15b should be considered approximate, and greater emphasis should be placed on the ecoregion descriptions. The ecoregions described here are similar to those developed by the U.S. Environmental Protection Agency (EPA) at the Corvallis Environmental Research Laboratory. Information on these ecoregions and how they compare to those in this methodology can also be found in Appendix C.

Step 2: Rank the Wetland for Each of the Evaluation Criteria - Table 8, 9, or 10 should be used to rank the wetland according to the criteria described below. The choice of table is based on the ecoregion identified in step 1. An example of the procedure is given in table 11.

Wetland Class Richness - Wetland class richness serves as an indication of the diversity of the wetland and therefore as an indicator of potential wildlife species richness and diversity. The following criteria should be used to determine the minimum size of a wetland class unless there are specific reasons for using different criteria.

a) Prairie Region - Each class should be a minimum of 2 acres in size.

b) Northern and Southern Forest Regions - Each class should be at least 5 acres in size.

Wetlands smaller than the minimum size criteria should be counted as having one class.

Dominant Wetland Class - Certain classes of wetlands are more valuable than others because they support a greater diversity of wildlife species. Certain classes may also be more valuable because they are scarce and make important contributions to regional diversity. Wetland classes and subclasses are described in Appendix C.

Size Category - The principle used in ranking wetland size is that larger wetlands tend to provide greater wildlife value. The specific size categories used for an ecoregion are intended to provide separation between the wetlands in the ecoregion.

Subclass Richness - Similar to wetland class richness, the number of wetland subclasses also provides an indication of potential wildlife diversity. A subclass should be at least one acre or 20 percent of the size of the wetland class (whichever is smaller). Subclass definitions are given in Appendix C.

Site Type - The site type criterion is an indicator of water permanence in the wetland. Sites with more permanent water are given higher scores.

Lacustrine - Wetlands 20 acres or more in size that have a permanent hydrologic connection with a lake, pond, or flowage ("L" hydrologic modifier on Wisconsin wetland maps).

Riverine - Wetlands with permanent hydrologic connection to the primary or secondary channels of rivers or streams ("R" hydrologic modifier on Wisconsin wetland maps).

Palustrine-Streamside - Wetlands with an intermittent hydrologic connection to the primary or secondary channel of a river or stream.

Palustrine-Lakeside - Wetlands with an intermittent connection to a lake, pond, or flowage.

Palustrine-Isolated - Wetlands that are not connected to a lake or river (e.g., prairie pothole wetland).

Surrounding Habitat - Wetlands surrounded by habitat that provides cover, feeding, or reproductive value are more valuable to wildlife than wetlands surrounded by land not providing these values (e.g., wetlands with primarily developed shorelines). The ranking categories consider the type, amount, and diversity of the surrounding habitat. For the purposes of this methodology, surrounding habitat should be considered the area within 200 feet of the wetland's edge.

Cover Category - The cover categories provide a measure of the percent and interspersion of open water in the wetland. Categories are illustrated on figure 16.

Vegetative Interspersion Category - The interspersion categories are a measure of the amount and variety of edge between vegetation types. Categories are illustrated on figure 17.

Low Interspersion - Length and types of edge are at a minimum. The wetland consists of concentric class or subclass zones or a single subclass zone. Subclass zones are large and unbroken.

Moderate Interspersion - Edge is moderate in length and diversity. There is some irregularity in the distribution of subclass stands, but class stands remain largely intact.

High Interspersion - Edge is abundant and consists of many kinds. Class zones are broken into segments of variable size and shape. Subclass stands are small and scattered.

Wetland Juxtaposition - A wetland that is located near other wetlands is generally of higher wildlife value because of the increased area (and possibly diversity) provided by the surrounding wetlands. The hydrologic connection is important in the northern and southern forest regions because wetlands tend to be more widely distributed, and movement corridors (hydrologic connections) become critical. In the prairie grassland region, wetlands are more closely spaced and travel corridors are not as important. What is more important in the prairie region is whether or not the wetland is functioning as a part of a complex of wetlands. In a wetland complex, the wetlands are closely spaced, and each provides a portion of the habitat requirements for species using the complex. The following criteria can be used to determine if the wetland being evaluated is part of a wetland complex.

a) Distance to Surrounding Wetlands - Locate the 5 wetlands closest to the site being evaluated. Measure the shortest distance between the evaluation site and the third-closest wetland. If this distance is less than 0.5 mile, consider the wetland to be part of a complex (rank = 8 or 12).

b) Complex Diversity - If none of the 5 closest wetlands identified in step (a) are of the same dominant class as the evaluation wetland, then the wetland should be considered critical to the complex (rank = 12).

Water Chemistry - Measurement of wetland pH is included for the laurentian mixed forest ecoregion for reasons presented in Appendix C. The ranking categories (pH greater than 7.4, pH 5.5 to 7.4, pH less than 5.5) are the same as those proposed by Golet (1978) and correspond to critical pH values used by Cowardin (1979).

Step 3: Compute the Value Score - The general wildlife diversity/productivity score is the sum of the rank scores for criteria. The score is then normalized using the following equations so that the maximum score for each ecoregion is 100.

Northern Forest Region:
Wetland score x 100/108 (round to closest whole number)

Prairie Grassland Region:
Wetland score x 100/108 (round to closest whole number)

Southern Forest Region:
Wetland score x 100/120 (round to closest whole number)

Figure 15a

ECOREGION MAP
WISCONSIN

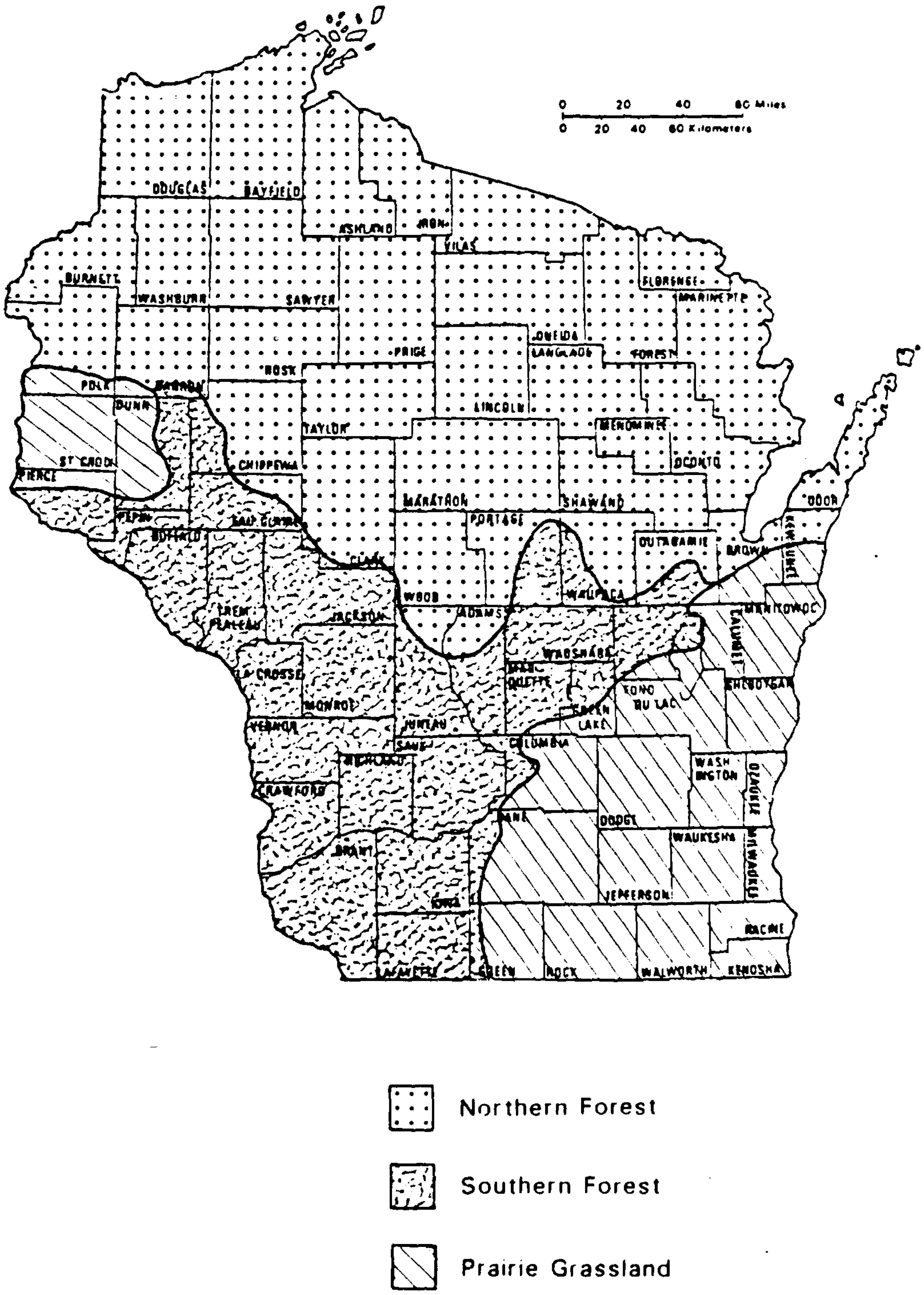


Figure 15b

ECOREGION MAP
MINNESOTA

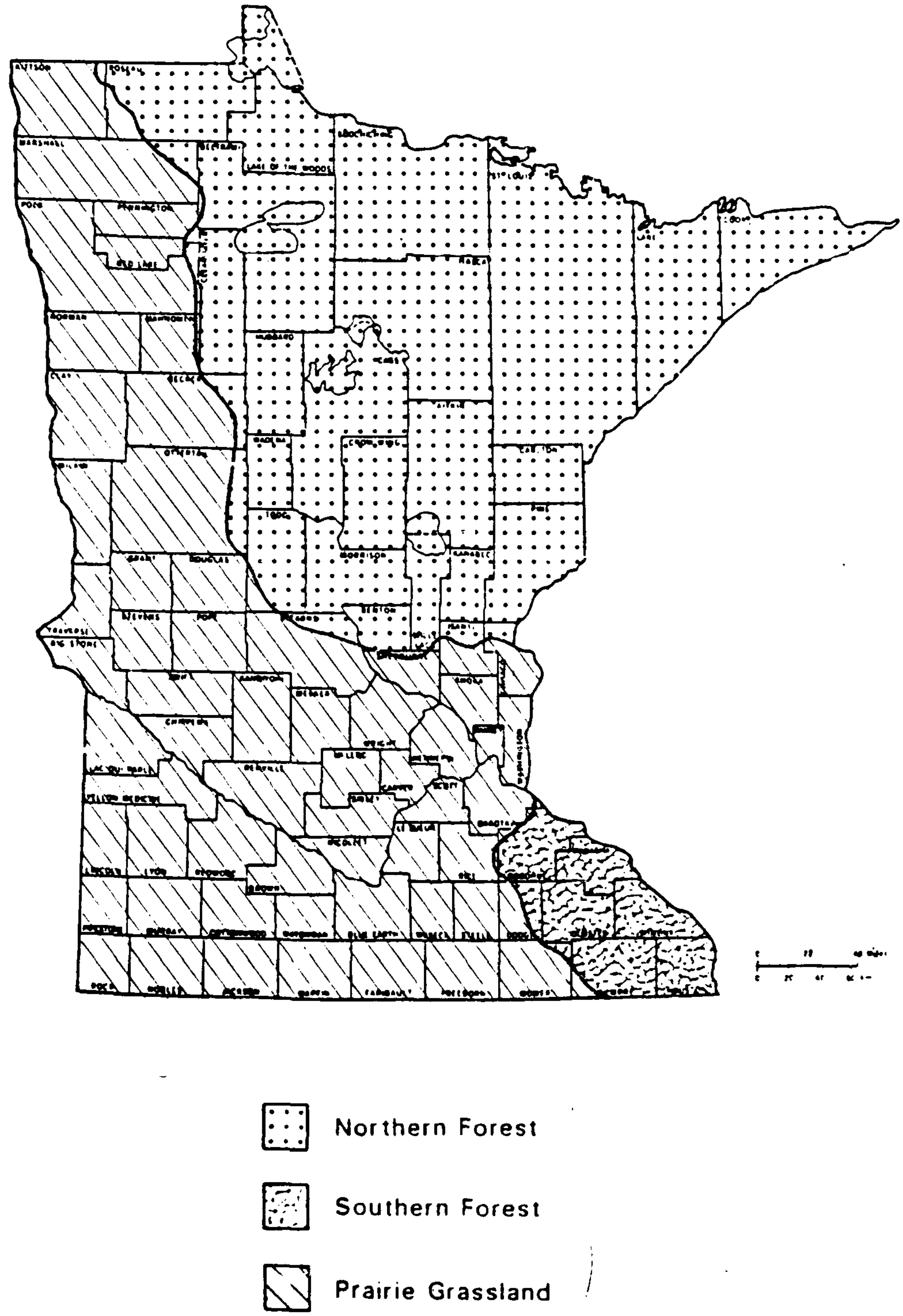


Table 8: General Wildlife Diversity/Productivity – Southern Forest Region.

Rank	(12)	(10)	(8)	(6)	(4)
Criteria	Specifications				
Wetland Class Richness	5 or more classes	4 classes	3 classes	2 classes	1 class
Dominant Wetland Class	DM, SM,	WS, SS,	M–ungrazed	OW–veg, M–G	BG OW–no veg
Size Category (acres)	over 500	100–499+	50–99+	10–49+	under 10
Subclass Richness	10 or more subclasses	6–9 subclasses	4–5 subclasses	2–3 subclasses	1 subclass
Site Type	Lacustrine, Riverine		Palustrine–streamside, Palustrine–lakeside		Palustrine–isolated
Surrounding Habitat	10% of surr. habitat is developed and at least 2 of the following habitat types are present: 1. forestland 2. agricultural land 3. pasture or grassland 4. shrubland		50% of surr. habitat is developed and at least 2 of the following habitat types are present: 1. forestland 2. agricultural land 3. pasture or grassland 4. shrubland (or) 10% of surr. habitat is developed and one of the above habitat types are present.		All Other Possibilities

Table 8: General Wildlife Diversity/Productivity – Southern Forest Region. (cont'd)

Rank	(12)	(10)	(8)	(6)	(4)
Criteria	Specifications				
Cover Category	Category 5	Category 4	Category 3 Category 7	Category 1 Category 2 Category 6	Category 8
Vegetative Interspersion Category	Category 3		Category 2		Category 1
Wetland's Hydrologic Relationship	Permanently connected by streams to other wetlands (diff. dominant class) or open water bodies within 1 mile (or) Permanently connected by streams to other wetlands (same dominant class) within 1/4 mile (or) Wetland greater than 500 acres with 3 or more wetland classes (including DM or SM)	Seasonally connected by streams to other wetlands (diff. dominant class) or open water bodies within 1 mile (or) Seasonally connected by streams to other wetlands (same dominant class) within 1/4 mile	Permanently connected by streams to other wetlands (diff. dominant class) or open water bodies within 1–3 miles (or) Permanently connected by streams to other wetlands (same dominant class) within 1/4 – 1 mile (or) within 1/2 mile of other wetlands (diff. dominant class) or open water bodies but not connected by streams	Seasonally connected by streams to other wetlands (diff. dominant class) within 1–3 miles (or) Seasonally connected by streams to other wetlands (same dominant class) within 1/4 – 1 mile	All Other Possibilities

Table 9: General Wildlife Diversity/Productivity – Prairie Grassland Region.

Rank	(12)	(10)	(8)	(6)	(4)
Criteria	Specifications				
Wetland Class Richness	3 or more classes		2 classes		1 class
Dominant Wetland Class	DM, SS–D, SM–R	SM–NP	M–ungrazed	OW–vegetated M–grazed	OW–no veg.
Size Category (acres)	over 10	5–10	2–under 5	1–under 2	under 1.0
Subclass Richness	7 or more subclasses	5–6 subclasses	3–4 subclasses	2 subclasses	1 subclass
Site Type	Lacustrine, Riverine		Palustrine–streamside, Palustrine–lakeside		Palustrine–isolated
Surrounding Habitat Types (within 200 feet of the wetland's edge)	1 or more of the following constitute more than 75 percent of surrounding habitat: 1. forestland 2. shrubland 3. grazed grassland 4. ungrazed grassland including hay		1 or more of the following constitute 25 to 75 percent of surrounding habitat: 1. forestland 2. shrubland 3. grazed grassland 4. ungrazed grassland including hay		All Other Possibilities
Cover Category	Category 5	Category 4	Category 3 Category 7	Category 1 Category 2 Category 6	Category 8
Vegetative Interspersion Category	Category 3		Category 2		Category 1
Wetlands Hydrologic Relationship	Wetland is the only one in its veg. class within a wetland complex		Wetland is part of a wetland complex		Wetland is not a part of a wetland complex

Table 10: General Wildlife Diversity/Productivity – Northern Forest Region.

Rank	(12)	(10)	(8)	(6)	(4)
Criteria	Specifications				
Wetland Class Richness	5 or more classes	4 classes	3 classes	2 classes	1 class
Dominant Wetland Class	DM, SM,	SS, M–ungrazed	WS, M–grazed	OW–veg	BG, OW–no veg OW–no veg
Size Category (acres)	over 500	100–499+	50–99+	10–49+	under 10 acres
Subclass Richness	10 or more subclasses	6–9 subclasses	4–5 subclasses	2–3 subclasses	1 subclass
Site Type	Lacustrine, Riverine		Palustrine–streamside, Palustrine–lakeside		Palustrine–isolated
Surrounding Habitat	10% of surr. habitat is developed and at least 2 of the following habitat types are present: 1. forestland 2. agricultural land 3. pasture or grassland 4. shrubland		50% of surr. habitat is developed and at least 2 of the following habitat types are present: 1. forestland 2. agricultural land 3. pasture or grassland 4. shrubland (or) 10% of surr. habitat is developed and one of the above habitat types is present.		All Other Possibilities

Table 10: General Wildlife Diversity/Productivity – Northern Forest Region. (cont'd)

Rank	(12)	(10)	(8)	(6)	(4)
Criteria	Specifications				
Cover Category	Category 5	Category 4	Category 3 Category 7	Category 1 Category 2 Category 6	Category 8
Vegetative Interspersion Category	Category 3		Category 2		Category 1
Wetland's Hydrologic Relationship	Permanently connected by streams to other wetlands (diff. dominant class) or open water bodies within 1 mile (or) Permanently connected by streams to other wetlands (same dominant class) within 1/4 mile (or) Wetland greater than 500 acres with 3 or more wetland classes (including DM or SM)	Seasonally connected by streams to other wetlands (diff. dominant class) or open water bodies within 1 mile (or) Seasonally connected by streams to other wetlands (same dominant class) within 1/4 mile	Permanently connected by streams to other wetlands (diff. dominant class) or open water bodies within 1–3 miles (or) Permanently connected by streams to other wetlands (same dominant class) within 1/4 – 1 mile (or) within 1/2 mile of other wetlands (diff. dominant class) or open water bodies but not connected by streams	Seasonally connected by streams to other wetlands (diff. dominant class) within 1–3 miles (or) Seasonally connected by streams to other wetlands (same dominant class) within 1/4 – 1 mile	All Other Possibilities
Water Chemistry	pH greater than 7.4		pH 5.5–7.4		pH less than 5.5

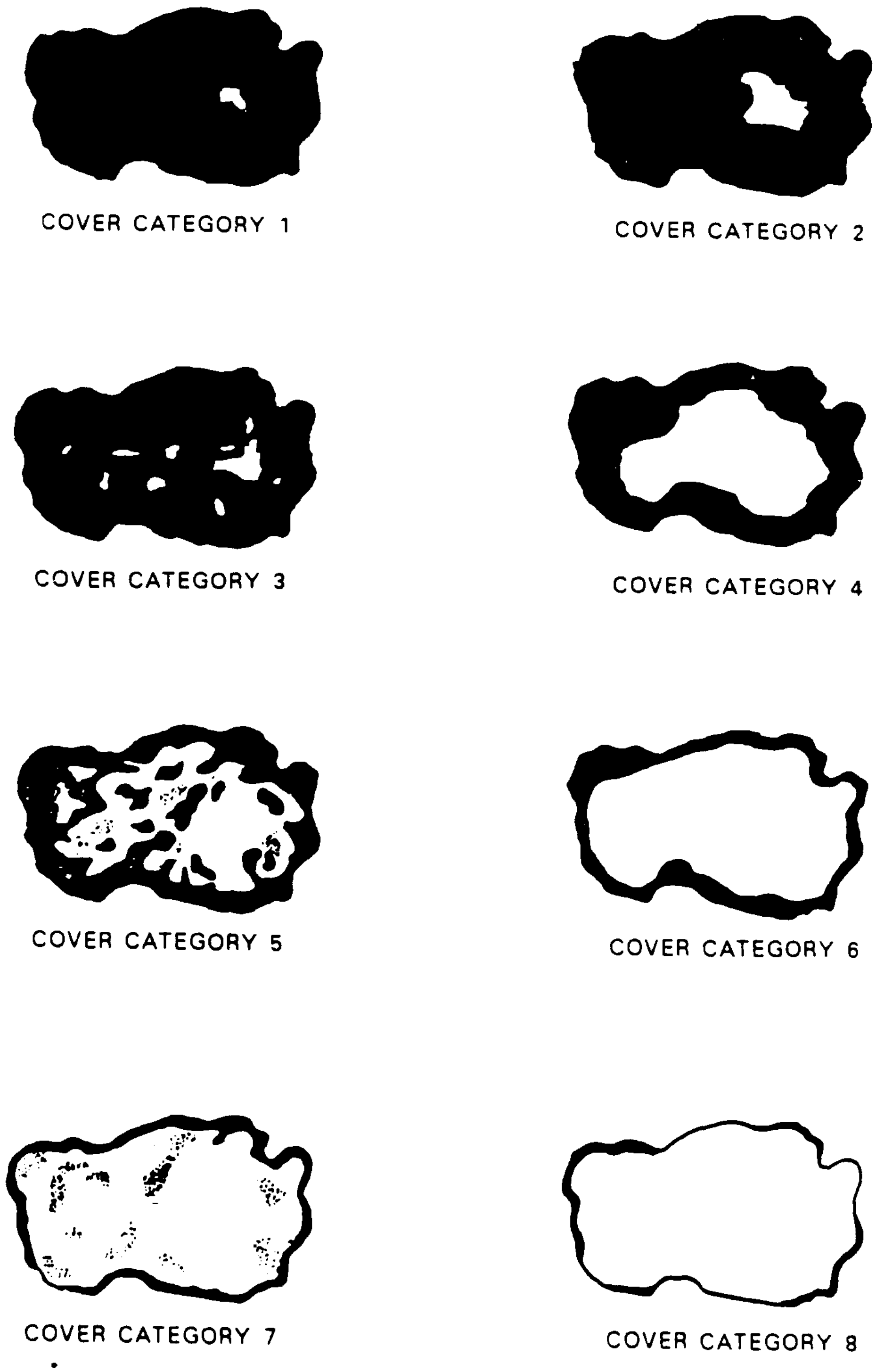
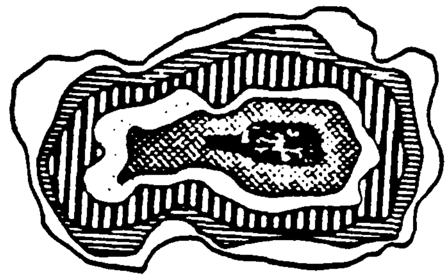
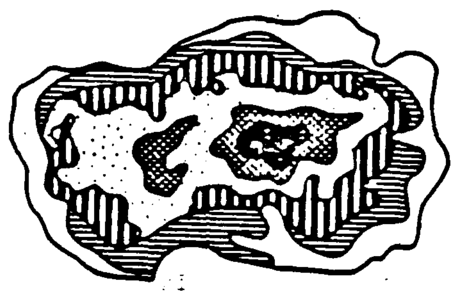


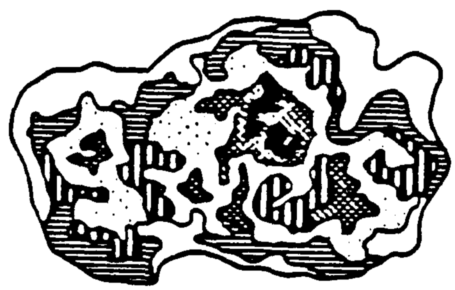
Figure 16. Wetland cover categories: white areas indicate water (with or without surface plants); black area sindicate emergents, shrubs, or trees (from Golet, 1976)



INTERSPERSION CATEGORY 1



INTERSPERSION CATEGORY 2



INTERSPERSION CATEGORY 3

- Deciduous trees
- Tall slender shrubs
- Bushy shrubs
- Tall meadow emergents
- Robust emergents
- Broad-leaved emergents

FIGURE. 17 Examples of the three wetland vegetative interspersion categories (from Golet, 1976).

Table 11. An example illustrating determination of the general wildlife diversity and productivity score for a tall-grass prairie wetland.

Criterion	Characteristics of the wetland	Rank score
Class richness	3 classes	12
Dominant class	Shallow marsh	10
Size	50 acres	12
Subclass richness	9 subclasses	12
Site type	Upland-isolated	4
Surrounding habitat	25 percent grassland, 10 percent forest, remainder is agricultural	8
Cover category	Category 4	10
Interspersion category	Category 2	8
Juxtaposition	Wetland is a significant part of complex	12
pH	N/A	
	Total	88

General diversity/productivity score: 88 x 100/108 = 81

FISH

INTRODUCTION

The purpose of this method is to provide a means for evaluation of wetland values to fish in the north central region of the United States. The method enables the user to evaluate the habitat potential for warmwater species and provides evaluation criteria for northern pike (Esox lucius) spawning habitat. Coldwater species are addressed in the special features section because they are relatively rare and because wetlands (according to traditional definition) do not provide habitat for spawning trout but have an indirect effect through improving water quality. In the north central region, spawning habitat for warmwater species is one of the most important functions of a wetland, and northern pike are among the most valuable warmwater species spawning in wetlands (table 12).

The method produces a rating (low, moderate, high) of the potential for use by warmwater species. Ratings are derived from a series of questions whichevaluate such things as water quantity and quality, cover, and sediment types, including suitability of the spawning substrate.

The user of this method is encouraged to seek input and assistance in completing the evaluation from someone who has knowledge of wetland hydrologic and vegetation characteristics in addition to knowledge of local fish resources (e.g., area fish manager). In many cases, this will be the only source of information needed to answer the questions without conducting detailed studies. In cases where the user needs more detailed data, this method may best be supplemented with the more detailed and precise Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service.

There is a recent trend to use wetlands for the commercial development of minnows, rough fish, turtles, or frogs for harvest. The use of wetlands for aquaculture has not been specifically included in this edition of the methodology; it should be addressed separately. This industry is not as fully developed in the Midwest as it is in other areas of the country and presently includes practices that are damaging to native wetland fauna. If the user wishes to address the value of a wetland for aquaculture, more specific information is required on the habitat needs of the species to be raised.Also, specific information on the management of the habitat by the harvester would be necessary.

Table 12: Wetland use by major fish groups

Fish	Spawning	nursery	Use food	Wintering
Pike (Esocidae)	HU	HU	U	LU
Perch (Percidae)	LU	U	U	LU
Sunfish/Bass (Centrarchidae)	LU	U(cover)	U(cover)	LU
Minnnows (Cyprinidae)	HU	HU	U	LU
"Rough Fish"	U	U	U	LU

HU - high use U - used LU - little use

METHODOLOGY DEVELOPMENT

The methodology is based on several other methodologies. The northern pike spawning habitat evaluation is most similar to the fish section of the Michigan Wetland Evaluation Technique (Michigan DNR, 1981) which also has its primary focus on northern pike spawning values. The general fishery values evaluation is similar to and based on the techniques found in a Method of Wetland Functional Assessment (Adamus, 1983) and Wetland Evaluation Methodology for the State of Wisconsin (COE, 1983). The logic structure for the northern pike spawning evaluation is also similar to that used by Adamus (1983) although it does not place such a strong emphasis on water quality criteria.

The criteria used in developing the questions and the *rationale for their inclusion are based on the* assumption that knowledge of various factors, including cover, substrate, depth, velocity, and water chemistry, can be used to predict the probability of the use of an area by fish. A more detailed explanation of the rationale behind the method is contained in Adamus (1983).

THE METHOD

The method offers two approaches, depending upon the needs of the user. The evaluation for northern pike spawning habitat produces a rating using seven questions and a logic flow chart (figure 18). The general fisheries evaluation uses the same type of approach but requires answering more questions and using a different logic flow chart (figure 19).

Northern Pike Spawning Habitat

The logic flow chart in figure 18 should be used in conjunction with the following questions to obtain a rating for northern pike spawning potential in a wetland.

1. *Connection to a fish source* : Is the wetland connected to a lake or streamthat has a population of northern pike?

A permanent connection to the fish source is not required; however, it is necessary that the connection be sufficient to allow fish movement in and out of the wetland during spring when spawning occurs.

2. *Spawning substrate* : Does the wetland contain vegetation of a type that canbe used by pike for spawning?

Any of the following types of vegetation can be used by pike for spawning and should elicit a "yes" response to the question: grasses and sedges, cattails, rushes, arrowhead, waterlilies, submerged plants, and shrubs or lowland hardwoods with grass or low emergents. Note that this question focuses simply on the presence or absence of any sort of spawning substrate. Question 6 addresses substrate quality.

3. *Frequency of flooding*: Is the wetland flooded during spawning season (early spring) at least once every 3 years?

4. *Duration of flooding and connection* : When the wetland floods during spawning season, does it remain flooded and connected to the fish source forat least 20 days?

Twenty days is the approximate time required for the eggs to hatch and for the fry to leave the wetland (Inskip, 1982). Maintenance of the connection is required to allow the fry to retreat with floodwaters to the main body of water.

5. *Scarcity of spawning habitat* : Is there enough potential spawning habitat in the area to support local pike populations?

Lacustrine areas should have 4 to 8 acres of actual spawning area for each 100 littoral acres of lake (MDNR, 1981). This optimal ratio can be used as a basis for evaluating the scarcity of spawning habitat in general and whether or not the wetland under evaluation is a significant part of the available spawning habitat.

In riverine situations, the scarcity of spawning habitat is not as easily measured; hence, the answer to this question is left to the judgment of the evaluator with the recommendation that the decision be made after consulting persons familiar with local fish populations (e.g., area fish manager).

6. *Quality of spawning substrate* : Are the areas that might be used for spawning vegetated primarily with reeds, grasses, or sedges?

Reeds, grasses, or sedges are the preferred spawning substrates for northern pike, although other types of vegetation can be used (see question 2).

7. *Recorded use* : Are northern pike known to spawn in the wetland being evaluated?

It will most likely be necessary to gather this information from secondary sources, preferably the area fish manager.

General Fishery Values For Warmwater Species

This focus should be selected if the primary fish species of concern in the evaluation include bass, bluegill, crappie, or other non-salmonid species excluding northern pike.

The logic flow chart (figure 19) should be used to obtain a rating of potential use. The following is a detailed listing of the questions used in the logic flow chart. Many of these questions and much of the basic logic in the flow chart are taken from the Method for Wetland Functional Assessment (Adamus, 1983). The numbers in parentheses following each of the questions correspond to questions from that method.

8. *Maximum depth* : Is the maximum depth of wetland greater than 0.1 m?

9. *Oxygenation of substrate* : Is the substrate of the wetland and adjacent deep water areas ("wet basin," as defined on the first page of the flood flow characteristics section) well-oxygenated by currents and wind mixing? (36)

Use the following guidelines if mixing is unknown: Aeration is probably adequate if:

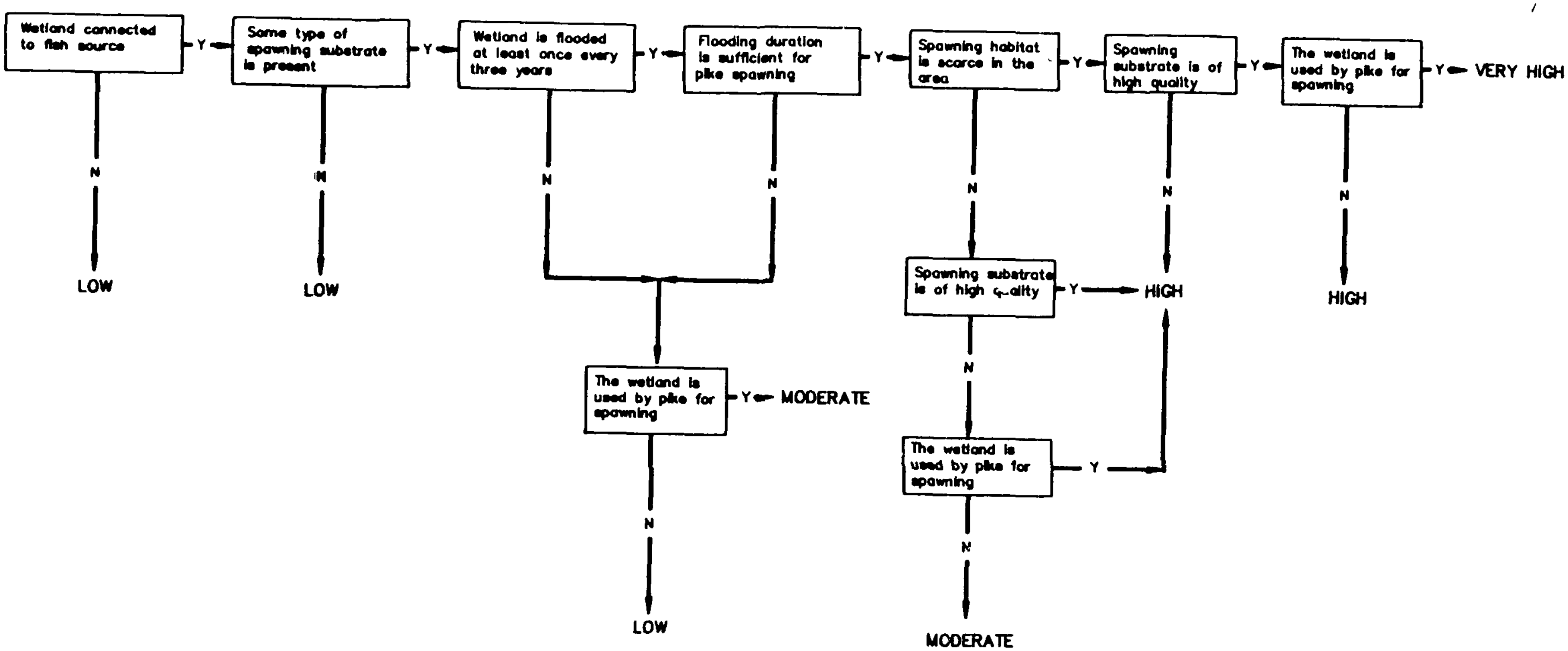
(a) the wet basin is at least 0.5 acre in size, AND

(b) unless riverine, most of the wet basin in summer is shallower than 22 feet (9.1 m) if lacustrine, 6 feet (1.8 m) if palustrine, AND

(c) The maximum mid-winter ammonia concentra tion in the wet basin is less than 0.5 mg/l, or if this is unknown, then the wetland (all areas less than 6 feet deep) at all seasons comprises less than 30 percent of wet basin (less than 60 percent if system is riverine). Note that the term "Impact Area" on the flow chart is the same as the wet basin.

10. *Winter fishkills* : Have fishkills been reported for the wet basin in late winter or summer? (60.1)

VALUES FOR NORTHERN PIKE SPAWNING FIGURE 18



11. *Suspended solids* : Runoff entering the wetland does not have suspended solids exceeding 1,200 mg/l yearly. (57.3)

12. *Alkalinity* : CaCO 3 alkalinity in the wetland is greater than 20 mg/l. (58.1)

13. *Water temperature* : The warmest summer water temperature measured at the deepest part of the wet basin is not greater than 69 o F. (63.2)

14. *Dissolved oxygen* : The dissolved oxygen content in the water column at the bottom of the basin in late winter and late summer is above 5 mg/l and at least 80 percent saturation, almost constantly. (64)

15. *Presence of outlet* : Does surface water (not runoff) enter or leave the wetland through a well-defined outlet? (1.2) (e.g., a defined channel, or culvert)

16. *Barriers to fish movement* : Are there any permanent barriers that block the movement of fishes to the wetland from downstream? (39.5)

17. *Known fish use* : Are fish known to use the wetland? The area fish manager or another reliable source should be contacted if the user is not familiar with the site or is not certain of use of the area by fish.

Use the following lists to answer the questions in the logic flow chart for warmwater species.

LIST A

(1) Wetland's pH is above 6.0 (25.2N).

(2) Water levels in the wetland are not artificially manipulated more oftenthan about 4 times per year (28.1N).

(3) Emergent macrophytes in the wetland do not cover an annual maximum of 100percent of the wet basin (41.4N).

(4) CaCO 3 alkalinity in the wetland is greater than 20 mg/l (58.1N).

LIST WR

(1) The wetland is generally sinuous or irregularly shaped (3.1Y).

OR

Land cover within 200 feet of the wetland is predominantly cropland and/or grazed grassland (15.4Y).

(2) The predominant class/subclass of the wetland is not open water (22.6N).

(3) Flooding regime of the wetland is not permanently flooded (26.1N).

(4) The wetland is greatly expanded for several weeks around peak time of natural flooding each year (27.2Y).

(5) Runoff entering the wet basin does not have suspended solids exceeding 4,000 mg/l yearly (57.4N).

OR

Wet basin is generally eutrophic at some time during the growing season (59.2Y).

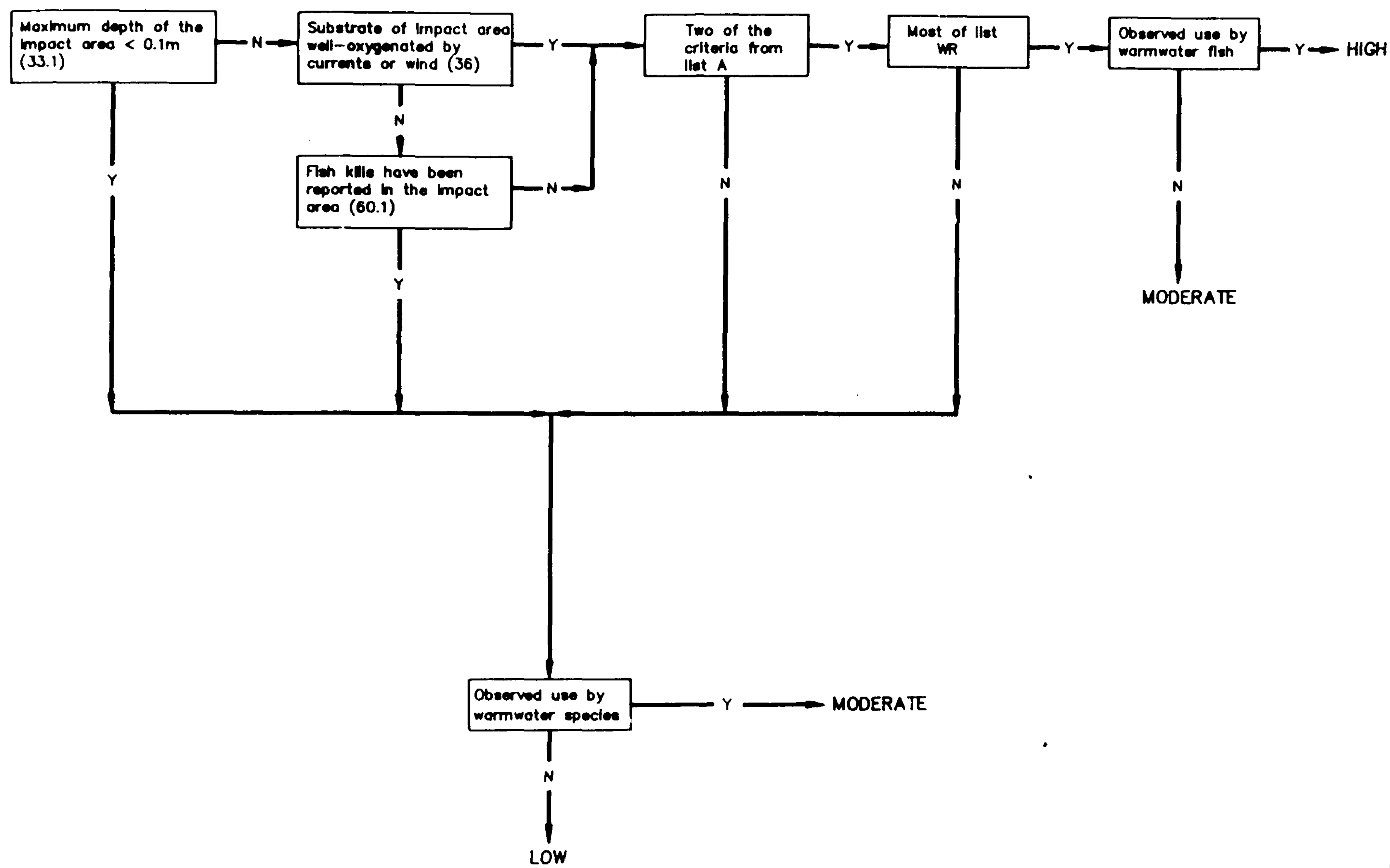
OR

Total nitrogen levels in the wet basin are generally between 0.15 and 0.25 mg/l (59.3Y).

OR

Warmest summer water temperature measured at the deepest part of the wet basin is not less than 50 degrees (63.1N).

HABITAT FOR WARMWATER FISH FIGURE 19



SHORELINE ANCHORING

INTRODUCTION

Shoreline erosion is controlled to a large degree by the characteristics of the transition zone between the shore (upland) and deepwater areas of the adjacent water body. Under the current definition, this transition zone is wetland; hence, wetland characteristics play an important role in the shoreline erosion process simply by virtue of their physical location in areas that are critical to that process.

The degree to which a wetland affects shoreline erosion depends upon two factors: (1) wetland topography and (2) wetland vegetation characteristics. The erosive strength of waves or currents can be greatly dissipated by a dense vegetation cover or by shallow water. In this methodology, primary emphasis is placed on the role of wetland vegetation in erosion prevention. The erosion considered is that caused by wave action and not by ice damage. Although topographic factors may also be important, wetland vegetation is felt to be more of a wetland characteristic than the topography of the site.

This methodology seeks to measure the probability that vegetation alteration within a wetland will affect the erosion rate on adjacent shoreline areas. Five ratings are possible: very high, high, moderate, low, and very low probability that wetland vegetation affects the erosion rate.

THE METHOD

Step 1: Critical Erosion Areas - Within the wetland site, identify the portion of the shoreline that is subject to the strongest erosive force. In riverine situations, look for areas on the outside of a river bend, and in situations where wave erosion is important (lakes), look for areas that lie in the line of greatest wind fetch. If erosion forces seem to be uniformly spread along the entire shoreline, a "typical" shoreline area should be selected for evaluation.

Step 2: Determine Rating - Determine the probability that alteration in wetland vegetation density will affect shoreline erosion using the following questions and the logic flow chart in figure 20.

1. *Vegetation Cover*
   Do rooted macrophytes cover
   a) less than 10 percent of the site?
   b) less than 50 percent of the site?

2. Erosive Forces
   The approximate strength of the erosive forces * at the site is
   a) strong (i.e., wave or current action is so strong that it precludes establishment of vegetation)
   b) negligible ** (i.e., erosive forces are small or absent so that complete removal of vegetation would not cause erosion)

* Do not include runoff from upland sites; include only the erosive force of the water body that contains the wetland.

** Small areas without much open water or areas that are completely vegetated (e.g., prairie pot holes) would fall into this category.

3. Current Condition of Shoreline
Is the shoreline in the area identified in step 1 currently being eroded by the water body (not including erosion caused by runoff from upland areas)?

4. Width of the Wetland
Is the wetland between the shoreline and deep water (water greater than 2 meters deep) greater than 2.5 meters wide?

5. Vegetation Anchoring Characteristics
Are any of the dominant (or co-dominant) plant species within the area identified in Step 1 listed as having potentially high value for shoreline anchoring in table 13?

6. Sediment Trapping
Is there evidence of sediment trapping in the vegetated areas of the wetland? Evidence can consist of rack lines, debris accumulation, sediment deposition, indication of inceptisols in a soil survey, or other signs of surface accretion.

7. Vegetation Type
Are the dominant (or co-dominant) plant species emergent-persistent?

8. Erosion Protection During Floods
Do the dominant (or co-dominant) plant species remain emergent during periods of high water or floods?

RATING LOGIC FOR SHORELINE ANCHORING FIGURE 20

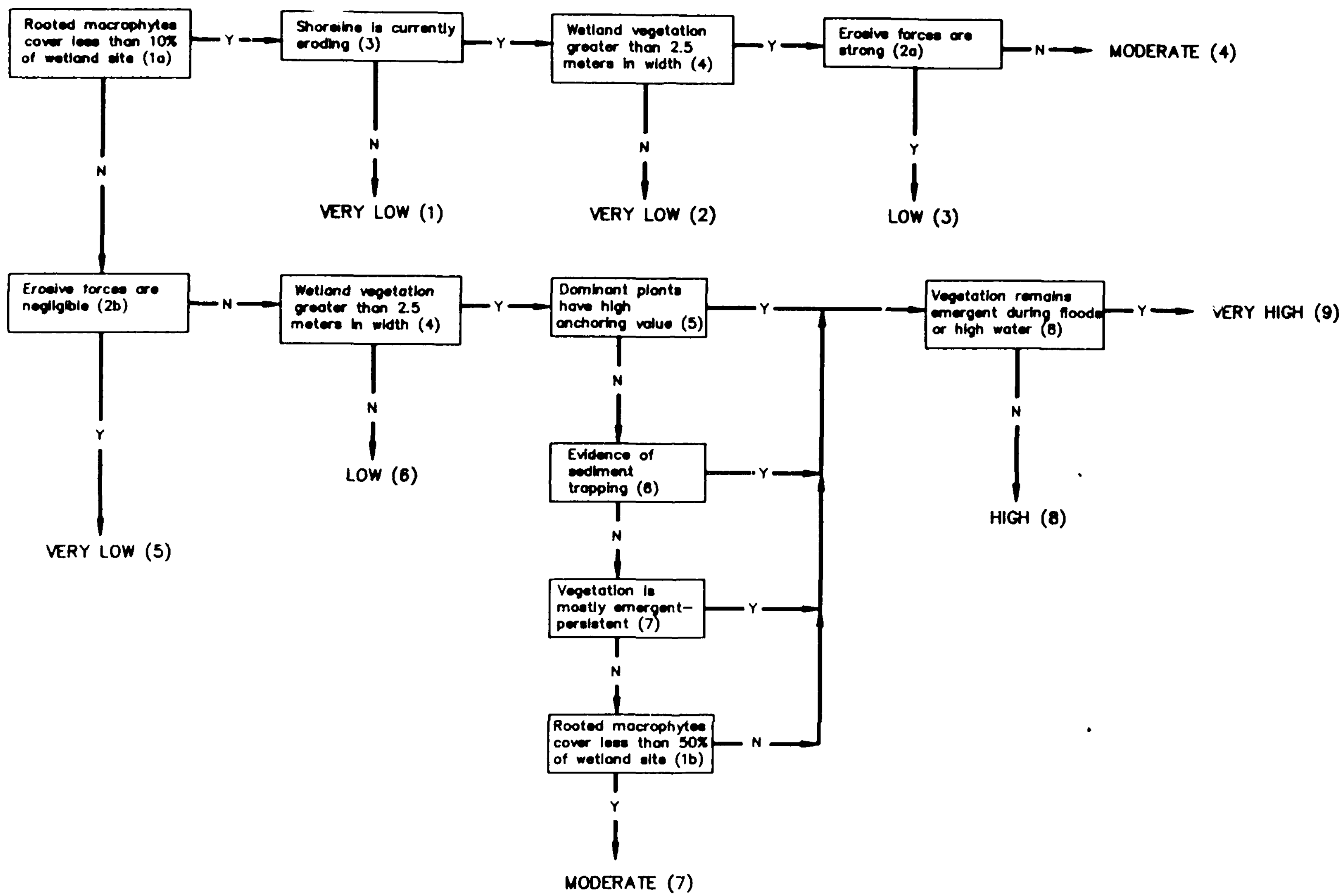


Table 13. Plant Species of Potentially High Value for Shoreline Anchoring

Plant Species Of Potentially High Value For Shoreline Anchoring, And/Or Which Can Be Artificially Established With Usually Good Success (Adapted from Kadlec and Wentz 1976 and Garbisch 1980).

Species	Common Name	Shoreline Anchoring	Artificially Established
Abies balsamea	Balsam fir	X	
Acorus calamus	Sweetflag		X
Alnus rugosa	Speckled alder	X	
Avicennia sp.		X	
Avicennia germinans	Black mangrove		X
Calamagrostis canadensis	Blue joint	X	
Carex spp.	Sedges	X	
Carex lyngbye	Lyngbye's sedge		X
Carex obnupta	Slough sedge		X
Cephalanthus occidentalis	Buttonbush		X
Cornus stolonifera	Red-osier dogwood	X	
Deschampsia caespitosa	Tufted hairgrass		X
Distichlis spicata	Salt grass		X
Eleocharis palustris	Spike rush	X	
Equisetum fluviatile	Scouring rush	X	
E. hyemale	Scouring rush	X	
Glyceria maxima		X	
Juncus balticus	Baltic rush	X	
Juniper communis	Juniper	X	
Laguncalaria racemosa	White mangrove		X
Leersia oryzoides	Rice cutgrass		X
Nymphaea spp.		X	
Panicum virgatum	Switchgrass		X
Phalaris arundinacea	Reed canary grass	X	
Phragmites communis	Common reed	X	
Polygonum	Smartweeds		X
Pontederia cordata	Pickerelweed		X
Populas deltoides	Cottonwood	X	
Potamogeton natans		X	
Potamogeton pectinatus	Sago pondweed		X
Prunus pumilla	Sand cherry	X	
Rhizophora mangle	Red mangrove		X
Ruppia maritima	Widgeongrass		X
Sagittaria spp.	Arrowhead		X
Salix spp.		X	
Salix cordata	Heart-leaved willow	X	
Salix interior	Sandbar-willow	X	
Saururus cernuus	Lizardtail		X
Scirpus spp.	Bulrushes	X	
Scirpus acutus	Great bulrush	X	
Scirpus americanus	Bulrush	X	
Scirpus paludosus		X	
Scirpus robustus	Saltmarsh bulrush		X
Scirpus validus	Bulrush	X	
Spartina alterniflora	Smooth cordgrass		X
S. cynosuroides	Big cordgrass		X
Spartina patens	Saltmeadow cordgrass		X
Thalassia testudinum		X	
Typha spp.	Cattail		X
Typha latifolia	Cattail	X	
Zostera marina	Eelgrass, wrack-grass		X

MEANING OF RESULTS

The purpose of this analysis is to provide some indication as to the probability that changes in wetland vegetation density will affect the erosion rate on adjacent shoreline areas. There are nine different ending points in the logic flow chart (figure 20), each of which indicates a different rating or meaning for a rating. The nine different end points are numbered on figure 20 and their meaning is described below.

(1) There is very low probability that changes in vegetation density will affect erosion rates because there is currently very little vegetation at the site and yet the shoreline is not eroding.

(2) There is very low probability that changes in vegetation density will affect erosion rates because the wetland is not wide enough to provide an effective buffer against erosion even if a very dense vegetation cover is established.

(3) There is low probability that changes in vegetation density will affect erosion rates because erosive forces at the site are too strong to permit establishment of any vegetation community capable of dissipating the erosive energy.

(4) There is moderate probability that changes in vegetation density will affect erosion rates because although vegetation density in the wetland is currently low, the physical characteristics of the site (width, and magnitude of erosive forces) are such that establishment of a denser vegetation cover may retard the erosion rate on the adjacent shoreline.

(5) There is very low probability that changes in vegetation density will affect erosion rates because erosive forces at the site are negligible.

(6) There is low probability that changes in vegetation density will affect erosion rates because the zone of wetland vegetation is not really wide enough to act as an effective buffer if erosive forces are very strong.

(7) There is moderate probability that changes in vegetation density will affect erosion rates because physical characteristics of the wetland site are adequate for erosion prevention, but the existing plant community is not.

(8) There is high probability that changes in vegetation density will affect erosion rates because physical characteristics of the site are adequate for erosion prevention as is the existing plant community.

(9) There is very high probability that changes in vegetation density will affect erosion rates because physical characteristics and characteristics of the plant community are good for erosion prevention and vegetation appears to be good for retarding erosion during flood or high water periods.

VISUAL VALUES

INTRODUCTION

Of all potential wetland functions or values, perhaps the greatest in terms of public awareness and opinion stems from the aesthetic qualities of the wetland. Of these qualities, visual values are virtually institutionalized in wildlife paintings, duck stamps, sculptures, carvings, and other forms of wildlife art. Wetlands frequently provide a unique visual environment in areas that are highly altered by human development activities.

This section of the methodology is included to provide a standardized means of assessing wetland visual values. It is often argued that a standardized visual assessment procedure is doomed to failure because "beauty is in the eye of the beholder," meaning that the results of such a procedure would depend too much on the evaluator and therefore lack reproducibility. To accept such an argument would mean ignoring a potentially important wetland value and could lead to the loss of many "beautiful" wetlands.

The method presented in the following pages is based on principles for visual and aesthetic evaluation proposed by Richard Smardon (1984). It assesses wetland visual values in three categories: (1) visual variety which addresses the concepts of spatial definition and diversity of views within a wetland; (2) visual importance which basically examines the number of people who might be enjoying the wetland's visual values; and (3) visual integrity which looks at the degree of human intrusion into the wetland's natural aesthetic qualities. This method does not specifically rate aesthetic qualities related to the other senses, but these are implied in the questions used.

THE METHOD

Visual Variety

This portion of the method rates the impressiveness of the view to a person who might be standing at a viewpoint overlooking the wetland site. There are four factors which contribute to the impressiveness of a view:

a) whether or not the wetland is a focal point in the scene.

b) whether or not the wetland and surrounding landforms create spatial definition within the scene.

c) whether or not there is visual diversity to the view.

d) whether or not the scene provides a feeling of expansiveness .

The rating scheme for visual variety is as follows:

High if the wetland has at least 2 of the 4 characteristics listed above

Moderate if the wetland has 1 of the 4 characteristics listed above

Low if the wetland has none of the above characteristics

The following is a detailed description of the four characteristics with criteria for deciding whether or not the characteristic is present:

1. *Focal Point* - The wetland is a focal point if surrounding landforms (hills, valleys, vegetation patterns) focus the viewer's attention on the wetland (refer to figure 21).

2. *Spatial Definition* - The wetland is surrounded by a landform (e.g., bluffs) that provides visual definition to the wetland/upland edge.

3. *Visual Diversity* - Visual diversity can be provided by the presence of a variety of different vegetation forms (e.g., pockets of trees in a cattail marsh) or by an interspersion of open water and vegetation. The wetland should be considered visually diverse if it meets either of the following criteria:

a) within the wetland, scattered pools comprise 10 to 50 percent and are mostly dispersed throughout.

b) vegetation interspersion is most clearly approximated by "type 3" in figure 22.

and

There are at least three different vegetation forms in the wetland (e.g. narrow-leaved emergents, broad-leaved emergents, shrubs).

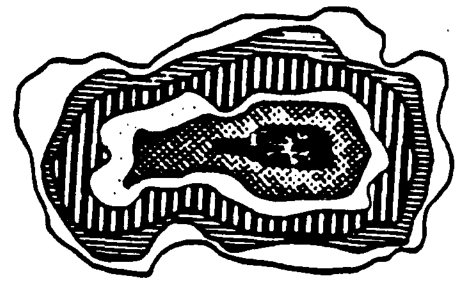
4. *Expansiveness* - A feeling of expansiveness is indicated by some or all of the following criteria:

a) absence of spatial definition.

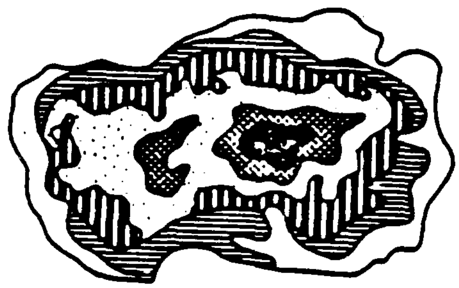
b) wetland is greater than 200 acres in size.

c) vegetation appears to be a continuous form (e.g. a "sea" of grass).

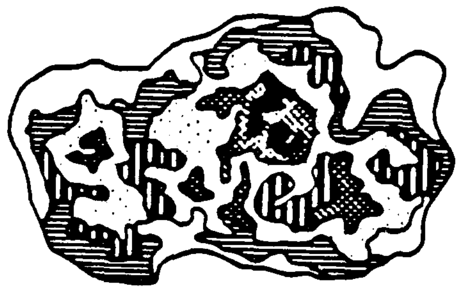
Figure 21. Examples of focal point wetlands.



INTERSPERSION CATEGORY 1



INTERSPERSION CATEGORY 2



INTERSPERSION CATEGORY 3

- Deciduous trees
- Tall slender shrubs
- Bushy shrubs
- Tall meadow emergents
- Robust emergents
- Broad-leaved emergents

FIGURE 22. Examples of the three wetland vegetative interspersion categories (from Golet, 1976).

Visual Importance

Visual importance is a rough measure of the number of people who might have the opportunity to observe the wetland. Importance is indicated by the wetland's proximity to urban areas, parks, roadways, and trails and by notable characteristics such as official protection or recognition. The visual importance rating ranges from very high to low and is obtained using the logic flow chart in figure 23 and the following questions:

1. *Public Recreational Areas* - Is the wetland officially designated as a park, scenic route, historic site, wilderness, primitive area, or landmark; or is it part of a "Wild and Scenic River," "Recreational River," or "Wilderness Lake or River"?

2. *Size/Scarcity* - Is the wetland the largest remaining in the county?

3. *View Duration* - Is the wetland viewed primarily by

   3.1 automobile (either by driving past the wetland or by stopping at an observation point or scenic overlook)?
   3.2 active recreation (e.g., hunting, hiking, canoeing, photography, bird watching, etc.)?

4. *Accessible by Navigable Waters* - Is the wetland immediately adjacent to a river, stream, lake, pond, or impoundment?

5. *Shoreline Vegetation Diversity and Density* - Are the density and diversity of shoreline vegetation such that distinct plant forms are visible from across the wetland, or is it possible from across the wetland to see through the first few rows of shoreline vegetation to the upland landscape beyond the wetland?

6. *Recreational Accessibility* - Is the wetland or project site associated with an intensively used recreation area?

7. *Physical Accessibility* - Is the physical access to the wetland easy or moderate (as opposed to difficult or impossible)?

8. *Accessibility* - Is the wetland located within 60 miles of an urban or suburban area?

Visual Integrity

A high degree of visual integrity is indicated by absence of non-natural disruptions in the field of view. Potential disruptions can stem from three sources: a) alterations or development within a wetland, b) alterations or development adjacent to a wetland, and c) the presence of pollution or litter.
The method for assessing visual integrity involves rating the potential for disruption from each of these three sources and combining the three separate ratings to obtain an overall rating for visual integrity. The ratings are determined using table 14 and the following questions:

9. *Wetland Alteration* - What percentage of the wetland contains alterations; i.e., filling, dredging, roads, utility corridors, buildings, etc.?

   9.1 0%
   9.2 less than 25%?
   9.3 25-50%?
   9.4 50-75%?
   9.5 greater than 75%?

10. *Wetland Intrusion* - Does the alteration within the wetland contrast greatly in any way with the surrounding vegetation (i.e., color, scale, height)?

11. *Land Cover of Adjacent Upland* - Is the majority of the land cover on upland areas adjacent to the wetland (particularly the area closest to the wetland) developed? (including industrial, commercial, residential, and mowed grass areas)

12. *Adjacent Development* - Does the adjacent development contrast greatly in any way with the surrounding vegetation (i.e., color, scale, height)?

13. *Pollution* - Is pollution (i.e., water, air, litter, junk):

   12.1 severe?
   12.2 moderate?
   12.3 low or not apparent?

RATING LOGIC FOR VISUAL IMPORTANCE FIGURE 23

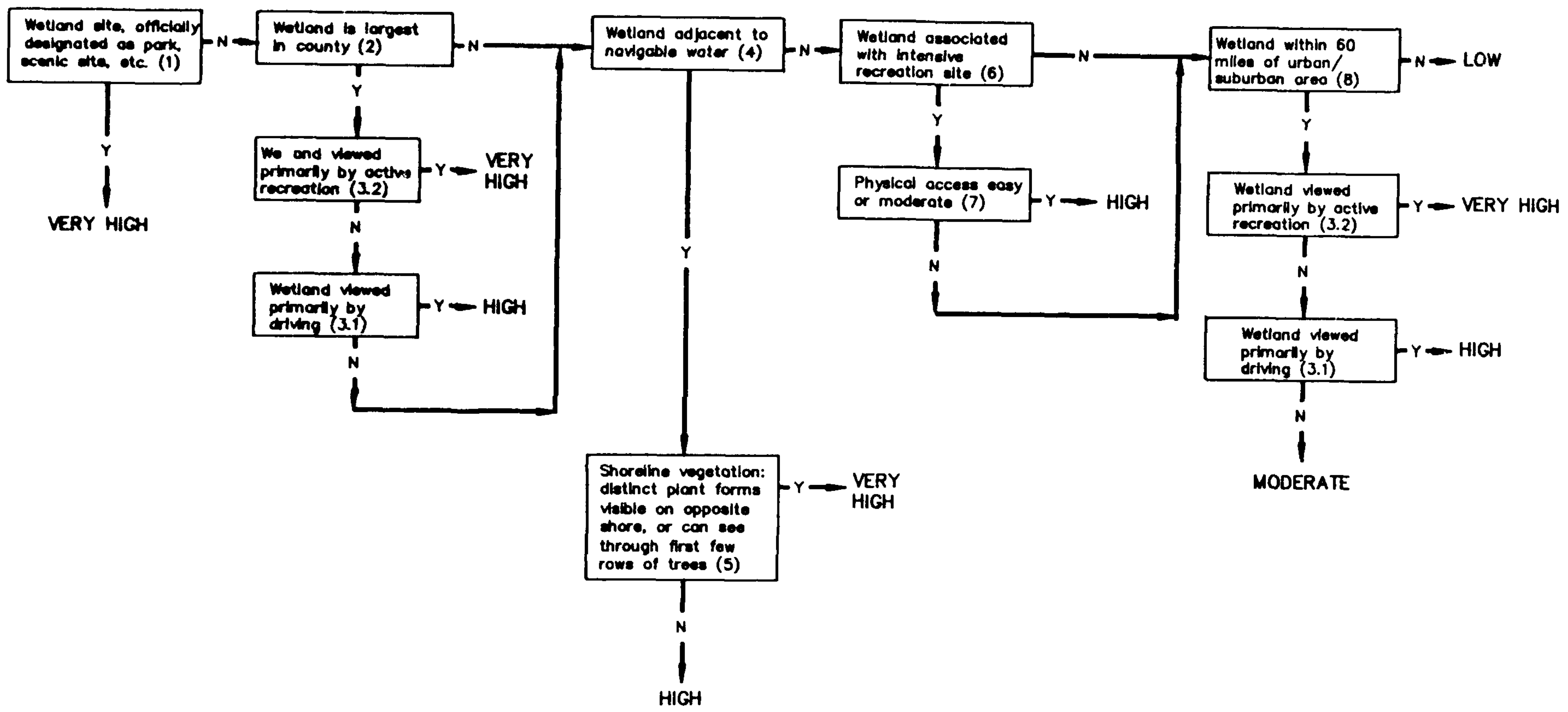


Table 14: Visual Integrity Rating (VH - very high, H - high, M - moderate, L - low)

VISUAL INTEGRITY RATING:

LOW .... Any one of conditions A, B, or C (below) is low

MODERATE .... Two of A, B, or C are moderate and the remaining condition is high, or A, B, and C are all moderate

HIGH .... Two of A, B, or C are high and the remaining condition is moderate, or A, B, and C are all high

Condition A: Alterations within the wetland

		percent altered (question 9) 0	1-25	26-50	51-100
contrast	Y	H	M	L	L
(question 10)	N	H	M	M	L

Condition B: Alterations adjacent to the wetland

		development adjacent to wetland (question 11) Y	N
contrast	Y	L	M
(question 12)	N	M	H

Condition C: Presence of pollution (question 13)

Low or not apparent	Moderate	Severe
H	M	L

SPECIAL FEATURES

INTRODUCTION

The special features portion of the wetland evaluation method will help the user identify special types of wetlands, important study areas, endangered species, and critical habitat.

Some wetlands are important for reasons not specifically discussed in the other sections of this wetland evaluation methodology. There are often laws protecting these important areas which require further coordination with other agencies. If the wetland has any of the characteristics outlined below, it should alert the user to make additional contacts with the appropriate agencies to ensure the protection of these important natural, cultural, and social resources.

The special features section is divided into three parts; each part lists questions about resources that are either identified as important on various levels of government or are not yet widely recognized, but are nevertheless important. The resources that are protected by law on many levels of government are considered more critical in the synthesis of functions and are given a higher "score".

SOURCES OF INFORMATION

Many of the areas and species in question have already been identified. State natural heritage program personnel and fish and wildlife managers are important sources of information. Maps and lists available from Federal, State, and local agencies identify the locations of some of these important resources. Below is a list of resources that should be available to the user:

U.S. Geological Survey (USGS) 1:24,000 scale maps and/or air photos ofthe area
State or Federal wetland inventory maps
Lists of threatened or endangered species (State and Federal)
Lists of species of special emphasis (State and Federal)
SCS soil surveys
Minnesota Geological survey maps or ground water maps
Access to the National Register of Historic Places

The following agencies and personnel will also be important sources of information:

County Agencies such as Parks, Zoning and Land Use
Soil and Water Conservation Districts
Watershed Districts
Regional Planning Agencies
The State Historic Preservation Officer
The State Department of Natural Resources
U.S. Department of Agriculture (USDA) Agricultural Stabilization and Conservation Service

The following questions should lead the user to determine if the wetland has resources that have been identified on various levels of government for their unique ecological, cultural, or social significance. Projects in these areas will most likely require a review by a variety of agencies at each level of government.

1. Is the wetland important for threatened or endangered species? Choose the one most appropriate answer.

a. Is the wetland within the known range of any State- or Federally-listed threatened or endangered species? Note that coordination with the U.S. Fish and Wildlife Service (USFWS) and the State Natural Heritage Program (NHP), or other Department of Natural Resources sections, should be initiated.

b. Is the wetland considered critical habitat for any State- or Federally-listed threatened or endangered species? Note that more extensive coordination is required with the USFWS and NHP personnel.

c. Is the wetland known to be inhabited by threatened or endangered species? This will require the most extensive coordination with Federal and State resource agencies and will often result in changes in the proposed project.

2. Is the wetland regulated by the State or by the Corps of Engineers (COE)? State protected waters, wetlands, and streams are designated bythe Department of Natural Resources. Waters of the United States,including wetlands, are regulated under Section 404 of the Clean Water Act and the Rivers and Harbors Act of 1899 by the COE.

3. Does the wetland contain any properties that are listed on, or eligible for inclusion on, the National Register of Historic Places?

4. Is the wetland within or near tribal lands?

5. Is the wetland adjacent to a State- or Federally-designated Wild and Scenic river, or a tributary of a Wild and Scenic river?

Many of these wetlands are also protected by law, statute, or ordinance but would not necessarily involve coordination on many levels of government.

1. Some wetlands are important for the enhancement or preservation of wildlife or natural areas. These can include a refuge, wildlife area public hunting area, park, or similar area. Note that coordination will be primarily with the public agency responsible for the purchase or easement. If there are other concerns such as endangered species or rare habitats, coordination with additional agencies may be required.

a. Is the wetland being considered for purchase or easement by a public agency?

b. Is the wetland adjacent to a publicly-owned area similar to those described above?

c. Is the wetland within a publicly-owned area similar to those described above?

2. Has the wetland been the subject of any long-term studies or research?

The following questions should lead the user to identify areas that are also important for ecological, cultural, or educational reasons but are not as widely recognized on various levels of government or as fully protected by law as are the above areas.

1. Is the wetland a rookery, staging, or resting area for migrating or wintering birds whether or not those species are listed as threatened or endangered?

2. Does the wetland provide habitat for species whose populations are in decline? Some of these are considered species of special concern or emphasis by State or Federal agencies.

3. Is the wetland within a locally-designated open space or environmental corridor?

4. Is the wetland used by schools or universities?

5. Are there known groundwater interactions in the wetland site?

a. Are there springs in the wetland or in similar wetlands in the watershed or in nearby watersheds?

b. Is the wetland located in a region known for groundwater recharge? (You may wish to consult USGS or MSGS groundwater maps.)

Note that groundwater effects of wetlands are quite complex and do not easily lend themselves to rapid assessment or evaluation methods.

6. Is the wetland unlike others in the area with respect to size or vegetation type? NHP personnel should be contacted to verify answers to the following questions:

a. Is the wetland a calcareous fen?

b. Is the wetland an orchid bog?

c. Is the wetland at the extreme limit of its range? (eg. a brackish marsh east of the Dakotas or cedar swamps south of the northern forested regions)

d. Is the wetland a wet prairie or part of a prairie pothole complex?

7. Is the wetland important to coldwater fish species?

a. Is the wetland adjacent to a direct tributary of one of the Great Lakes?

b. Is the wetland adjacent to a State-designated trout stream or trout lake?

SYNTHESIS OF FUNCTIONAL RATINGS

SYNTHESIS OF FUNCTIONAL RATINGS

This synthesis of ratings was developed to provide a method to combine the various ratings from each of the wetland methodology sections. The specific wetland functional value ratings should be relied upon for documenting the wetland characteristics; the synthesis should only be used to generate a "bottom-line" value for comparison of wetlands in a general way. The synthesis does not show the user any detail about the functions that the wetland performs. Its contribution is that it helps the user to make structured decisions in the addition of "apples and oranges" necessary to a synthesis of functional ratings.

The functional ratings generated by the WEM program are shown on the program's summary of ratings sheet (see WEM Computer Program - User Information). The synthesis converts these qualitative and quantitative values to a whole number 1 through 5. The method of conversion differs for each section of the methodology and each is described in the following pages. Five values were used, as opposed to three or a straight percentage, because each section of the methodology provides a different degree of detail. More than 5 values might imply that some sections of the methodology provide more precision than they offer.

This synthesis rating is then multiplied by a factor of 1, 2, or 3. This factor is used to indicate the relative importance of that function compared to other functions in that wetland, or the importance of that function to the user or group using the methodology. The importance factor can be used to tailor the program to the user's needs. The user can be an individual or an agency; the choice of the importance factor can be the individual's or agency's choice. Regardless of which factor is chosen, the choice should be documented. The program will ask the user to choose an importance factor as part of the synthesis; there are no default factors chosen by the program.The choice might reflect an agency's reasons for conducting an evaluation, Or, it might reflect a value judgment on the opportunity for a wetland to perform a function or the need for that function in the watershed, county, or State.

In summary, the functional rating, be it qualitative or quantitative, is converted to a synthesis rating, a number 1 through 5. This is multiplied by the importance factor, a number 1 through 3.

The resulting numbers for each function are then added together and their average is determined. This average is then normalized to 15 and then divided into 5 equal portions. Each portion is assigned a qualitative value from very low to very high as follows: A normalized average of 0 to 3 is assigned a qualitative value of very low; 3.1 to 6, a value of low; 6.1 to 9, a value of moderate; 9.1 to 12, a value of high; and 12.1 to 15, a value of very high. This is the "bottom-line" qualitative value for that wetland. The numerical value, a maximum of 15, can also be compared to those of other wetland sites or to the preproject and postproject values of one wetland site.

Note that both the Flood Flow Characteristics section and the Water Quality section must be done before the synthesis of functional ratings can be accomplished. If there are fewer than two functions being rated, the automated synthesis portion of the program need not be done.

SYNTHESIS OF FLOOD FLOW CHARACTERISTICS

Small Watersheds

The small watershed method flood flow characteristics section measures the average annual peak inflows to and outflows from the wet basin (the wetland plus adjacent deep water areas) in cubic feet per second. The program also measures the importance of the basin to peak flow reduction which is a ratio of how much of the inflow is stored in the wet basin. This measurement is then reduced by computing the percentage of the storage volume of the wet basin that can be attributed to the wetland. Appendix A contains more information on the development of this methodology.

Because the final number is a percentage, it can be divided into equal portions and assigned a synthesis rating of 1 through 5 as follows:

Importance to Flow Reduction	Synthesis Rating
0 - 20%	1
21 - 40%	2
41 - 60%	3
61 - 80%	4
81 - 100%	5

This synthesis rating is then revised to include the downstream damage potential. The program will assign a new synthesis number based on the following table:

Downstream Damage Potential	Synthesis Rating (Described Above) 1	2	3	4	5
Low	1	1	2	3	4
Moderate	1	2	3	4	5
High	2	3	4	5	5

The revised synthesis rating from the table is multiplied by an importance factor chosen by the user. This product is added to those from the other functions evaluated, and an average is determined. The average is divided into 5 equal portions to determine the qualitative rating for all the functions being evaluated. The average numerical value can also be used to compare wetlands.

Large Watersheds

In the large watershed method of the flood flow characteristics section, the user is asked to determine whether the wetland is hydrologically important or not. As in the small watershed section, palustrine, lacustrine, and floodplain sites are discussed.

The methodology first directs the user to determine the hydrologic importance of the wet basin, including the wetland site being evaluated. If the basin is considered important, then the user determines what percentage of the basin contains the wetland site. If the storage of the wetland site is 10 percent of the wet basin or more, the site is considered important hydrologically. In the case of floodplain sites, the volume of flow across the wetland is used instead of the storage measurement.

For palustrine and lacustrine sites, the wet basin is considered hydrologically important if one of the three following criteria is met: it is larger than 10 percent of its upstream watershed; or it can store more than 1 percent of the volume of water coming in from the upstream watershed; or the wetland has a moderating effect on downstream flow as indicated by changes in water surface area or volume upstream and downstream of the wetland site. Note that the definition of large watersheds used in this methodology includes those that are at least 100 square miles in size. If the wetland site comprises at least 10 percent of an important wet basin, that wetland site would also be considered hydrologically important.

Floodplain pools and control points are assumed to be hydrologically important because alteration of these areas will potentially alter river hydrology above or below the wetland site. The user must determine if the wetland site being evaluated comprises 10 percent of the total storage volume of the pool for floodplain pool sites. For floodplain control point wetland sites, the volume of water passing the control point is determined. High, moderate, and low qualitative values are assigned for sites that convey less than 10 percent of the total flow, between 10 percent and 20 percent, and more than 20 percent, respectively, across the control point wetland site.

The synthesis ratings are assigned as follows: Those palustrine, lacustrine, and floodplain pool wetland sites that are considered hydrologically important are assigned a value of 4; those not considered important are assigned a value of 2.
Floodplain pool sites are assigned 4, 3, and 2, respectively, for high, moderate, and low proportions of flows conveyed. Other floodplain sites do not generally have significant effects on flood flows and are assigned a synthesis rating of 2.

The synthesis ratings described above are revised by combining them with the downstream damage potential as shown on the following table:

Downstream Damage Potential	Synthesis Rating (From Above) 2	3	4
Low	1	2	2
Moderate	2	3	4
High	3	4	5

The revised synthesis rating from the table is multiplied by an importance factor chosen by the user. This product is added to those from the other functions evaluated, and an average is determined. The average is divided into 5 equal portions to determine the qualitative rating for all the functions being evaluated. The average numerical value can also be used to compare wetlands.

SYNTHESIS OF WATER QUALITY

Small Watersheds

The WEM program computes the effectiveness of the wetland at retaining nutrient and sediment loads from upstream runoff. The summary of ratings also gives the user an idea of the opportunity for the retention of sediment and nutrient loads from the sediment/nutrient input rating. The percentages determined for the effectiveness are used in the synthesis of ratings. Note that the WEM program uses computations from the flood flow section so that low values from the previous section will carry over into the water quality analysis. Appendix B contains information about the development of this methodology.

As in the flood flow characteristics section, the "efficiency" of the basin, or percentage of sediment and nutrients retained, is reduced by a fraction depending on the portion of the wet basin occupied by the wetland site. This final percentage is the "effectiveness" of the basin. For the synthesis, the percentages are assigned the following synthesis ratings.

Effectiveness Rating	Synthesis Rating
0-20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

This synthesis rating is then revised by combining it with one of the four downstream sensitivity ratings as shown in the table below:

Downstream Sensitivity	Synthesis Rating (From Above) 1	2	3	4	5
Low	1	1	2	3	4
Moderate	1	2	3	4	5
High	1.5	2.5	3.5	4.5	5.5
Very High	2	3	4	5	5

The revised synthesis rating from the table is multiplied by an importance factor chosen by the user. This product is added to those from the other functions evaluated, and an average is determined. The average is divided into 5 equal portions to determine the qualitative rating for all the functions being evaluated. The average numerical value can also be used to compare wetlands.

Large Watersheds

As in the flood flow section, the results for the analysis of water quality functions in large watersheds are qualitative. The vegetation, presence of turbulent flow at the site, and flow patterns are considered when determining the importance of the water quality function.

The user must first determine if the wetland site is hydrologically important. The flood flow characteristics section provides information on how to accomplish this. Wetlands that are not hydrologically important are given low effectiveness ratings as sediment and nutrient traps.

For hydrologically important sites, the above characteristics are assigned numerical values which are added together to obtain a qualitative value of low, moderate, or high. This qualitative value is assigned a synthesis rating of 2, 3, or 4, respectively.

The synthesis rating is combined with the downstream sensitivity rating to obtain a revised synthesis rating as shown in the following table:

Downstream Sensitivity	Synthesis Rating (From Above) 2	3	4
Low	1	2	3
Moderate	2	3	4
High	2.5	3.5	4.5
Very High	3	4	5

The revised synthesis rating from the table is multiplied by an importance factor chosen by the user. This product is added to those from the other functions evaluated, and an average is determined. The average is divided into 5 equal portions to determine the qualitative rating for all the functions being evaluated. The average numerical value can also be used to compare wetlands.

SYNTHESIS OF WILDLIFE RATINGS

The wildlife section provides a method to evaluate general wildlife diversity and productivity of the wetland site. Appendix D is a methodology that can be used to determine the value of the wetland to major waterfowl groups. Appendix C explains the rationale behind the methodologies described as well as some definitions and comparisons of various evaluation methodologies.

Nine criteria are used to evaluate the wetland's general diversity and productivity. Points are assigned under each of the criteria and are added together, then normalized so the maximum final score is 100.
To synthesize the results, the scores are assigned synthesis ratings as follows:

Wildlife Score	Synthesis Rating
33-46	1
47-60	2
61-74	3
75-88	4
66-100	5

This synthesis rating is then multiplied by an importance factor of 1, 2, or 3 at the user's discretion. This factor will show the relative importance of the wetland's wildlife diversity and productivity. Professional judgment of the individual or agency can be used to determine this factor, or the results of the waterfowl use evaluation in appendix D can be considered when determining the relative importance factor. The products are added together and the average is used to determine a qualitative value for the wetland. The average can also be used to compare wetlands.

Both the wildlife section and appendix D use flow charts to determine the value of the wetland for these resources. The questions from the flow charts appear in the computer program and follow the same pattern as the flow charts. In some cases, it may be easier to answer the questions from the flow chart in the field instead of at the computer terminal. Eventually, the answers need to be logged into the terminal if the user wishes to synthesize the results.

SYNTHESIS OF FISH RATINGS

This section of the methodology has two parts. The user can determine a qualitative rating of the wetland as a warmwater fishery in general, or for northern pike spawning in particular.

For the synthesis of ratings, the program will select the higher of the two functional ratings. The numerical values 2, 3, and 4 will be assigned to low, moderate, and high ratings for general fish habitat or northern pike spawning values, respectively. The user then assigns an importance factor of 1, 2, or 3. The product of the synthesis rating and importance factor is added to the products of the other functions being evaluated. An average score is computed and used to determine a qualitative value for the wetland. The numerical average can also be used to compare wetlands.

SYNTHESIS OF SHORELINE ANCHORING RATINGS

The shoreline anchoring section of the methodology is designed to measure the probability that vegetation alteration will affect the erosion rate. It provides the user with one of 5 qualitative ratings, from very high to very low. To synthesize the rating, numerical values are assigned as follows:

Qualitative Rating	Synthesis Rating
Very Low	1
Low	2
Moderate	3
High	4
Very High	5

The user is then asked to assign an importance factor of 1, 2, or 3 to this function. The product of the synthesis rating and importance factor is added to the products of the other functions being evaluated. An average score is computed and used to determine a qualitative value for the wetland. The numerical average can also be used to compare wetlands.

SYNTHESIS OF VISUAL VALUES RATINGS

There are three categories to measure in the visual values section. These are visual variety, visual importance, and visual integrity. Other non-visual qualities that are part of the aesthetics of wetlands are implied but not specifically rated. These include things such as clean air and water, solitude, and accessibility.

In the visual variety and visual integrity categories, the evaluation results in qualitative ratings of high, moderate, or low. As in other sections, these ratings are assigned synthesis ratings of 4, 3, and 2, respectively. The visual importance category results in one of the three above ratings or a very high rating. The three ratings are averaged to determine the synthesis rating.

The user is then asked to assign an importance factor of 1, 2, or 3 to this function. The product of the synthesis rating and importance factor is added to the products of the other functions being evaluated. An average score is computed and used to determine a qualitative value for the wetland. The numerical average can also be used to compare wetlands.

SYNTHESIS OF SPECIAL FEATURES

The special features section is included to help the user identify special types of wetlands, important study areas, and threatened and endangered species and their critical habitat. These resources are not specifically included in other sections of the methodology.

This section has 14 questions which have been grouped into three categories. Each category requires less coordination than those before it because fewer laws currently protect those important resources or features. This grouping can be thought of as a "red flag" index. The user notes the presence or absence of these special features. This section can serve as a guide for the user in determining the importance factor, or can be synthesized with the other functions being evaluated.

In synthesis of the special features section, each question is assigned one point for every affirmative answer. Some questions have multiple parts differing in the level of protection of the resource; others have multiple answers that are equally important. The point values were changed to reflect these differences.

For multiple part questions, only one answer is appropriate. The point values of each of the parts differ by 0.1 to indicate a change in the level of protection currently offered the resource. An example is the question on threatened or endangered species. A wetland known to be inhabited by such a species will receive a score of 1.2 while one with critical habitat but no threatened or endangered inhabitants would receive 1.1 points. The point values reflect the subtle difference in protection offered wetlands that could provide habitat to endangered species compared to those that do. It also indicates that both conditions are nearly equally important.

Some of the questions provide multiple examples or choices, all of which are equally important. For these questions, an affirmative response to any of the choices results in a score of 1 point for that question.

To differentiate between the three categories of questions, each category is multiplied by either 1, for those with the least legal protection, or lowest red flag index; 2.0 for those with the most protection; or 1.5 for those in between.

The resultant values are added together and then normalized to provide a maximum value of 20. That normalized value is then assigned a synthesis rating of 1 through 5. The user then assigns a relative importance factor of 1, 2, or 3 to the special features section. The result will be added to similar results from the other sections and averaged to obtain the final "bottom line" value for the wetland. The average is also assigned a qualitative value which can be used to compare wetlands.

Below is an outline of the point values for each question, the number each category is multiplied by, and the fraction used to normalize the sum of the point values.

Category 1 - Resources that have been identified on many levels of government. The factor for this category is 2.

Question	Point value	x 2	Result
1a	1.0		2.0
1b	2.2		2.2
1c	1.2		2.4
2	1.0		2.0
3	1.0		2.0
4	1.0		2.0
5	1.0		2.0

Note: Only one of the three parts to question 1 should be answered affirmatively.

Category 2 - Resources that are protected by law but not on as many levels of government as those above. The factor for this category is 1.5.

Question	Point value	x 1.5	Result
1a	1.0		1.5
1b	1.1		1.65
1c	1.2		1.8
2	1.0		1.5

Note: Only one of the three parts to question 1 should be answered affirmatively.

Category 3 - Resources that are important for ecological, cultural, or educational reasons but are not protected on as many levels of government as those above. The factor for the category is 1.

Question	Point value	x 1	Result
1	1.0		1.0
2	1.0		1.0
3	1.0		1.0
4	1.0		1.0
5a	1.0		1.0
5b	1.1		1.1
6	1.0		1.0
7	1.0		1.0

Note: Only one of the two parts to question 5 should be answered affirmatively.

Note: Assign questions 6 and 7 one point if any choices are present.

Add the 14 resulting point values together, then multiply by 20/20.70 to normalize the sum. This will result in a number between 0 and 20. The normalized value is assigned a synthesis rating as follows:

Normalized Value	Synthesis Rating
0-4	1
4.1-8	2
8.1-12	3
12.1-16	4
16.1-20	5

The next step for the synthesis for this and all other sections of the methodology is to assign an importance factor of 1, 2, or 3. The product of the synthesis rating and the importance factor will be added to those obtained for each section of the methodology. The average can represent the "bottom line" rating for the wetland. Alternatively, a qualitative value may be determined by splitting the average into 5 equal portions can be used.

SUMMARY OF THE SYNTHESIS OF RATINGS

FUNCTION	FUNCTIONAL RATING CHOICES	SYNTHESIS RATING	IMPORTANCE FACTOR
1. Flood Flow Characteristics			
Small Waterhseds-Importance Rating	percentage	1 - 5	1 - 3
Large Watersheds			
palustrine sites	important or not	2 or 4	1 - 3
lacustrine/floodplain-pool sites	important or not	2 or 4	1 - 3
floodplain control-point sites	L, M, or, H	2,3,or 4	1 - 3
other floodplain sites	not important	2	1 - 3
Downstream Damage Potential	L, M, or, H	(combined w/one of the above to form sy	
2. Water Quality			
Small Watershed Sediment Trapping	percentage	1 - 5	1 - 3
Small Watershed Nutrient Trapping	percentage	1 - 5	1 - 3
Large Watersheds	L, M, or, H	2,3,or 4	1 - 3
Downstream Sensitivity	L, M, H, or, VH	(combined w/one of the above to form sy	
3. Wildlife			
General Diversity and Productivity	Score from 33		
Northern Forest Region	to 100 for one	1 - 5	1 - 3
Southern Forest Region	of the three	1 - 5	
Prairie Grassland Region	regions	1 - 5	
4. Fish			
Northern Pike Spawning Habitat	L, M, H or, VH	2,3,4, or 5	1 - 3
Warmwater Fish Habitat	L, M, or, H	2,3,or 4	
		(Highest rating is used for synthesis)	
5. Shoreline Anchoring	VL, L, M, H, or VH	1 - 5	1 - 3
6. Visual Values			
Visual Variety	L, M, or, H	2,3,or 4	1 - 3
Visual Importance	L, M, H, or, VH	2, 3, 4, or 5	
Visual Integrity	L, M, or, H	2,3,or 4	
		(Average of the above 3 is the synthesi	
7. Special Features	Yes or No for each of 14 questions.	1 - 5	1 - 3

APPENDIX A

FLOOD FLOW CHARACTERISTICS

FLOOD FLOW CHARACTERISTICS: EXPLANATION OF BACKGROUND AND ASSUMPTIONS

INTRODUCTION

This appendix presents the background, supporting logic, and assumptions used in the procedures for characterizing flood flows through a wetland site. The appendix focuses on the methods used in the characterization of peak flows for wetlands with small, hydrologically uniform upstream watersheds. The logic portions of the flood flow procedures (large watershed methods, downstream damage potential) are easily deduced from descriptions given in the methodology.

This appendix begins with a brief discussion of the role of topography and the wetland in the moderation of peak flows at a wetland site. An overview of the three main components of the hydrologic model is then presented, and is followed by a description of how some of the input values are used in that model. The appendix concludes with a description of how model outputs are computed.

WETLAND VERSUS TOPOGRAPHIC EFFECTS

Flood peak moderation involves a distinction between the wetland and the topographic site containing the wetland. Although flood peak moderation is commonly referred to as a wetland function (Adamus, 1983; Ontario Ministry of Natural Resources, 1983; Ammann, 1984; and others), it is actually controlled by topographic variables. Peak moderation is a physical process that happens to occur at a wetland site rather than a function of the wetland itself.

This interpretation does not imply that wetland characteristics do not influence flood flows. On the contrary, wetland vegetation type, evapotranspiration rates, and groundwater losses or discharges occurring in the wetland will affect the peak moderation characteristics. In spite of this, it must be remembered that topographic effects are basic to the peak moderation process in the sense that they determine the degree to which other characteristics influence flows.

The model used in this methodology includes the effect of upland portions of the outlet and storage available over upland areas that are adjacent to the wetland. Conclusions drawn from the analyses should therefore be considered a description of a physical process (moderation of peak flows) occurring in a topographic depression that contains a wetland.

THE HYDROLOGIC MODEL

The hydrologic model used in the methodology is based on standard hydrologic methods used by the Corps of Engineers (COE) for design of interior drainage ponding facilities and by the Soil Conservation Service (SCS) for design of small water control structures. The standard methods were streamlined and computerized so that only those computations necessary for hydrologic characterization of wetland sites are in the model.

MODEL COMPONENTS

The model has three components corresponding to the principal hydraulic and hydrologic processes governing flood flows: (1) rainfall (computation of a rainfall distribution), (2) runoff (amount and temporal distribution of runoff from the watershed), and (3) site hydraulics (modification of flow by the depressional site). The following descriptions summarize methods used to model each component.

Rainfall Distribution

The amount and temporal distribution of rainfall over the wetland's upstream watershed must be known to determine the expected amount and temporal distribution of runoff entering the wetland. The temporal distribution of rainfall assumed in the methodology is a standard type used by the COE (figure A-1). This type of distribution produces the maximum amount of runoff for a given rainfall event, thereby simulating conditions during the more severe flooding situations. Rainfall amounts are used as input in this portion of the model.

Watershed Runoff

The amount and timing of runoff from the watershed (inflow hydrograph) resulting from a given rainfall event are computed using relationships between the size and shape of the watershed and its absorptivity (a function of land use). The SCS method (SCS, 1972) is used for computation of the inflow hydrograph and uses the following inputs.

1. Rainfall distribution computed in the previous step
2. Watershed size (square miles)
3. Time of concentration (an indicator of water shed size)
4. Runoff curve number

Site Hydraulics

The primary influence on flows passing through the wetland is the topographic characteristics of the depression containing the wetland. Characteristics necessary for describing site effect on flows include the capacity of the site's outlet and the volume available for storage of floodwater.

An outflow hydrograph for the site is computed by routing the inflow hydrograph through the wetland using the Modified Puhl's procedure (Chow, 1964, p. 25-38). The following inputs are required:

1. Inflow hydrograph computed in the previous step
2. Volume/elevation/discharge relationship within the wet basin

MODEL INPUTS

Most of the inputs described above and in the methodology (e.g., rainfall data, watershed area, time of concentration, curve number, ratio of impervious surfaces) are used directly in the hydrologic models. However, two of the inputs, acreage/elevation data and outlet characteristics, are used in preliminary procedures to define the elevation-storage-discharge relationship which is used in the Modified Puhl's routing procedure to compute the outflow hydrograph. The following paragraphs describe how the elevation -storage-discharge relationship is computed from elevation/acreage input and the outlet characteristics.

Elevation/Acreage Input

The elevation/acreage data (step 6a, small watershed methods) is used to compute the storage volume available within the wet basin at elevation increments within the basin. The basic computation used to determine the volume of storage between two elevation points is based on the volume of a fulcrum (a standard method in limnology, see Lind, 1974):

Equation A-1

$$v = h/3 \ (a_1 + a_2 + /a_1 \ a_2)$$

v = volume in acre-feet
a_1 = acreage at the lower elevation
a_2 = acreage at an upper elevation
h = elevation difference between the two acreage estimates

In the WEM computer program, at least two acreage/elevation points are required, and the program computes storage volumes for elevation increments between the required input points. These storage volumes are computed as follows (an example is given in figure A-1).

1. *Set reference elevations* - Reference elevations are set at one-tenth the elevation difference between the maximum and minimum elevations.

2. *Acreage computation* - The acreage at each reference elevation is interpolated from the maximum and minimum input elevations based on a linear increase in the radius of circles with the equivalent areas.

3. *Volume Computation* - The total storage volume available at reference elevation "i" is computed as the sum of all storage volumes at lower elevations and the storage volume between elevations "i" and elevation "i-1". All storage volumes are computed based on the volume of a fulcrum (see equation A-1).

Outlet Characteristics

Data characterizing the outlets from a wet basin (step 6b, small watershed methods) are used to compute total discharge in cubic feet per second (cfs) from the basin at each elevation increment defined in step 1, above. The methodology provides instructions that enable computation of discharge through three different types of outlets (weirs, channels, and culverts). The WEM computer program computes the discharge though the identified outlets at the elevation increments specified above. The methods used to compute discharge through each of the outlet types are summarized below:

1. ***Weir outlets*** - The weir equation is used to compute discharge over a weir-type outlet:

$$Q_i = cL\ (h_i - b)^{3/2}$$

where: Q_i = discharge at reference elevation "i"
c = weir constant
L = weir length
b = elevation of the weir crest
h_i = reference elevation point "i"

2. ***Channel outlets*** - Discharge through a channel outlet is computed using Manning's equation:

$$Q = \frac{1.49}{n} S^{1/2} A^{5/3} W^{-2/3}$$

where: Q = discharge
n = Manning's roughness coefficient
S = slope of the channel
A = cross-sectional area
W = wetted perimeter

To simplify computations, the program assumes discharge through the channel may be closely approximated by assuming the channel has a trapezoidal cross section. This assumption makes it possible to compute the cross-sectioned area (A) and the wetted perimeter (W) using inputs that are easily collected in the field:

Figure A-1: Sample computation of storage volume

<u>Inputs</u>:

Elevation	Acreage
1000	200
1005	400

<u>Reference Elevations</u>:

Difference between max. and min. elevation = 5 feet.
Therefore increment used = 5/10 = 0.5 foot.

<u>Acreage Computation</u>:

Elevation	Radius (feet)*	Acres**
1000	1,665	200
1000.5	1,734	216.85
1001	1,803	234.45
1001.5	1,872	252.74
1002	1,941	271.71
1002.5	2,010	291.38
1003	2,079	311.72
1003.5	2,148	332.76
1004	2,217	354.48
1004.5	2,286	376.89
1005	2,355	400

* The first and last radii are computed from the input acreages:

$$\text{radius} = \left(\frac{43{,}560 \times \text{acres}}{3.14159}\right)^{1/2}$$

All other radii are interpolated between the first and last values.

** Acreages are computed from the radius: Acres = $(3.14159)(\text{rad})^2/43{,}560$

<u>Volume Computation</u>:

Elevation	Acres	Volume between elevation increments*	Cumulative volume
1000	200	0	0
1000.5	216.85	104.18	104.18
1001	234.45	112.80	216.98
1001.5	252.74	121.77	338.75
1002	271.71	131.08	469.83
1003	311.72	150.75	761.32
1003.5	332.76	161.09	922.41
1004	354.48	171.78	1,094.19
1004.5	376.89	182.81	1,277.01
1005	400	194.19	1,471.20

* Volume is computed using equation A-1

$$A_i = \left(B + \frac{(h_i - b)(T-B)}{2H}\right)(h_i - b)$$

$$W_i = B + 2\sqrt{(h_i - b)^2 + \left(\frac{h_i - b}{H}\right)^2 (T-B)^2}$$

where: B = width of channel bottom
T = width of channel top
H = difference in elevation of channel top and channel bottom
b = elevation of channel bottom
h_i = reference elevation point "i"
A_i = cross sectional area at elevation "i"
W_i = wetted perimeter at elevation "i"

Using this procedure, discharge through a channel outlet at all reference elevations can be computed with the following inputs from the user:

n = Manning's roughness coefficient
s = channel slope
T = width at the top of the channel
B = width of the channel bottom
H = elevation difference between channel top and bottom
b = elevation of channel bottom

3. ***Culvert Outlets*** - The procedures used to compute discharge through a culvert outlet assume that the characteristics of the culvert inlet are the only factors affecting flow through the culvert (inlet control). This assumption eliminates the need to consider water levels downstream of the wetland, thereby reducing the amount of data collection and analysis required to compute discharge through the outlet. Nomographs are used to determine the discharge through a variety of culverts.

In addition to the three common outlet types described above, the WEM computer program gives the user the option of inputting a predetermined outlet rating curve. Upon selecting this option, the user is prompted for a series of elevation/discharge points. The program then interpolates between the input data to get discharge at the reference elevations established earlier. Discharges from all outlets identified in the analysis are summed for each reference elevation to get total discharge which, with the storage data computed earlier, established the elevation/storage/discharge relationship used in Modified Puhl's routing procedure.

Detailed Analysis

In some applications, it may be desirable to spend more time refining inputs to the hydrologic model to obtain a more accurate characterization of peak flows through the wetland site. To facilitate more detailed analyses, alternative procedures for computing the time of concentration and runoff curve number are given below (these procedures were extracted from the Minnesota Hydrology Guide, SCS, n.d.). The hydrologic model used in this analysis is most sensitive to the time of concentration; hence, if more work is to be done, primary attention should be focused on refining this estimate.

The runoff curve number may be more precisely computed using the forms in figures A-2 and A-3. The following definitions should be used with these forms:

1. *Condition or Rotation* - Ratings of "Poor" or "Good" should be based largely on the proportion of dense vegetation in the rotation. "Good" will generally be used for cultivated land in Minnesota except where land is very droughty or severely abused.

a. Pasture should be considered "poor" if it is heavily grazed and has no mulch. "Fair" pasture has between 50 and 75 percent of the area with plant cover and is moderately grazed. "Good" pasture is lightly grazed and has more than 75 percent plant cover.

b. "Poor" woods (farm) is heavily grazed and has no litter or new young growth. "Good" woods is protected from grazing and has a good undercover. "Fair" is in between.

c. Commercial forests should be rated according to Forest Service procedures as covered in the "Forest and Range Hydrology Handbook," U.S. Forest Service. Excerpts from that handbook are given in Chapter 9 of Section 4, "Hydrology," National Engineering Handbook .

d. Swamps and marshes that have one-third of the surface area or more in open water have a runoff curve number of 85. Swamps and marshes with up to one-third of the surface area in open water and the design is a 25-year frequency or less have a runoff curve number of 78. If the design is greater than a 25-year frequency, it is assumed that over one-third of the surface area will be in open water on all swamps and marshes, resulting in a curve number of 85.

2. *Practice* - Straight row farming on land slopes of 1 to 2 percent which is generally across the slope may be considered the same as contoured. Straight row farming on land slopes of less than 1 percent may be considered the same as contoured and terraced.

Time of Concentration - Care should be taken to

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FIGURE A-2

U. S. DEPARTMENT OF AGRICULTURE
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HYDROLOGIC CURVE NUMBER COMPUTATION SHEET

______________ LAND USE FOR RURAL AREAS
Present or Future

Watershed ______________ Site ______________ D.A. ______________ Acres

Computed by ______________ Date ________ Checked by ______________ Date ________

Cover	Practice	Condition or Rotation	Acres Per Practice	Curve Numbers Moisture Condition II: A Soils	B Soils	C Soils	D Soils	Product
Fallow	Straight Row			77	86	91	94	
Row Crops	Straight Row	Poor		72	81	88	91	
	Straight Row	Good		67	78	85	89	
	Straight Row	Mulch till		61	76	84	87	
	Contoured 2/	Poor		70	79	84	88	
	Contoured 2/	Good		65	75	82	86	
	Contoured 2/	Mulch till		62	73	80	85	
	C and T 1/	Poor		66	74	80	82	
	C and T 1/	Good		62	71	78	81	
	C and T 1/	Mulch till		61	70	77	80	
Sm. Grain	Straight Row	Poor		65	76	84	88	
	Straight Row	Good		63	75	83	87	
	Straight Row	Mulch till		58	74	82	86	
	Contoured 2/	Poor		63	74	82	85	
	Contoured 2/	Good		61	73	81	84	
	Contoured 2/	Mulch till		59	72	80	83	
	C and T 1/	Poor		61	72	79	82	
	C and T 1/	Good		59	70	78	81	
	C and T 1/	Mulch till		58	69	77	80	
Legumes or Rotation Meadow	Straight Row	Poor		66	77	85	89	
	Straight Row	Good		58	72	81	85	
	Contoured 2/	Poor		64	75	83	85	
	Contoured 2/	Good		55	69	78	83	
	C and T 1/	Poor		63	73	80	83	
	C and T 1/	Good		51	67	76	80	
Pasture		Poor		68	79	86	89	
		Fair		49	69	79	84	
		Good		39	61	74	80	
Meadow (Permanent)		Good		30	58	71	78	
Wood or Forest Land		Poor		45	66	77	83	
		Fair		36	60	73	79	
		Good		25	55	70	77	
Farmsteads		—		59	74	82	86	
Roads (Inc.R.O.W.)	Dirt Surface	—		72	82	87	89	
	Hard Surface	—		74	84	90	92	
Impervious Surfaces		—		100	100	100	100	
Water Surfaces (lakes, ponds)		—		100	100	100	100	
Swamp (open water) 3/		—		85	85	85	85	
Swamp (vegetated) 4/		—		78	78	78	78	
Low Density Residential		—		47	65	76	82	
Medium Density Residential		—		54	70	79	84	
High Density Residential		—		70	81	87	90	
Commercial and Industrial		—		86	91	93	94	

Total Acres ______________ Product Total = ______________

Weighted Runoff Curve No. $\frac{\text{Product Total}}{\text{Total Acres}}$ = ______________ = ______________

1/ Contoured and graded terraces or land with less than 2% slope.
2/ Includes level terraced areas. (runoff corrected by volume)
3/ 1/3 of swamp surface is open water.
4/ Swamp has no open water and the design is a 25-year frequency or less.

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FIGURE A-3

U. S. DEPARTMENT OF AGRICULTURE
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HYDROLOGIC CURVE NUMBER COMPUTATION SHEET

______________ LAND USE FOR URBAN AREAS
Present or Future

Watershed ______________ Site ______________ D.A. ______________ Acres

Computed by ______________ Date ________ Checked by ______________ Date ________

LAND USE DESCRIPTION	Acres Per Practice	Curve Numbers Moisture Condition II A Soils	B Soils	C Soils	D Soils	Product
Cultivated Land: without conservation treatment		72	81	88	91	
with conservation treatment		62	71	78	81	
Pasture or range land: poor condition		68	79	86	89	
good condition		39	61	74	80	
Meadow: good condition		30	58	71	78	
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83	
good cover		25	55	70	77	
Open Spaces, lawns, parks, golf courses, cemeteries, etc.						
good condition: grass cover on 75% or more of the area		39	61	74	80	
fair condition: grass cover on 50% to 75% of the area		49	69	79	84	
Commercial and business areas (85% impervious)		89	92	94	95	
Industrial districts (72% impervious)		81	88	91	93	
Residential:						
Average lot size — Average % Impervious						
1/8 acre or less — 65		77	85	90	92	
1/4 acre — 38		61	75	83	87	
1/3 acre — 30		57	72	81	86	
1/2 acre — 25		54	70	80	85	
1 acre — 20		51	68	79	84	
Paved parking lots, roofs, driveways, etc.		98	98	98	98	
Streets and roads:						
paved with curbs and storm sewers		98	98	98	98	
gravel		76	85	89	91	
dirt		72	82	87	89	
Marsh		85	85	85	85	
Other						

Total Acres ________ Product Total ________

Weighted Runoff Curve No. $\frac{\text{Product Total}}{\text{Total Acres}}$ = ______________

develop the time of concentration as accurately as possible. Figure A-4 should be used to estimate the velocity for overland flow, and figures A-5 through A-7 should be used for estimating channel flow velocities.

The steps to complete the time of concentration computation sheet are as follows:

1. Divide up the travel path from the hydraulically most distant part of the watershed to its outlet into reaches. The reaches should be broken wherever there is a major slope change or a change in the flow condition (Example - overland flow to waterway flow; waterway flow to deep open channel flow; etc.)

2. Divide this path into reaches from the top of the watershed to the outlet using a scale on an aerial photograph, soils map, or U.S. Geological Survey quadrangle and add hatch marks along the path wherever there is a major slope change or a flow condition change.

3. From this map, complete the time of concentration computation sheet. List the reach, flow condition, reach length, drop, and slope.

4. From figures A-4 through A-7, obtain the flow velocity based on the slope and flow condition listed.

5. Determine the travel time for the reach by dividing the reach length by the velocity.

6. Add the individual reach travel times and divide by 3,600 to obtain the time of concentration in hours for the entire watershed.

For a more complete discussion of the time of concentration, see Chapter 15 of Section 4, "Hydrology," National Engineering Handbook (SCS, 1972) and Chapter 3 of "Urban Hydrology for Small Watersheds," SCS Technical Release Number 55.

MODEL OUTPUTS

Hydrologic models constructed with the WEM computer program are used to obtain five values:

a) average annual peak inflow
b) average annual peak outflow
c) peak effects value
d) percentage of inflow volume retained
e) average detention time

The last two values are only used in the water quality analysis and are explained in appendix B. The peak effects value is derived from the first two values:

$$S = (1 - Q_o/Q_i) \times 100$$

where: S = peak effects value
Q_o = average annual peak outflow
Q_i = average annual peak inflow

Hence, the last portion of this appendix describes the procedure used to compute average annual peak inflow and outflow.

The concept of average annual peak flows was developed after an analogous concept in economics: average annual damages.

It is defined as the area under a peak discharge, frequency curve (figure A-8). The computation procedure uses the hydrology model in the WEM computer program to compute inflow and outflow peaks for the 1-yr, 2-yr, 5-yr, 10-yr, 25-yr, and 100-yr events. The inflow and outflow peaks are then plotted against their frequency of occurrence (Figure A-8) and the area under the resulting curves is approximated with the following equation to
give annual average peak inflow and outflow:

$$Q = 0.25P_1 + 0.40\,P_2 + 0.20\,P_5 + 0.08\,P_{10} + 0.04\,P_{25} + 0.015_P 50 + 0.005\,P_{100}$$

where:
Q_o = average annual peak inflow (or outflow)
P_1 = inflow peak (or outflow peak) for the 1-yr event
P_2 = inflow peak (or outflow peak) for the 2-yr event
P_5 = inflow peak (or outflow peak) for the 5-yr event
P_{10} = inflow peak (or outflow peak) for the 10-yr event
P_{25} = inflow peak (or outflow peak) for the 25-yr event
P_{50} = inflow peak (or outflow peak) for the 50-yr event
P_{100} = inflow peak (or outflow peak) for the 100-yr event

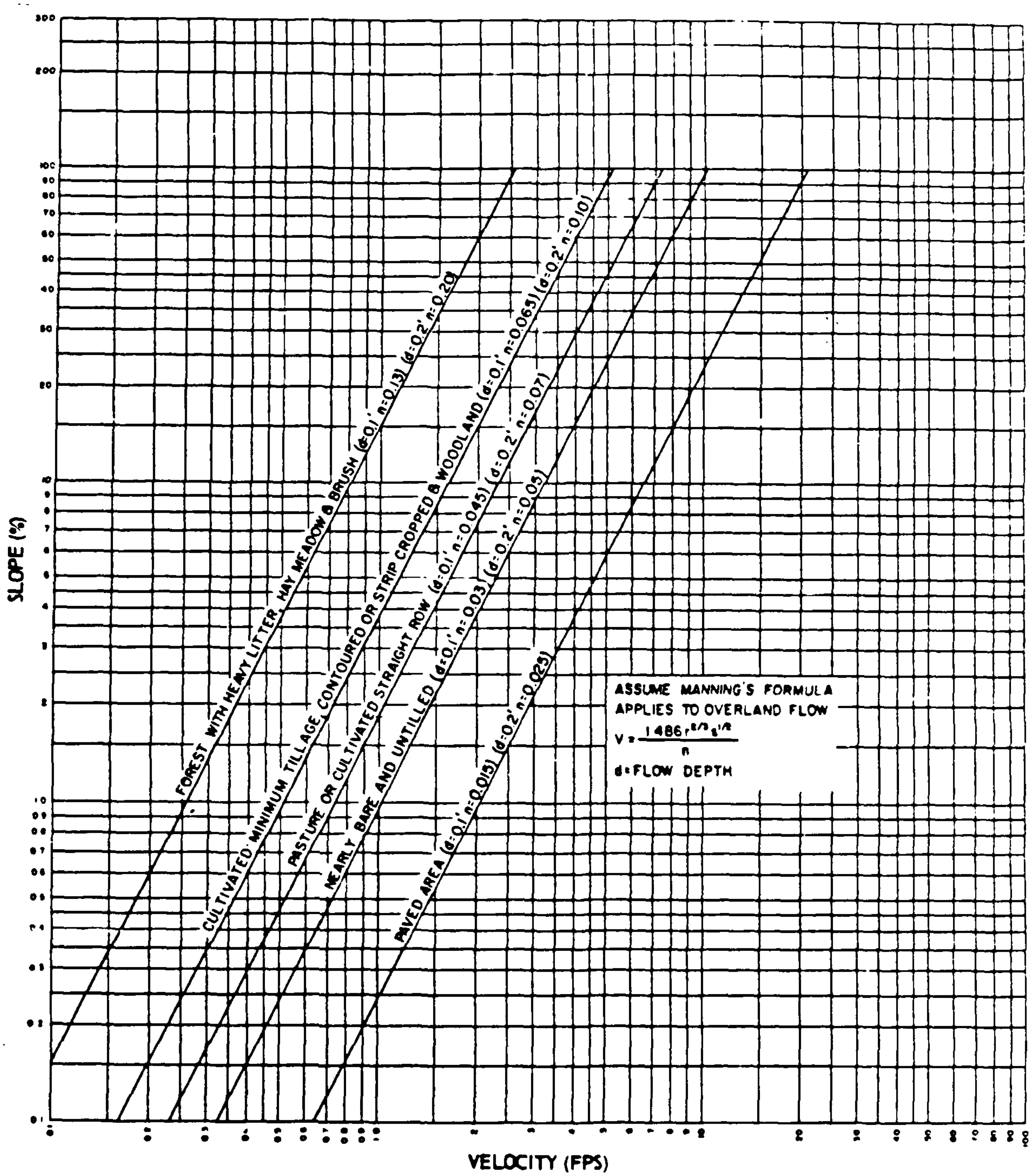


Figure A-4
SLOPE VS. VELOCITY
OVERLAND FLOW

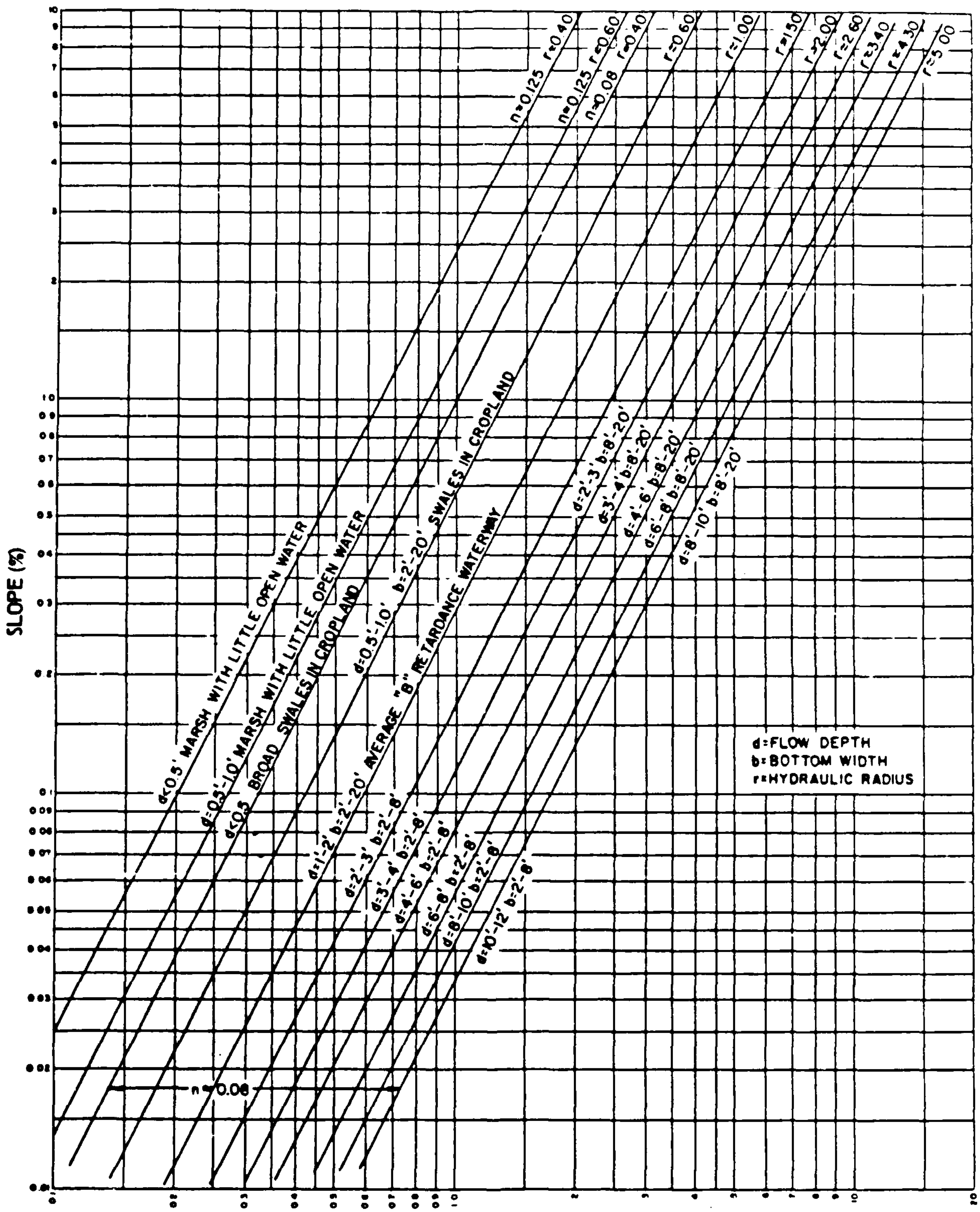


Figure A-5
SLOPE VS. VELOCITY
CHANNEL PHASE
HIGH RETARDANCE CHANNELS

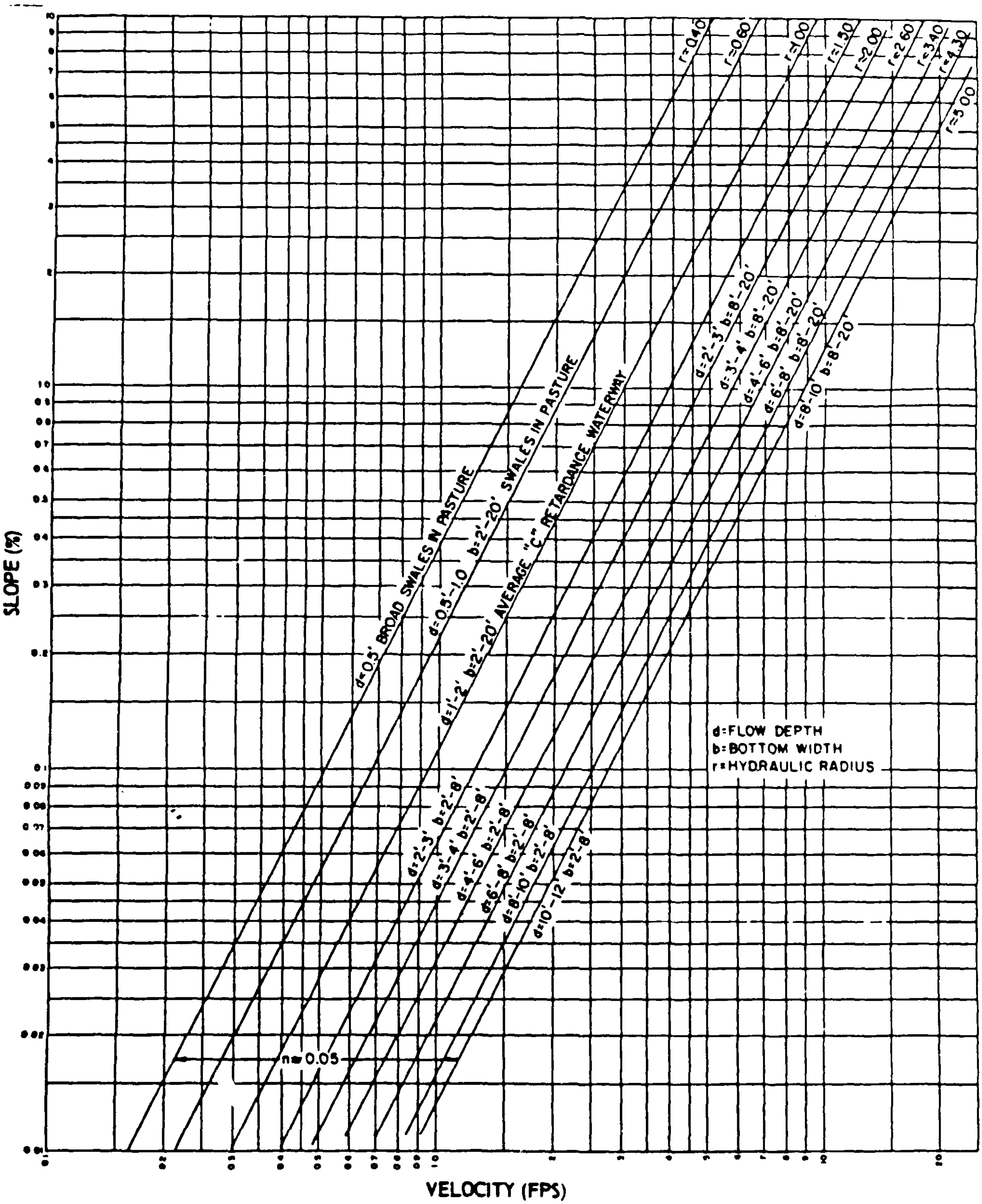


Figure A-6
SLOPE VS. VELOCITY
CHANNEL PHASE
MEDIUM RETARDANCE CHANNELS

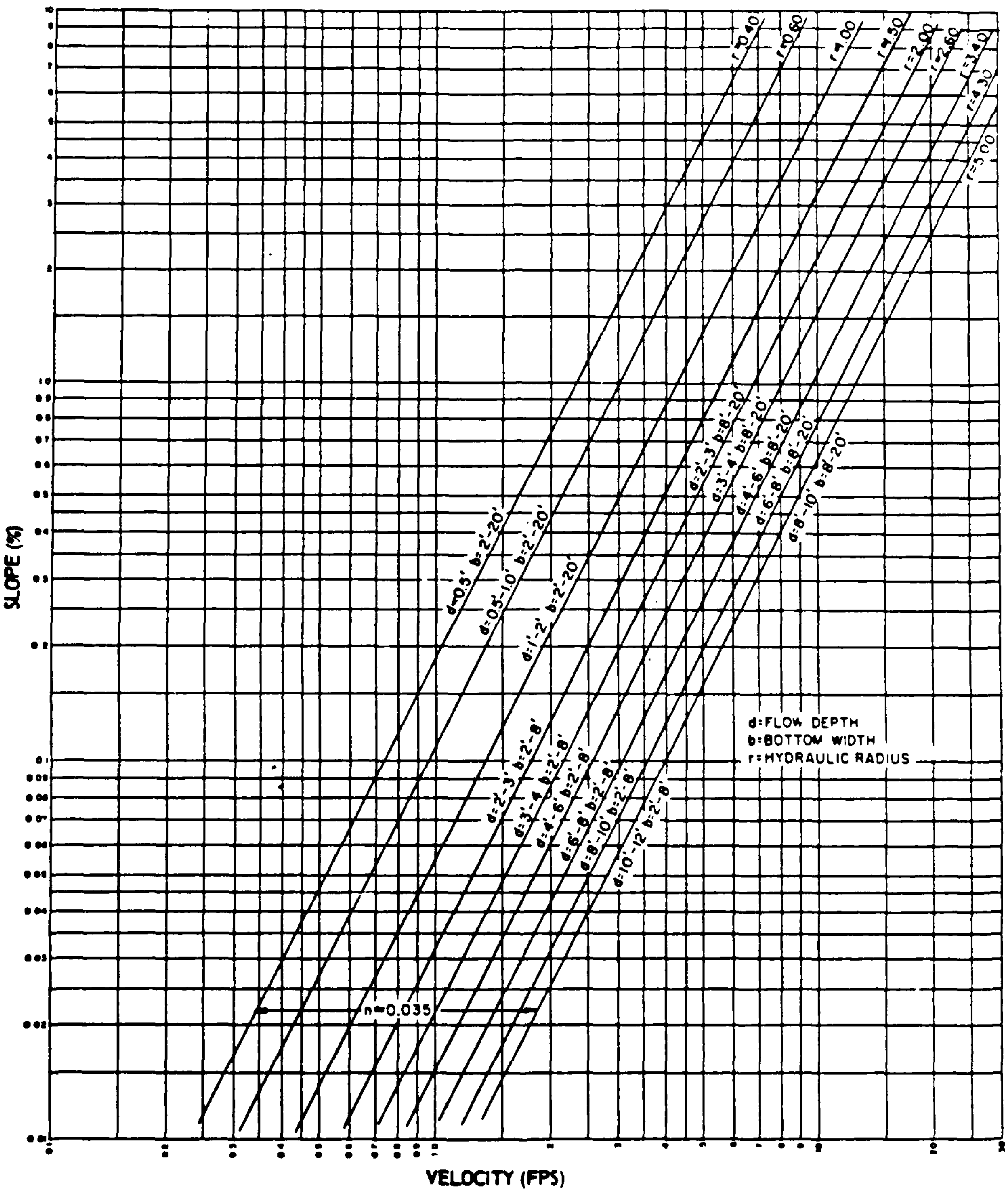
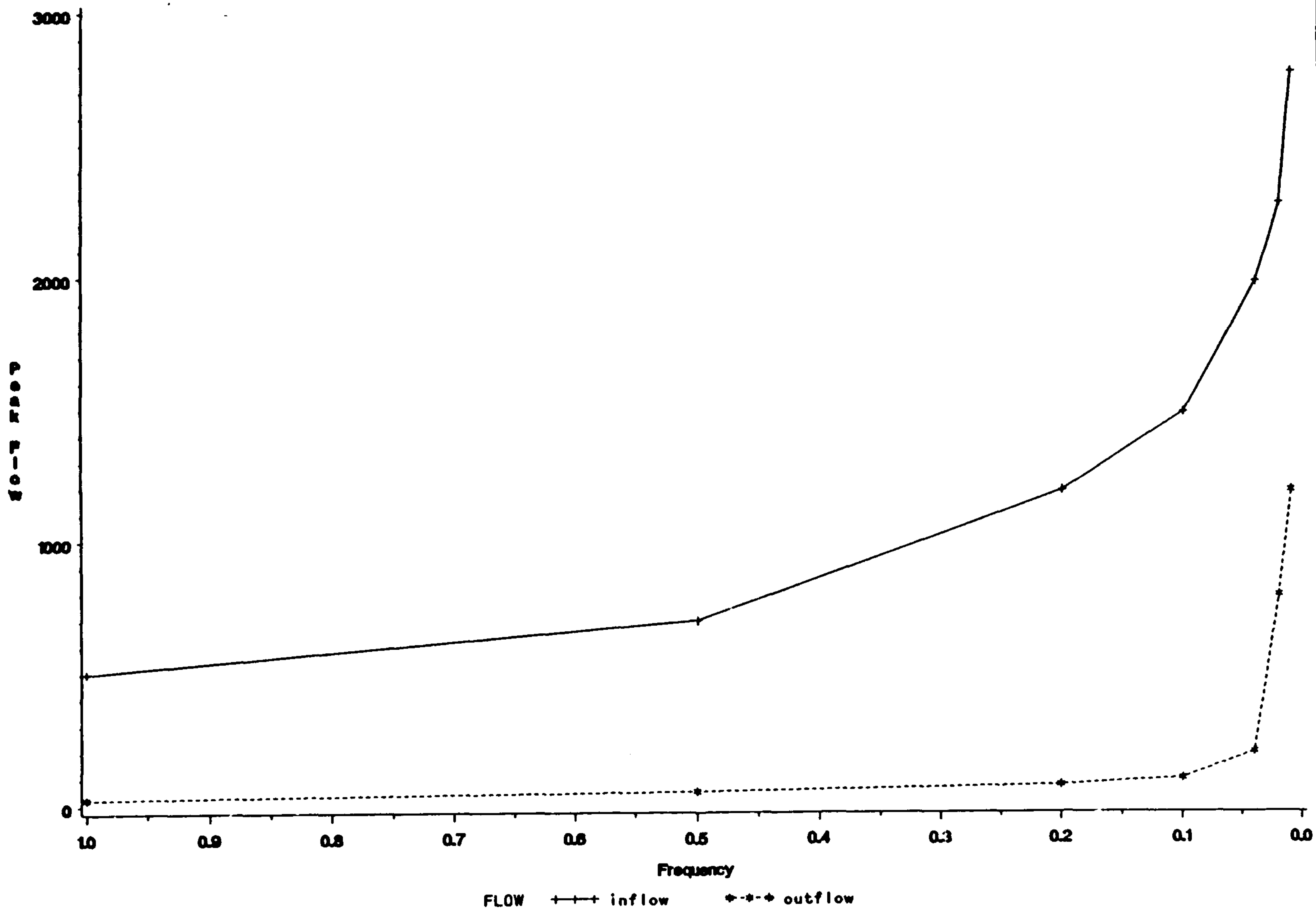


Figure A-7
SLOPE VS. VELOCITY
CHANNEL PHASE
LOW RETARDANCE CHANNELS

FIGURE A-8: PEAK INFLOW AND OUTFLOW VS. FREQUENCY



APPENDIX B

WATER QUALITY

APPENDIX B
WATER QUALITY:
EXPLANATION OF BACKGROUND AND ASSUMPTIONS

INTRODUCTION

This appendix presents the background, supporting logic, and assumptions used in the procedure for describing the potential water quality values provided by a wetland site. The appendix focuses on methods used to describe the trap efficiency of wetlands with small upstream watersheds. The logic used in other portions of the water quality analysis (sediment/nutrient input, trap efficiency-large watershed methods, and downstream sensitivity) is easily deduced from descriptions given in the methods.

This appendix is divided into two subsections. The first gives an overview of the logic and computations required for analysis of sediment and nutrient trapping efficiency. The second describes each of the four input values and how those values are used in the analysis.

OVERVIEW OF COMPUTATIONS

The rating of wetland trap efficiency involves computing the percentage of sediment and nutrient input that is likely to settle to the bottom and be retained in the wetland. Four major factors affect how much sediment and/or nutrient might be trapped in a wetland: (1) particle size of incoming sediment, (2) amount of incoming water retained in the wetland, (3) length of time water is detained in the wetland; and (4) depth of the wetland. The details of how these factors are computed are presented in the last part of this appendix. In this portion of the appendix, these four factors are assumed to be known and their use in computing wetland trap efficiency is explained.

SEDIMENT TRAPPING EFFICIENCY

The basic concept in analyzing sediment trapping efficiency is that holding water in a quiescent state within a wetland will allow sediment suspended in the water to fall to the bottom and become trapped. Since different sized particles settle at different velocities, the amount of sediment that will be trapped depends upon the size of the suspended particles and the amount of time those particles are allowed to settle.

The concepts behind the methods used are best illustrated in the following example.

Given the following:

- Particle size distribution for incoming sediments:
  - sand - 3%
  - large aggregate - 34%
  - small aggregate - 42%
  - silt - 13%
  - clay - 8%
- Average depth of the wetland: 5 feet
- Amount of water retained in wetland: 10% of incoming volume (2-year event)
- Average amount of time water is detained in the wetland:
  1 hour (2-year event)

It is possible to use known fall velocities to determine how far particles in the various size categories would fall in the hour (3,600 sec.) detention period:

Particle Category	Fall Velocity (ft/sec)	Distance Traveled (feet)
Sand	7.59×10^{-2}	273.2
Large aggregate	5.42×10^{-2}	195.1
Small aggregate	1.25×10^{-3}	4.500
Silt	2.63×10^{-4}	0.9468
Clay	1.02×10^{-5}	0.0367

Since the wetland is 5 feet deep, all particles larger than small aggregates would settle to the bottom and be trapped. Wetland trap efficiency is therefore computed as follows:

volume	10.0
phosphorous on sand	(0.3)(90%)= 2.7
phosphoroous on large aggregate	(0.34)(90%)=30.6
phosphorous trapped	43.3%

In this example, the wetland trapped 10 percent of the incoming sediment because 10 percent of the incoming water was retained; 3 percent of the remaining 90 percent of the incoming sediment because all of the sand settled to the bottom; and 34 percent of the remaining 90 percent of the incoming sediment because all of the large aggregate settled to the bottom. The overall trap efficiency was 43.3 percent.

NUTRIENT TRAPPING EFFICIENCY

In this methodology, nutrient trapping efficiency is measured by the amount of phosphorus that is trapped in the wetland. This is a good indicator of the trap efficiency for all nutrients that tend to bind to the surface of soil particles. This measure is not a good indicator for nutrients that tend to be dissolved in the water or bound to organic matter (nitrogen).

The basic idea behind nutrient trapping efficiency is that many nutrients are bound to soil particles in proportion to the amount of surface area in the particle. If the particle settles to the bottom, then nutrient bound to the soil surface will be trapped. The concepts and computations are illustrated by continuing with the preceding example.

Suppose that the distribution of surface area according to particle size is also known:

Particle Size	Percent by Weight	Percentage of Total Surface Area
Sand	3%	0.26
Large aggregate	34%	24.88
Small aggregate	42%	48.76
silt	13%	1.77
clay	8%	24.33

The distribution of phosphorus within the soil matrix is highly correlated with the distribution of surface area within the soil matrix (Young, Onstad and Bosch, 1985). Therefore, if the sand and large aggregate particle classes are trapped by the wetland, the portion of phosphorus retained is computed as follows:

volume	10.000%
phosphorous on sand	(0.0026)(90%) = 0.234%
phosphorous on aggregate	(0.2488)(90%) = 22.392%
phosphorous trapped	32.63%

REQUIRED INPUTS

The preceding computations are implemented in the water quality routine in the WEM computer program. The second part of this appendix looks at how the data used in the preceding computations are obtained and/or computed.

PARTICLE SIZE AND SURFACE AREA DISTRIBUTIONS

The user is asked to determine the proportion of sand, silt, and clay that is suspended in the incoming water. The water quality routine in the WEM computer program uses these proportions to estimate what fraction of the sediment is in each of five particle size categories (clay, silt, small aggregate, large aggregate, and sand). These estimates are based on the following equations which were developed using regression analyses by Foster, Young, and Neibling (1985):

Fraction of clay:
$Fcl = 0.26\ (Ocl)$

Fraction of small aggregate:
$Fsg = 1.8\ (Ocl)$ for $Ocl < 0.25$
$Fsg = 0.6\ (1\text{-}Ocl)$ for $0.25 \leq Ocl \leq 0.50$
$Fsg = 0.6\ (Ocl)$ for $0.50 < Ocl$

Fraction of silt:
$Fsi = Osi - Fsg$
if $Fsi < Ocl$ then $Fsg = Osi$ and $Fsi = O$

Fraction of sand:
$Fsa = Osa\ (1\text{-}Ocl)_5$

Fraction of large aggregate:
$Flg = 1 - Fcl - Fsi - Fsg - Fsa$

where: Ocl = proportion of clay suspended in inflow (user determined)
Oso = proportion of silt suspended in inflow (user determined)
Osa = proportion of sand suspended in inflow (user determined)
Fcl = fraction of sediment in the clay size category
Fsi = fraction of sediment in the silt size category
Fsg = fraction of sediment in the small aggregate size category
Flg = fraction of sediment in the large aggregate size category
Fsa = fraction of sediment in the sand size category.

The particle size distribution computed using these equations is used in conjunction with settling velocities, water depth, and detention time to determine the percentage of suspended sediment that is likely to be trapped in the wetland.

In addition to the particle size distribution, the WEM computer program estimates the distribution of surface area within the different particle classes. The estimate is based on a regression equation which predicts surface area in a soil matrix given the proportion sand, silt, and clay:

$$SS = 11.6(Osa) + 18.5(Osi) + 33.0(Ocl) + 10.7(M)(Ocl)$$

where: SS = soil surface area in m^2/g
M = fraction of Montmorillonite in the soil
and all other variables are as defined ear lier

Montmorillonite is a type of clay that has a lot of surface area. It is not reasonable to expect the user to estimate the percentage of montmorillonite in sediment delivered from a wetland's upstream watershed; therefore, an average value for M was determined using 29 Minnesota soils (M = 35.5), and this value is used in the preceding equation:

Equation B-1:

$$SS = 11.6(Osa) + 18.5(Osi) + 33.0(Ocl) + 10.7(35.5)(Ocl)$$
$$= 11.6(Osa) + 18.5(Osi) + 412.85(Ocl)$$

The coefficients in equation B-1 specify the relative amount of surface area associated with the three particle categories (sand, silt, clay). It is now necessary to determine the fraction of sand, silt, and clay in the large and small aggregate categories. Using the reasoning of Young and Onstad (1976), the following relationships emerge:

$$Fclsg = \left[\frac{Ocl}{Ocl + Osi}\right] Fsg$$

$$Fsisg = \left[\frac{Ocl}{Ocl + Osi}\right] Fsg$$

$$Fcllg = Ocl - Fcl - Fclsg$$

$$Fsilg = Osi - Fsi - Fsisg$$

$$Fsalg = Osa - Fsa$$

where: Fclsg = fraction of clay in the small aggregate category
Fsisg = fraction of silt in the small aggregate category
Fcllg = fraction of clay in the large aggregate category
Fsilg = fraction of silt in the large aggregate category
Fsalg = fraction of sand in the large aggregate category
All other variables are as defined earlier

The coefficients from equation B-1 are then used with the distributions of particle size and particle type to compute total surface area and the amount of surface area associated with each of the size/type categories:

$$Scl = 412.85\ (Fcl)$$
$$Ssl = 18.5\ (Fsi)$$
$$Sclsg = 412.85\ (Fclsg)$$
$$Ssisg = 18.5\ (Fsisg)$$
$$Scllg = 412.85\ (Fcllg)$$
$$Ssilg = 18.5\ (Fsilg)$$
$$Ssalg = 11.6\ (Fsalg)$$
$$Ssa = 11.6\ (Fsa)$$

S = total surf area
$= Scl + Ssi + Ssisg + Sclsg + Scllg + Ssilg + Ssalg + Ssa$

where all variables whose names begin with "S" represent the surface area associated with the specific size/type soil category. All other variables are as defined earlier.

The surface areas computed above are then converted to proportions by dividing by the total surface area. For example, the proportion of total surface area found inclay in the small aggregate category (Prclsg) is:

$$Prclsg = Sclsg / S$$

With the preceding computations, it is possible to determine what percentage of total surface area is associated with each particle category:

$$Pscl = Prcl$$
$$Pssi = Prsi$$
$$Pssg = Prclsg + Prsisg$$
$$Pslg = Prcllg + Prsilg + Prsalg$$
$$Pssa = Prsa$$

where: Pscl = percentage of total surface area in the clay category
Pssi = percentage of total surface area in the silt category
Pssg = percentage of total surface area in the small aggregate category
Pslg = percentage of total surface area in the large aggregatecategory
Pssa = percentage of total surface area in the sand category

The percentage of total sediment surface area trapped in the wetland is used as the measure of nutrient trapping effectiveness. It is easily computed once it is known which particle size categories will be trapped as explained in the first portion of this appendix.

VOLUME RETAINED

Another factor required to compute wetland trapping effectiveness is the percentage of total inflow water volume which never leaves the wetland. The method assumes that retention of a certain percentage of inflow water will result in the wetland trapping an equivalent percentage of incoming sediment and nutrient.

Volume retained is computed during characteristics of flood peaks and is reported as part of the output from that portion of the WEM computer program. The volume retained is equal to the volume of the wet basin between the average water surface elevation and the elevation of the bottom of the lowest outlet.

EFFECTIVE DETENTION TIME

In contrast to actual retention of water, sediment and nutrients are trapped when water is allowed to sit relatively undisturbed while particles settle to the bottom.

The amount of sediment trapped is directly related to the amount of time water is detained.

Like volume retained, average detention time is computed during analysis of peak flow characteristics and is reported as part of the output from that section of the computer program. Average detention time is defined as the difference between the time at the centroid of the outflow hydrograph and the time at the centroid of the inflow hydrograph. It is computed for the 2-year rainfall event because most of the sediment is moved during the relatively frequent flood events. The computer program approximates the average detention time with the following computation:

$$T = 1/80 \sum_{i=1}^{80} (O_i - I_i)$$

where: T = average detention time

O_i = time at which the ith volume percentile leaves the wetland

I_i = time at which the ith volume percentile enters the wetland

Only 80 percent of the inflow and outflow volume is used in this computation because the last 20 percent of the outflow hydrograph is not very accurate since discharge is usually approaching the time axis asymptotically.

In computing sediment and nutrient trapping efficiency, the average detention time just described is modified to account for the effects of turbulence. Turbulence inhibits the fall of sediment particles, thereby decreasing the settling velocity for the particles. To make the methodology simple for the user, the settling velocities are left constant and the average detention time is decreased if turbulence is present. The average detention time is decreased by an arbitrary factor to obtain "effective detention time" as described in the water quality section of the methodology.

EFFECTIVE DEPTH

The effective depth is the final factor used in determining the sediment and nutrient trapping effectiveness of the wetland. If it is determined that a category of particles (e.g., small aggregates) would settle a distance greater than the effective depth, then that category of particles is assumed to be trapped in the wetland.

The effective depth is the product of three variables: a measure of water depth in the wetland; a modifier for flow pattern through the basin; and a modifier for type of vegetation in the basin. Each of these variables is described below.

Water Depth

The user is instructed to use the lesser of the following depths as an estimate of the water depth in the wetland:

a) average depth of the wetland

b) difference between the inlet and outlet elevation

This condition is set because in some wetland types (e.g., lacustrine wetlands) a particle would only need to settle a small portion of average depth before it is trapped, while in other wetland types the average depth is a good estimate of the trapping depth (see figure B-1).

Flow Pattern

If the flow through the wetland is in a channel, it is more likely to pass directly through the wetland (without much improvement in water quality) than if water flows in a sheet across the wetland, thereby contacting a lot of the wetland's vegetation. The depth measure from the previous step is therefore decreased substantially if water flows through the wetland in a sheet which results in wetlands with sheet flow getting higher ratings for trap efficiency.

Vegetation Type

The type of vegetation in a wetland will also affect the effectiveness of the wetland as a sediment and nutrient trap. Vegetation can do two things to enhance sediment and nutrient trapping: first, it can slow down the passage of water through the site, thereby allowing more time for suspended particles to settle; secondly, plants may actually absorb nutrients from the water. Emergent persistent plants are best for water improvement because they grow fast, thereby absorbing nutrients, and yet tend to be strong enough to provide effective resistance to flow during flood events. Emergent non-persistent plants are not quite as effective as the persistent species because they tend to be less firmly rooted and therefore less resistant to flow. Shrubby plants follow emergent persistent species in effectiveness at water quality improvement because they do not absorb as many nutrients. Finally, submergent plant species tend to be the least effective at improving water quality because they do not provide much resistance to flow during flood events. The rating system set forth in the water quality section of the methodology causes effective depth to decrease (which causes a corresponding increase in the rating for wetland trap efficiency) in proportion to the effectiveness of the predominant plant community at improving water quality.

Figure B-1: Illustration of the reason for having two measures of trapping depth.

Figure B-1a: Particles only need to settle to the average depth before becoming trapped.

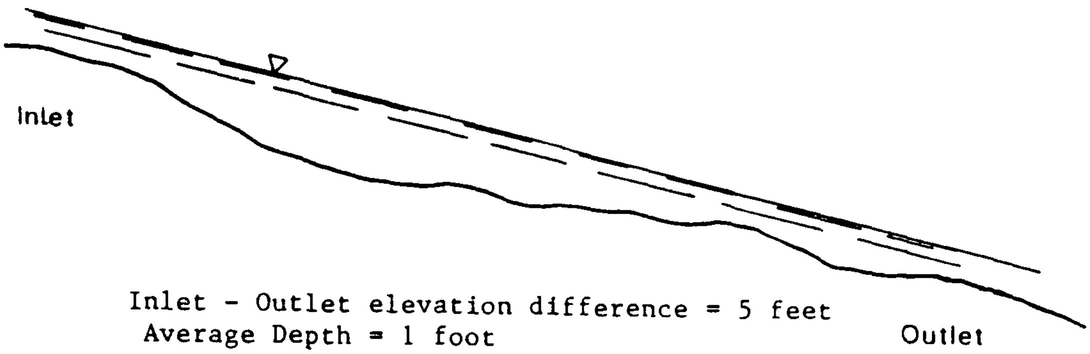
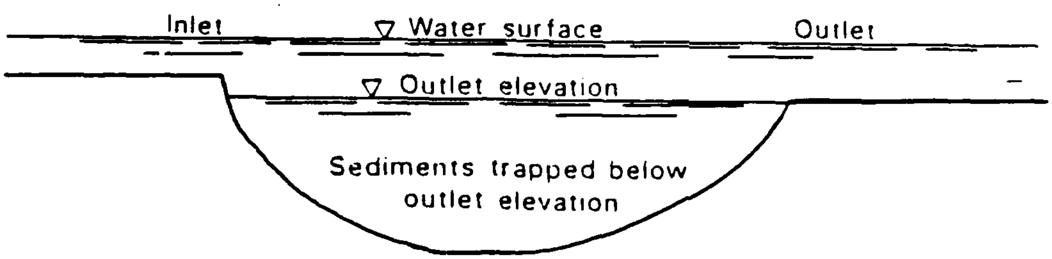


Figure B-1b: Particles only need to settle lower than the level of the outlet before becoming trapped.



APPENDIX C

WILDLIFE

APPENDIX C
WILDLIFE:
DESCRIPTIONS AND REASONS FOR MODIFYING EXISTING METHODOLOGIES

Wildlife valuation methods presented in this paper were developed through modification of techniques proposed by Golet (1978) and Adamus (1983). This appendix describes and gives reasons for the specific modifications to these procedures. Included are the following: a brief discussion of why some values (non-game wildlife values, wintering/migration values) are not included in the proposed method; what further studies are needed; how various weighting systems compare; and a more specific description of ecoregions used in this methodology.

MODIFICATIONS TO METHODS PROPOSED BY GOLET - General Diversity/Productivity

The Golet method (Golet, 1978; table C1) measures wetland values based on ratings for 10 different criteria. The criteria ratings are then weighted and summed to give a value score to the wetland. The numeric scores produced by the Golet system are based upon his professional judgment and are supported by extensive field testing in New England where the numeric scores seem to give a good approximation of wildlife value (Golet, 1984, personal communication). Golet states that his method is tailored to wetlands in the northeast and that it may have to be modified to be useful in other areas of the country.

It was necessary to make the following modifications to the Golet method for use in the north central region.

MODIFICATION 1: CRITERIA WEIGHTS

The criteria weights used in the Golet method are based on professional judgment as to which criteria are more important to wildlife in the New England region and may not be appropriate to other regions of the country. To modify these weights for use in the north central region, the Golet system was applied to 59 wetlands in Minnesota and Wisconsin using 5 different weighting systems. In reviewing the results, it was found that there were no significant differences between weighting systems (see the Comparison of Various Weighting Systems section at the end of this appendix).

The method for the north central region does not include weights for the evaluation criteria because there is little difference between weighting systems, the weights are arbitrary and hard to justify, and they make the reasons for a wetland's rating less apparent. Since weights are not included, the wetland's value score is simply the sum of all criteria values.

While specific criteria are not weighted, the synthesis of ratings does include an option for the user to give the different functions relative weights. This is a much more general application of a weighting system and is not comparable to criteria weights within a function.

MODIFICATION 2: REGIONALIZATION

In development of this approach to assessing wildlife values, there was an underlying uneasiness in recommending procedures that rated all wetlands throughout the north central region on the same scale. In particular, there was concern that prairie potholes (which are generally accepted as having a great deal of wildlife value) would be categorically rated low on a scale designed to measure wildlife values of all wetlands. To resolve the problem, the general diversity/productivity section of the method is regionalized using three broad ecoregions: (1) Southern Forest, (2) Prairie Grassland, and (3) Northern Forest (after Bailey, 1982) (see figures C-1a and C-1b). It is felt that wetlands within each of these regions can be rated on the same scale without categorically favoring one group of wetlands over another. The waterfowl section of the method is not regionalized in the same way because the habitat criteria for the waterfowl groups are appropriate in all three ecoregions.

The theory behind regionalization is that any method used for an ecoregion must be able to separate between the wetlands in that region. To accomplish this, each of the Golet criteria was addressed separately to determine the range of possible values that could be assumed in each ecoregion. The resultant range of values was then split into meaningful ranks so that each criterion (and thereby the entire method) would be able to distinguish between the value of wetlands in the region. The remainder of this section is a summary of the adjustments and modifications to the criteria for each ecoregion.

Table C1: Unmodified Golet Method (Golet 1978)

Rank Criteria[1]	(3.0)	(2.5) Specifications	(2.0)	(1.5)	(1.0)
Wetland Class Richness (5)	5 or more classes	4 classes	3 classes	2 classes	1 class
Dominant Wetland Class (5)	DM, SM	WS	SS, F, BG	OW	M
Size Category (5) (hectares)	over 500	100-500	50-100	10-50	under 10
Subclass Richness (4)	10 or more subclasses	6-9 subclasses	4-5 subclasses	2-3 subclasses	1 subclass
Site Type (4)	bottomland-lakeside bottomland-deltaic bottomland-streamside		bottomland-isolated upland-lakeside		upland-isolated
Surrounding Habitat Types (4)	2 or more of following consititute more than 90 percent of surrounding habitat: 1. forestland 2. agricultural or open land 3. salt marsh		1 or more of following constitute 50 to 90 percent of surrounding habitat: 1. forestland 2. agricultural or open land 3. salt marsh (or) 1 of preceding constitutes more than 90 percent of surrounding habitat.		1 or more of following constitute less than 50 percent of surrounding habitat: 1. forestland 2. agricultural or open land 3. salt marsh
Cover Type (2)	Type 5	Type 4	Type 3, Type 7	Type 1, Type 2, Type 6	Type 8
Vegetative Interspersion Type (2)	Type 3		Type 2		Type 1
Wetland Juxta-position (3)	Hydrologically connected to other wetlands (different dom. class) or open water bodies within 1 mi (or) Hydrologically connected to other wetlands (same dom. class) within 1.4 mile (or) Wetland greater than 500 acres with three or more wetland classes (including DM or SM)		Hydrologically connected to other wetlands (different dom. class) or open water bodies within 1-3 mi (or) Hydrologically connected to other wetlands (same dom. class) within 1/4 to 1 mile (or) Within 1/2 mile of other wetlands (different dom. class) or open water bodies, but not hydrologically connected		All other possibilities
Water Chemistry(1)	pH greater than 7.4		pH 5.5-7.4		pH less than 5.5

(1) Number in parentheses after each criterion is its significance coefficient.

Figure c-1a

ECOREGION MAP
WISCONSIN

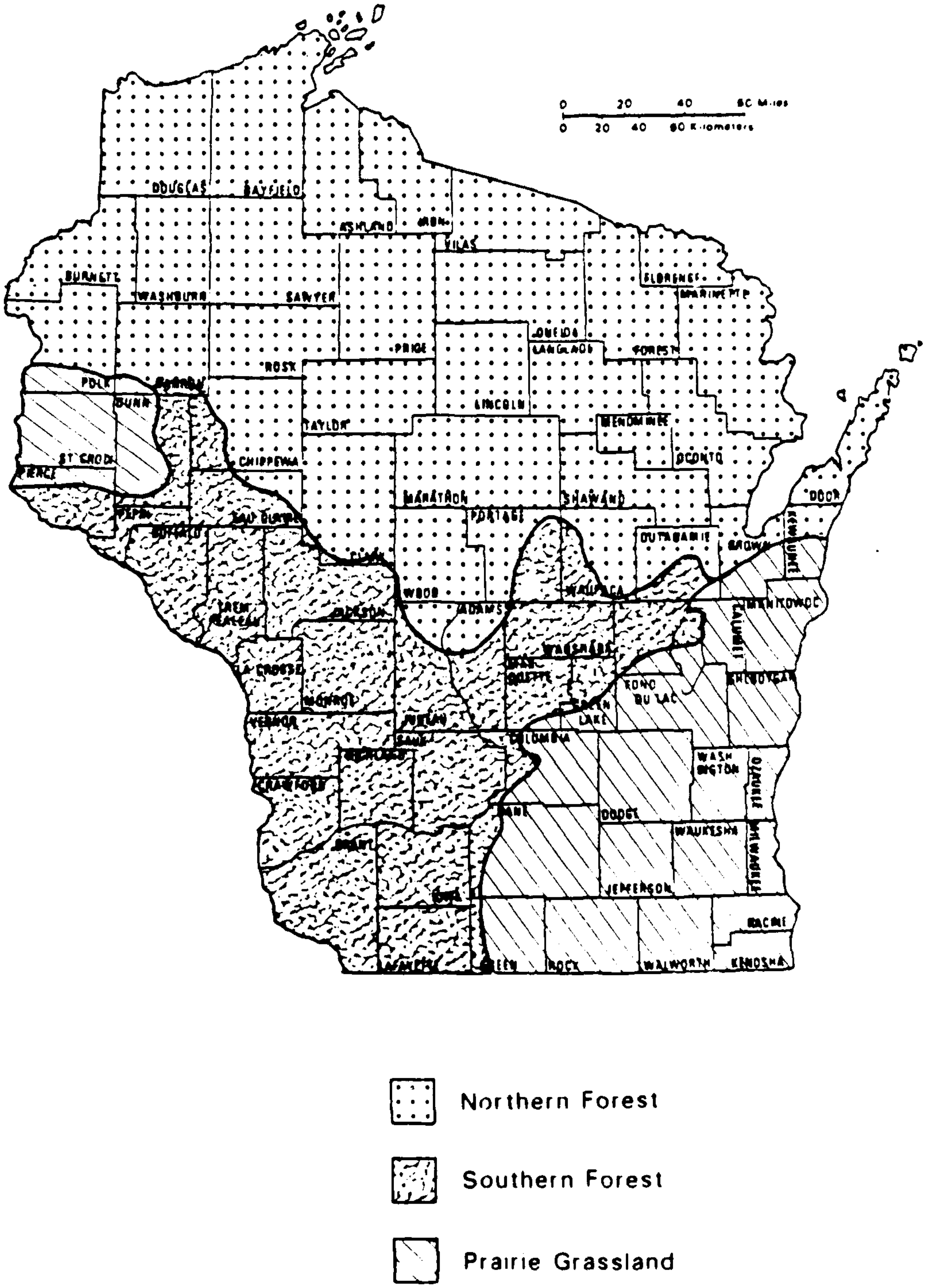
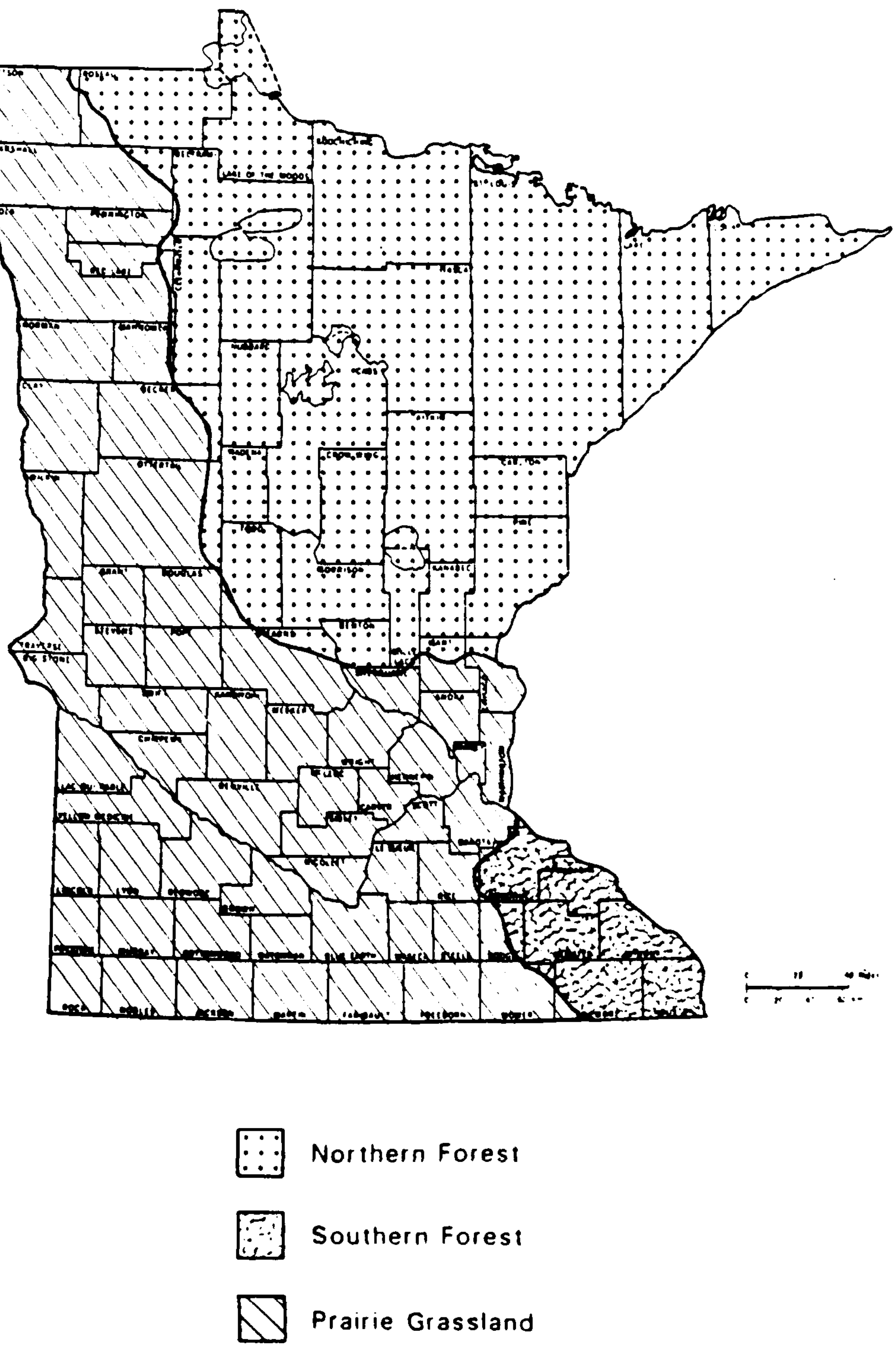


Figure c-1b

ECOREGION MAP
MINNESOTA



Southern Forest Region

Relatively few adjustments to the Golet method were necessary because this ecoregion is similar to the region in which the Golet method was developed (see Bailey, 1982). This area has been referred to in other methodologies as the Eastern Deciduous Forest region.

a. Dominant Wetland Class * - Golet presents eight wetland classes and 26 subclasses. In the north central region, there are major value differences between some of the wetland subclasses (e.g., meadow-grazed vs. meadow-ungrazed). In the southern forest method, *subclasses of different value are given different* scores. This results in the following class/subclass ranking:

Class	Subclass	Ranking
Open water (OW)	vegetated	6
	nonvegetated	4
Deep marsh (DM)	all	12
Shallow marsh (SM)	all	12
Meadow (M)	grazed	6
	ungrazed	8
Shrub swamp (SS)	all	10
Wooded swamp (WS)	all	10
Bog	all	4

*Definitions of wetland classes and subclasses are given later in this appendix in the Description of Ecoregions section. Dominance is defined as that class or subclass covering the greatest percentage of the wetland. If codominance occurs in the wetland, the ranking should be an average of all codominant classes (or subclasses).

b. Surrounding Habitat - Salt marshes are very rare in the north central region, whereas forestland, agricultural land, pasture or grassland, and shrubland are more common and make better indicators of the value of surrounding habitat. These habitat types are substituted for the habitat types given in Golet.

c. Cover Type and Vegetative Interspersion Type - The use of the term "type" has connotations of the "circular 39" wetland classification system (FWS, 1956). Hence, this method uses the term "category" instead of "type".

d. Water Chemistry - Although this factor may be important to wildlife, it is not considered as important as other factors in measuring habitat value. Since it is not easy to measure, it has been dropped from this method.

Prairie Grassland Region

The following criterion ranks were adjusted to create an evaluation method for the prairie grassland region. This has also been referred to in other methodologies as the tall-grass prairie region.

a. Wetland Class Richness - In general, wetlands in the prairie region may be characterized as having fewer classes than those in other regions (if for no other reason than prairie wetlands are small in size). Hypothesized rank: 3 classes (12 points), 2 classes (8 points), and 1 class (4 points).

b. Dominant Wetland Class (Dominance is as defined for the Southern Forest region) - As in the southern forest region, subclasses of different value are separated and given different scores in the prairie grassland region. The most common wetland classes in the ecoregion are DM, SM, OW, and M. Other wetland types are rare and are therefore given higher rank strictly because they provide special values in the ecoregion. The hypothesized class/subclass rank is given below.

Class	Subclass	Ranking
Open water (OW)	vegetated	6
	nonvegetated	4
Deep marsh (DW)	all	12
Shallow marsh (SM)	non-persistent	10
	rest	12
Meadow (M)	ungrazed	8
	grazed	6
Shrub swamp (SS)	deciduous	12

c. Size - Prairie wetlands tend to be smaller and more numerous than wetlands in other regions. Hence, the ranking categories were directed toward separation of smaller sized wetlands. The hypothesized rank was obtained from the frequency distribution of wetland sizes in Douglas and Stevens Counties in western Minnesota. The ranking categories are designed so that each contains approximately 20 percent of the wetlands in the ecoregion. Hypothesized rank (size in acres): 10+ (12 points), 5-10 (10 points), 2-5 (8 points), 1-2 (6 points), and 0-1 (4 points).

d. Subclass Richness - Since prairie wetlands have fewer dominant classes, they generally have fewer subclasses. Hypothesized rank: 7+ subclasses (12 points), 5-6 subclasses (10 points), 3-4 subclasses (8 points), 2 subclasses (6 points), and 1 subclass (4 points).

e. Surrounding Habitat Types - Wetlands in the prairie grassland region are almost entirely surrounded by agricultural land; hence, using agricultural land as one of the surrounding habitat types does not give good separation between wetlands. Surrounding habitat types that are better for separation of prairie wetlands include forestland, shrubland, grazed grassland, and ungrazed grassland (including hay). These are substituted for the habitat types given by Golet. The percentages and number of surrounding habitat types are also modified to better suit the prairie region.

f. Wetland Juxtaposition - Very few wetlands in the prairie grasslands are hydrologically connected by permanent streams. A better separation between wetlands is obtained by determining whether or not the wetland is a part of a complex of wetlands. For the purposes of this methodology, a wetland complex is defined as a group of 6 wetlands in close proximity, each of which has special characteristics so their combined value is greater than the sum of the value of each individual wetland. The ranking criteria uses the median distance between wetlands (distance to the third-closest wetland) and the presence of unique values in the wetland being studied.

g. Water Chemistry - Wetland pH in the prairie region will almost always be above 7.4. A better indicator of water quality in this region is alkalinity because some prairie wetlands are too alkaline to provide high wildlife diversity and productivity. Since alkalinity is not easily measured and since most highly alkaline wetlands in the prairie region would probably receive low scores on many of the other criteria, a water chemistry criterion is not necessary for this region.

Northern Forest Region

The following adjustments were necessary to create an evaluation method for the Northern Forest region. This area is also referred to as the Laurentian Mixed Forest.

a. Dominant Wetland Class - This criterion is adjusted as described under adjustments for the southern forest region.

b. Surrounding Habitat Types - Forestland and shrubland are very common around wetlands in this region. To improve the method's ability to separate between wetland types in this region, the following habitat types are substituted for those in the Golet method: forestland or shrubland, agricultural land, grassland, and pastureland.

c. Water Chemistry - The pH criterion is retained for this region for two reasons: (1) unlike other regions, changes in pH are not as well reflected by changes in other criteria, and (2) acidification of water in this region due to acid precipitation and mineral mining is of great concern and is most appropriately measured with a pH indicator.

MODIFICATION 3: SCALING OF VALUE SCORES

To facilitate interpretation, the value scores in each region should have the same maximum. The following linear transformations are used to make "25" the maximum score for all regions.

Southern Forest Region:

(Wetland Score) x 100/108 (round to closest whole number)

Prairie Grassland Region:

(Wetland score) x 100/108 (round to closest whole number)

Northern Forest Region:

(Wetland score) x 100/120 (round to closest whole number)

Note that this method should not be used to compare wetlands in two different regions. The assumptions made in adjusting the ranking criteria are too tenuous to allow this type of comparison.

MODIFICATIONS TO METHODS PROPOSED BY ADAMUS - Waterfowl

Methods presented in this paper (appendix D) are based on criteria proposed by Adamus (1983) for evaluating wetland values for waterfowl nesting and summering. The criteria used by Adamus are modified for use in the north central region as explained below. The modifications are illustrated with flow charts showing the unmodified and modified logic for each waterfowl group (figures C2-C13). Note that the impact area referred to in the flow chart is the wetland being studied.

In the following paragraphs, "exclusionary criteria" are those criteria within the actual framework of the flow chart, and "additional criteria" are those that are used in a "most-of-the-following" structure.

Waterfowl Group 1 (Figures C2 and C3): (Dabbling ducks that prefer grassland types: American widgeon, blue-winged teal, green-winged teal, gadwall, mallard, pintail, and shoveler).

Exclusionary Criteria: The mean depth criterion is changed to allow portions of the wetland that have appropriate water depths to be recognized for their value. For example, in a very large wetland, mean water depth may be less than 0.1 foot; however, there may be large areas in which the water depth is at an optimal level of 1.0 foot. Predictor 34 is therefore modified as shown in appendix D.

Additional Criteria: (15.4 or 15.7) - These criteria deal with value of surrounding habitat type. Adamus makes two assumptions (page 62, VI) regarding management of pasture and hayland which are not valid in the north central region of the United States. The criterion is modified to read "15.4 or 15.6" which basically assumes that unmanaged grassland has greater value than developed or grazed grassland areas.

(37.1 or 37.2) - This criterion was changed to simply 37.1 because islands are included in 37.1 and do not need to be addressed separately in 37.2.

(58.2) - This criterion is deleted because it is difficult to measure and is not a significant predictor of wetland values for waterfowl group 1.

Waterfowl Group 2 (Figures C4 and C5) : (Forest-nesting dabbling ducks: Black duck, wood duck, mallard - in some cases).

Exclusionary Criteria: A comparison of the exclusionary criteria for this group with those of group 4 (forest-nesting diving ducks) shows that the surrounding land cover, wetland class, and hydroperiod are included as exclusionary criteria for group 4, but not for group 2. Since forested areas are just as important to both groups, predictors (15.1 or 15.2) and (22.1 or 22.2) (both requiring forested cover types somewhere near the wetland) are moved from additional criteria to exclusionary criteria for group 2. The hydroperiod criterion (26.1 or 26.2 or 26.8) is left as an additional criterion for group 2 since a permanent water supply is not as important for dabbling ducks.

As explained for waterfowl group 1, question 34 has been revised to account for variation in water depth. This change is not reflected in the modified flow chart because it is not a change in the logic framework. The changes that do result from changes in question 34 are reflected in the flow charts in the first section of this report.

Additional Criteria: (37.1 or 37.2) - changed to 37.1 (see comments for waterfowl group 1).

(58.2) - Delete this criterion because it is difficult to measure and is not a highly significant predictor of wetland value for waterfowl group 2.

Waterfowl Group 3 (Figures C6 and C7) : (Carnivorous ducks: Common merganser, red-breasted merganser, and hooded merganser).

Exclusionary Criteria: Predictor 10.1 (stream order) is used to indicate stream size and permanency of water supply for riverine wetlands. Although it is questionable if this is a good indicator of size and permanence in the north central region, it is retained for lack of a good replacement.
Changes in the wording of predictor 34 necessitated restructuring the flow chart, although the criterion (mean water depth greater than 0.7 foot) remains unchanged. The restructuring is not shown in figure 10; however, it is reflected in the flow charts in the first part of this report (see comments for waterfowl group 2)
Additional Criteria: (9.2) - This predictor is deleted in the modified version because it seems arbitrary and is not supported by specific justification in Adamus VI.

(37.1 or 37.2) - Changed to 37.1 (see comments for waterfowl group 1).

Waterfowl Group 4 (Figures C8 and C9) : (Forest-nesting diving ducks: Barrow's goldeneye, common goldeneye, bufflehead, and ring-necked duck).

Exclusionary Criteria: The predictor allowing wetland class to be "moss" (22.5) has been modified from moss to scrub-shrub (22.2). As defined in Cowardin (1979), the moss-lichen class contains no large trees (a nesting requirement for these species). The modification allows scrub-shrub wetlands to be evaluated for being high value, whereas moss wetlands are placed in a lower value category.

Changes in the wording of predictor 34 necessitated restructuring the flow chart, although the criterion (mean water depth greater than 0.7 foot) remains unchanged. The restructuring is not shown in figure 10; however, it is reflected in the flow charts in the first section of this report (see comments for waterfowl group 2).

The stream order predictor (10.1) is used, although its validity is questioned (see comments under waterfowl group 3).

Additional Criteria: Criterion 37.1 or 37.2 is changed to 37.1 (see comments under waterfowl group 1).

Waterfowl Groups 5 and 6 (Figures C10 and C11) : (Prairie-nesting diving ducks: Canvasback, redhead, ruddy duck, and scaups).

Exclusionary Criteria: Changes in the wording of predictor 34 necessitated restructuring the flow chart, although the criterion (mean water depth greater than 0.7 foot) remains unchanged. The restructuring is not shown in figure 10; however, it is reflected in the flow charts in the main part of this report (see comments for waterfowl group 2).

Additional Criteria: The stream order predictor (10.1) is used, but its validity is questioned (see comment on waterfowl group 3). The surrounding land cover predictors (15.4 or 15.7) are changed to 15.4 or 15.6 (see comments under waterfowl group 1). Predictor 58.2 (alkalinity) is deleted for reasons given under waterfowl group 2.

Waterfowl Group 7 (Figures C12 and C13) : (Inland geese and swans: Canada goose, snow goose, white-fronted goose, mute swan, trumpeter swan, and tundra swan).

Exclusionary Criteria: The surrounding land cover predictors (15.4 or 15.7) are changed to 15.4 or 15.6 for reasons given under waterfowl group 1. The mean water depth criterion has been changed through changes in the phrasing of predictor 34 (see comments under waterfowl group 1).

Additional Criteria: Note that the stream order predictor (10.1) and the wetland class predictors (22.3 or 22.4) belong in the additional criteria section. Both the Adamus (1983) and Wisconsin (COE, 1983) methods are ambiguous as to where these criteria should be included.

The predictor indicating a maximum number of vegetation forms (predictor 49.1: less than 3 vegetation forms) is deleted in the proposed method because it seems to conflict with the following predictor requiring a minimum number of vegetation forms (predictor 49.2: more than 5 vegetation forms).

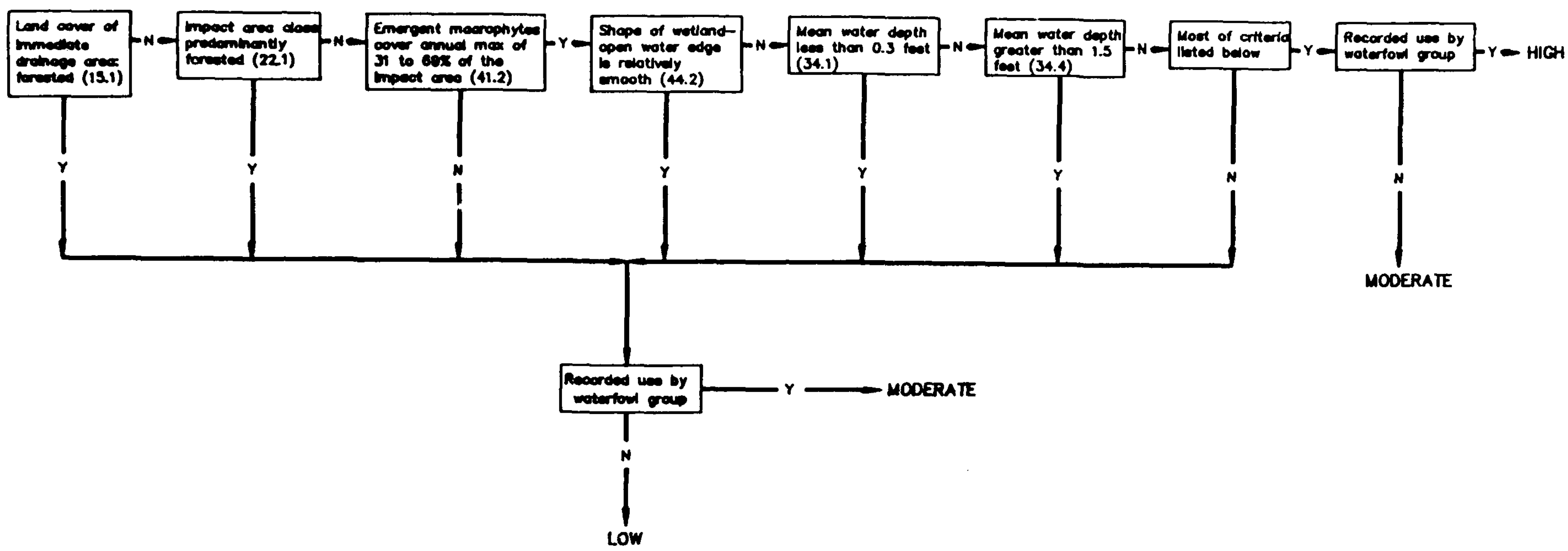
Criterion 37.1 or 37.2 is changed to 37.1 (see comments under waterfowl group 1).

Two criteria are used to indicate water permanence (9.2 or 10.3). Neither high stream order (10.3) nor location in the lower one-third of the local watershed (9.2) is a good predictor of water permanence in the north central region; hence, these criteria are deleted from the proposed method.

The validity of using predictor 10.1 is questioned (see comments under waterfowl group 3).

Criterion 3.1 is also deleted for two reasons: (1) Sinuous or irregular shape is used as an indicator of low water velocity (Adamus, VII, 1983; page 54), and this hypothesized relationship is questionable; (2) this is the only place predictor 3.1 is used for evaluation of wildlife habitat, and its relatively minor role does not justify its inclusion.

WATERFOWL GROUP I (UNMODIFIED) FIGURE C2



ADDITIONAL CRITERIA – WATERFOWL GROUP 1

1) 1.1 Impact area has an inlet NO
AND
1.2 Impact area has an outlet NO

2) 8.2 Wetland surface area greater than 40 acres YES

3) 50 A plant comprising more than 10% of wetland is rated as high value for waterfowl group YES

4) 58.2 $CaCO_3$ alk between 100mg/l and 800mg/l YES

5) 10.1 (Skip unless riverine) Wetland is in stream of order 1 and 2 NO

6) 40.2 Impact area contains more than 5 vegetation forms YES

7) 44.1 Shape of wetland – open water edge is sinuous or irregular YES

8) 15.4 Land cover of immediate drainage area : cropped and/or grazed YES
OR
15.7 Land cover of immediate drainage area : developed, cropped and/or grazed YES

9) 39.6 Artificial channels are major contributors to the basin or tributaries NO

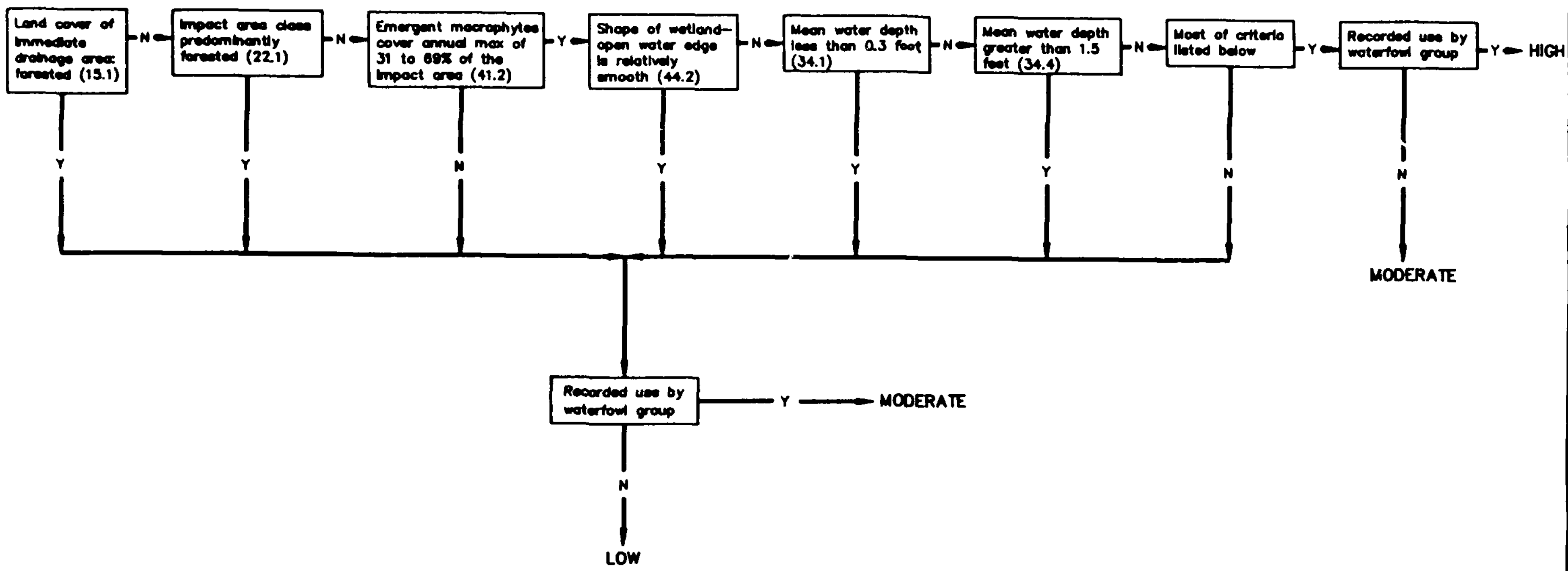
10) 26.3 Impact area predominantly semipermanently flooded YES
OR
26.4 Impact area predominantly seasonally flooded YES
OR
26.6 Impact area predominantly temporarily flooded YES

11) 29 Impact area characteristically "flashy" NO

12) 23.3 Substrate type: porous organic YES
OR
23.4 Substrate type: sand YES

13) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES
OR
37.2 Wetland comprises all or part of an island YES

WATERFOWL GROUP I (MODIFIED) FIGURE C3



ADDITIONAL CRITERIA – WATERFOWL GROUP 1

1) 1.1 Impact area has an inlet NO
AND
1.2 Impact area has an outlet NO

2) 6.2 Wetland surface area greater than 40 acres YES

3) 50 A plant comprising more than 10% of wetland is rated as high value for waterfowl group YES

4) 10.1 (Skip unless riverine) Wetland is in stream of order 1 and 2 NO

5) 49.2 Impact area contains more than 5 vegetation forms YES

6) 44.1 Shape of wetland – open water edge is sinuous or irregular YES

7) 15.4 Land cover of immediate drainage area : cropped and/or grazed YES
OR
15.6 Land cover of immediate drainage area : ungrazed or unmanaged grassland YES

8) 39.6 Artificial channels are major contributors to the basin or tributaries NO

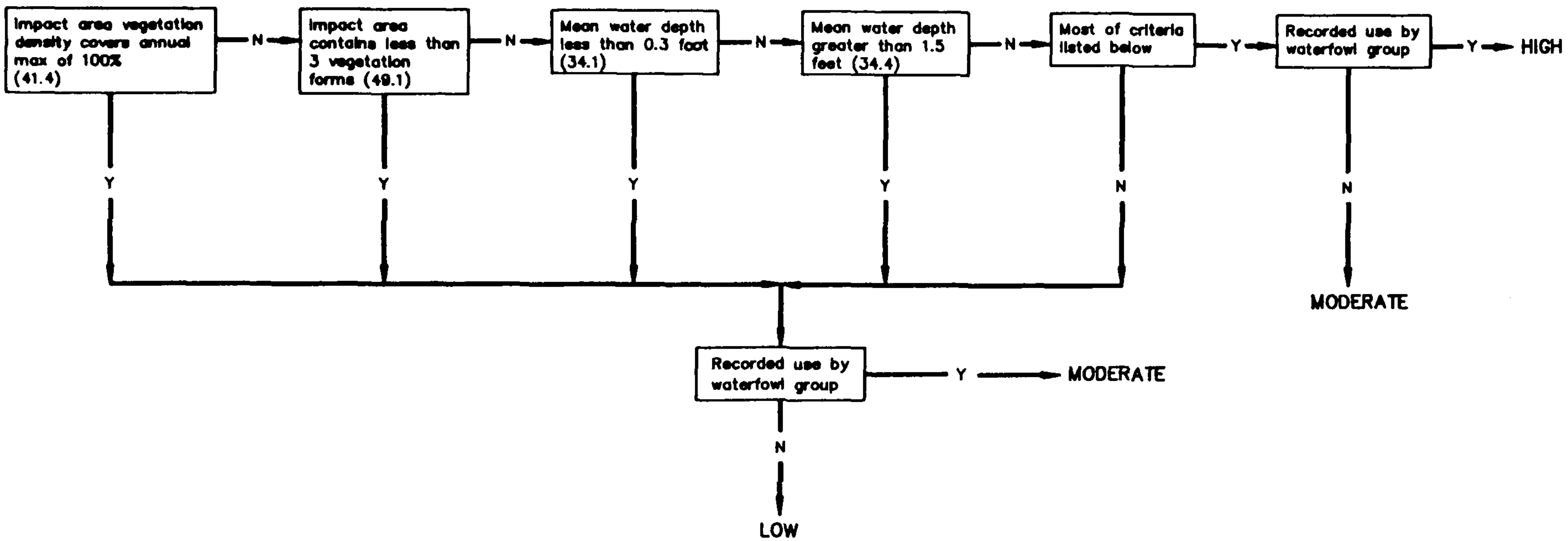
9) 26.3 Impact area predominantly semipermanently flooded YES
OR
26.4 Impact area predominantly seasonally flooded YES
OR
26.6 Impact area predominantly temporarily flooded YES

10) 29 Impact area characteristically "flashy" NO

11) 23.3 Substrate type: porous organic YES
OR
23.4 Substrate type: sand YES

12) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

WATERFOWL GROUP 2 (UNMODIFIED) FIGURE C4



ADDITIONAL CRITERIA – WATERFOWL GROUP 2

1) 50 A plant comprising more than 10% of wetland is rated as high value for given waterfowl group YES

2) 58.2 CaCO3 alk between 100mg/l and 600mg/l YES

3) 15.1 Land cover of immed drainage area : forested YES

OR

15.2 Land cover of immed drainage area : scrub–shrub YES

4) 22.1 Impact area class predominantly forested YES

OR

22.2 Impact area class predominantly scrub–shrub YES

5) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

OR

37.2 Wetland comprises all or part of an island YES

6) 41.1 Emergent macrophytes cover annual max of 0 to 30% of the impact area YES

41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

7) 44.2 Shape of wetland – open water edge is relatively smooth YES

8) 26.1 Impact area predominantly permanently flooded YES

OR

26.2 Impact area predominantly intermittently exposed YES

OR

26.8 Impact area predominantly artificially flooded YES

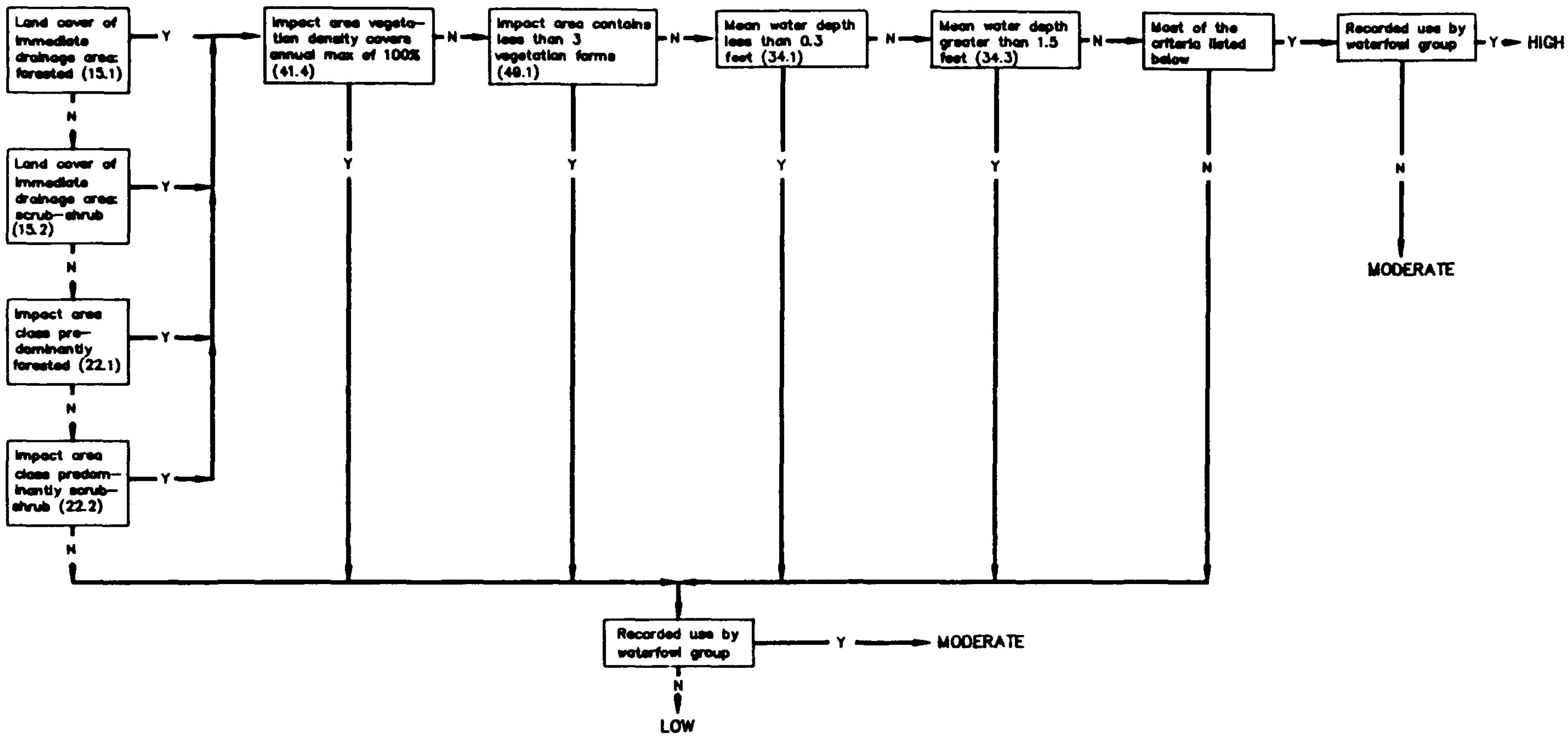
9) 1.1 Impact area has an inlet YES

AND

1.2 Impact area has an outlet YES

10) 29 Impact area characteristically "flashy" NO (Black duck only)

WATERFOWL GROUP 2 (MODIFIED) FIGURE C5



ADDITIONAL CRITERIA – WATERFOWL GROUP 2

1) 1.1 Impact area has an inlet YES
OR
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 44.2 Shape of wetland–open water edge is relatively smooth NO

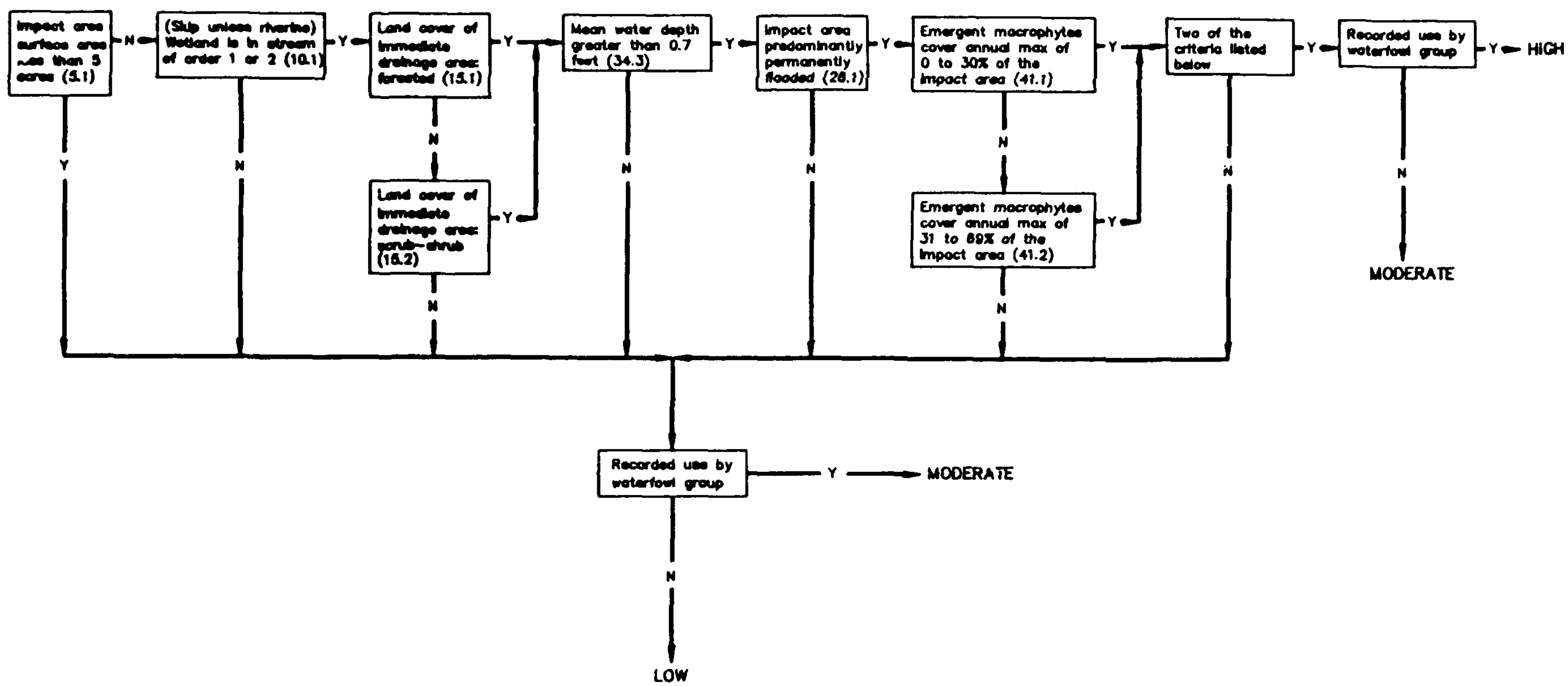
4) 26.1 Impact area predominantly permanently flooded YES
OR
26.2 Impact area predominantly intermittently exposed YES
OR
26.8 Impact area predominantly artificially flooded YES

5) 29 Impact area characteristically "flashy" (Black duck only) NO

6) 50 A plant comprising more than 10% of wetland is rated as high for given water-fowl group YES

7) 41.1 Emergent macrophytes cover annual max of 0 to 30% of the impact area YES
OR
41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

WATERFOWL GROUP 3 (UNMODIFIED) FIGURE C6



ADDITIONAL CRITERIA – WATERFOWL GROUP 3

1) 1.1 Impact area has an inlet YES

   OR

   1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

   OR

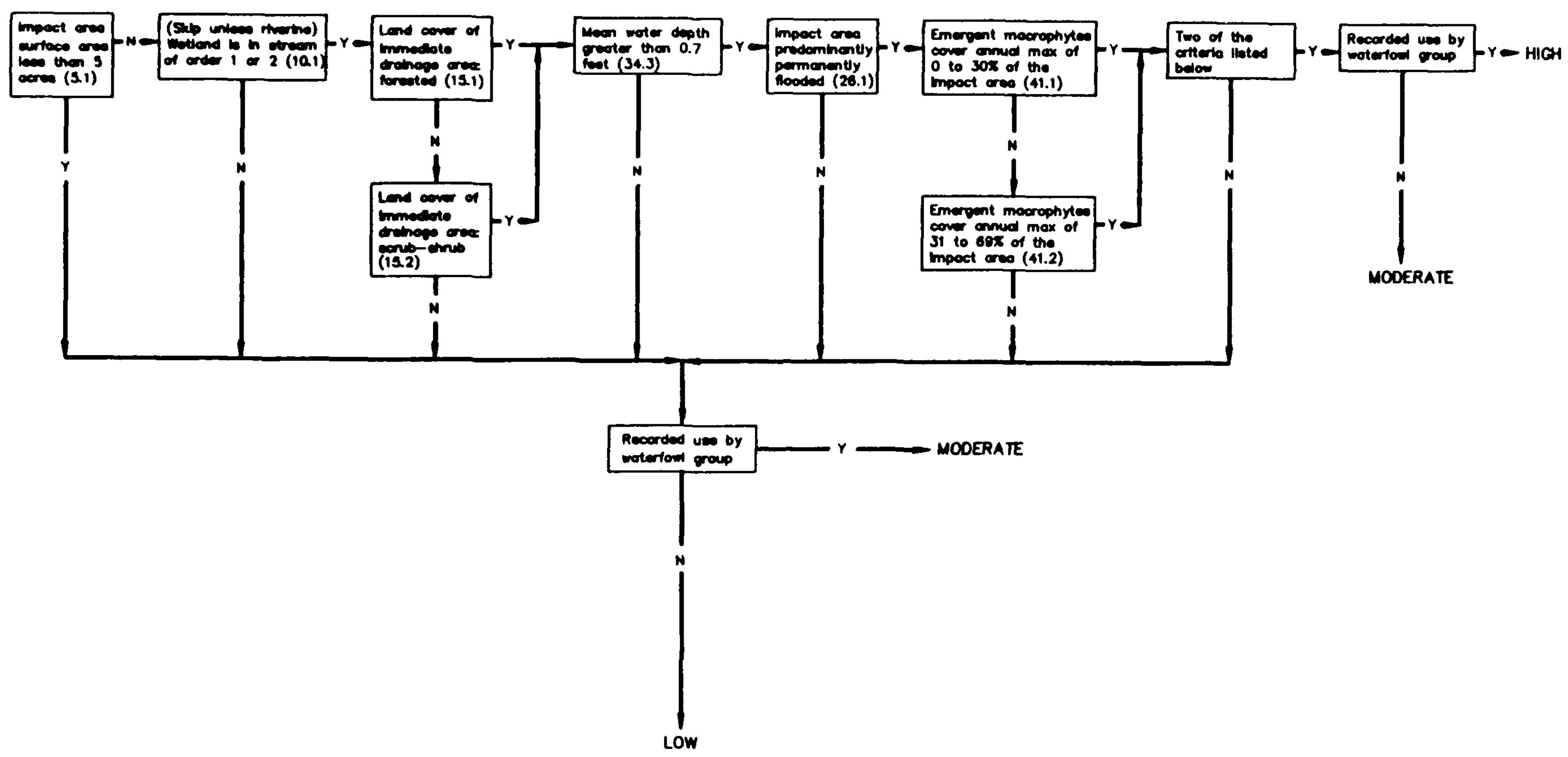
   37.2 Wetland comprises all or part of an island YES

3) 5.2 Impact area surface area greater than 200 acres YES

4) 9.2) Impact area located in lower one-third of local watershed NO

5) 29 Impact area characteristically "flashy" (Except hooded) NO

WATERFOWL GROUP 3 (MODIFIED) FIGURE C7



ADDITIONAL CRITERIA – WATERFOWL GROUP 3

1) 1.1 Impact area has an inlet YES

OR

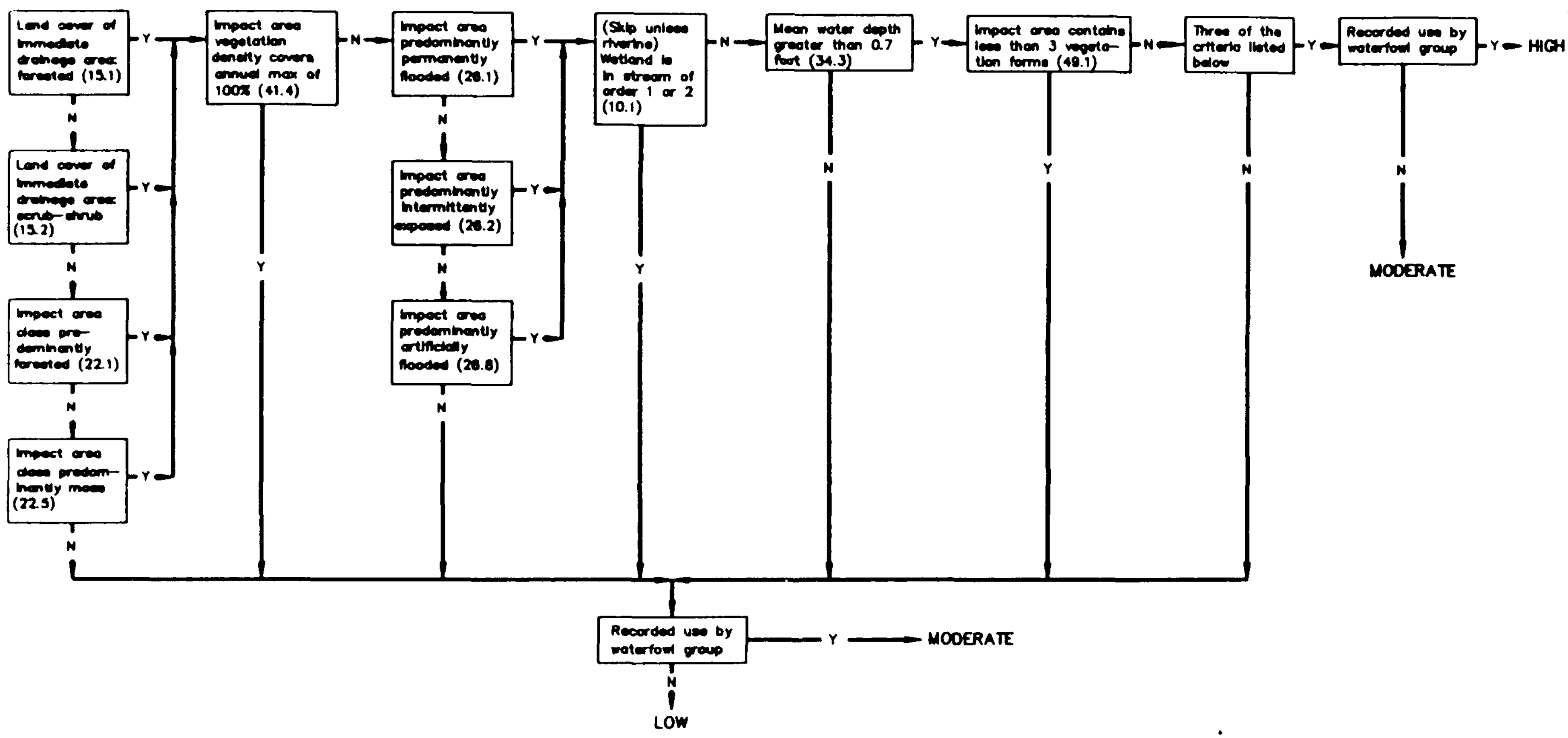
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 5.2 Impact area surface area greater than 200 acres YES

4) 29 Impact area characteristically "flashy" (Except hooded) NO

WATERFOWL GROUP 4 (UNMODIFIED) FIGURE C8



ADDITIONAL CRITERIA – WATERFOWL GROUP 4

1) 1.1 Impact area has an inlet YES

OR

1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

OR

37.2 Wetland comprises all or part of an island YES

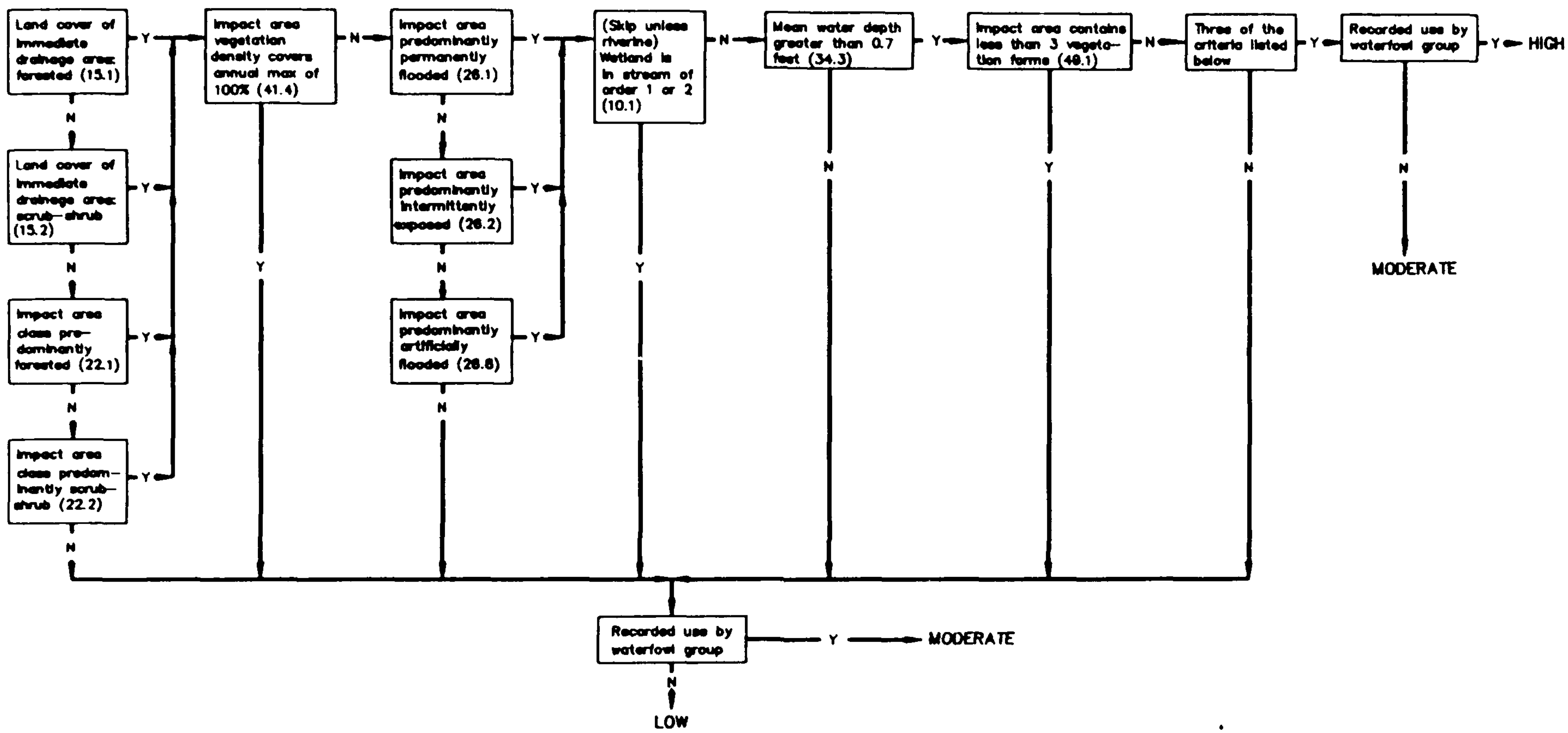
3) 44.1 Shape of wetland–open water edge is sinuous or irregular YES

4) 49.2 Impact area contains more than 5 vegetation forms YES

5) 6.1 Wetland surface area less than 5 acres NO

6) 41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

WATERFOWL GROUP 4 (MODIFIED) FIGURE C9



ADDITIONAL CRITERIA – WATERFOWL GROUP 4

1) 1.1 Impact area has an inlet YES

OR

1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

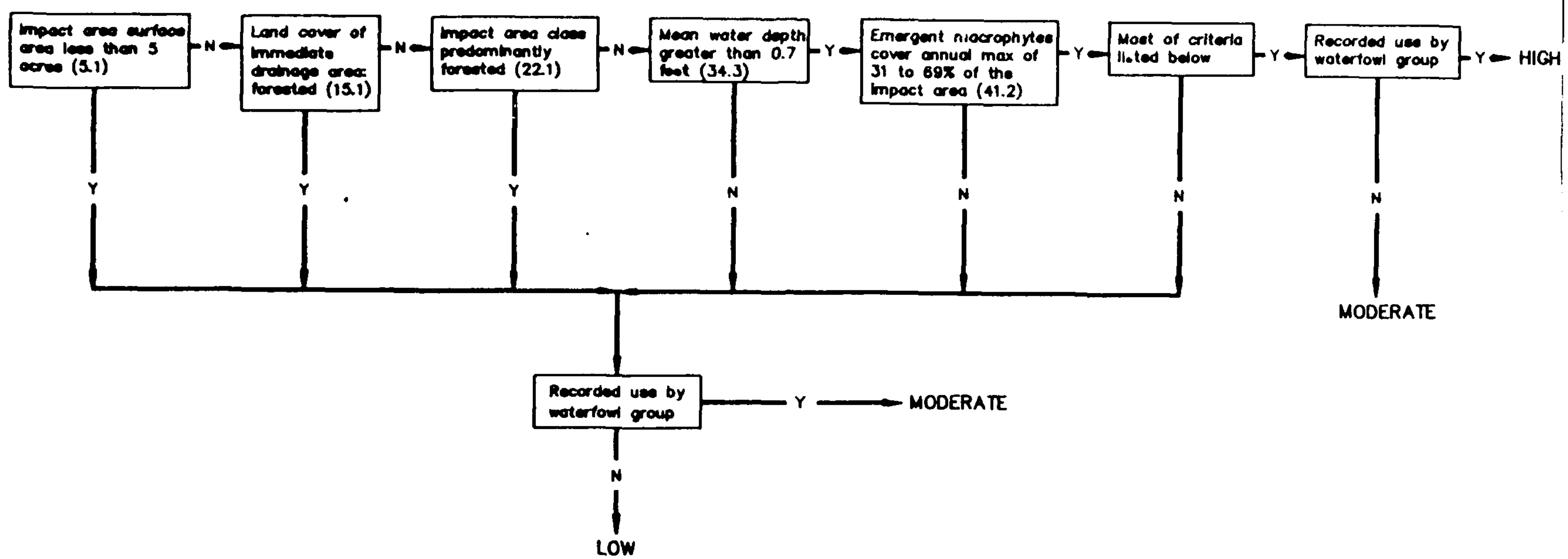
3) 44.1 Shape of wetland-open water edge is sinuous or irregular YES

4) 49.2 Impact area contains more than 5 vegetation forms YES

5) 6.1 Wetland surface area less than 5 acres NO

6) 41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

WATERFOWL GROUPS 5 & 6 (UNMODIFIED) FIGURE C10



ADDITIONAL CRITERIA – WATERFOWL GROUPS 5 & 6

1) 1.1 Impact area has an inlet NO
AND
1.2 Impact area has an outlet NO

2) 6.2 Wetland surface area greater than 40 acres YES

3) 50 A plant comprising more than 10% of wetland is rated as high value for waterfowl group (Group 5 only) YES

4) 58.2 CaCO3 alk between 100mg/l and 600mg/l YES

5) 10.1 (Skip unless riverine) Wetland is in stream of order 1 and 2 NO

6) 40.2 Impact area contains more than 5 vegetation forms YES

7) 44.1 Shape of wetland – open water edge is sinuous or irregular YES

8) 15.4 Land cover of immediate drainage area : cropped and/or grazed YES
OR
15.7 Land cover of immediate drainage area : developed, cropped YES

9) 30.6 Artificial channels are major contributors to the basin or tributaries NO

10) 26.3 Impact area predominantly semipermanently flooded YES
OR
26.4 Impact area predominantly seasonally flooded YES

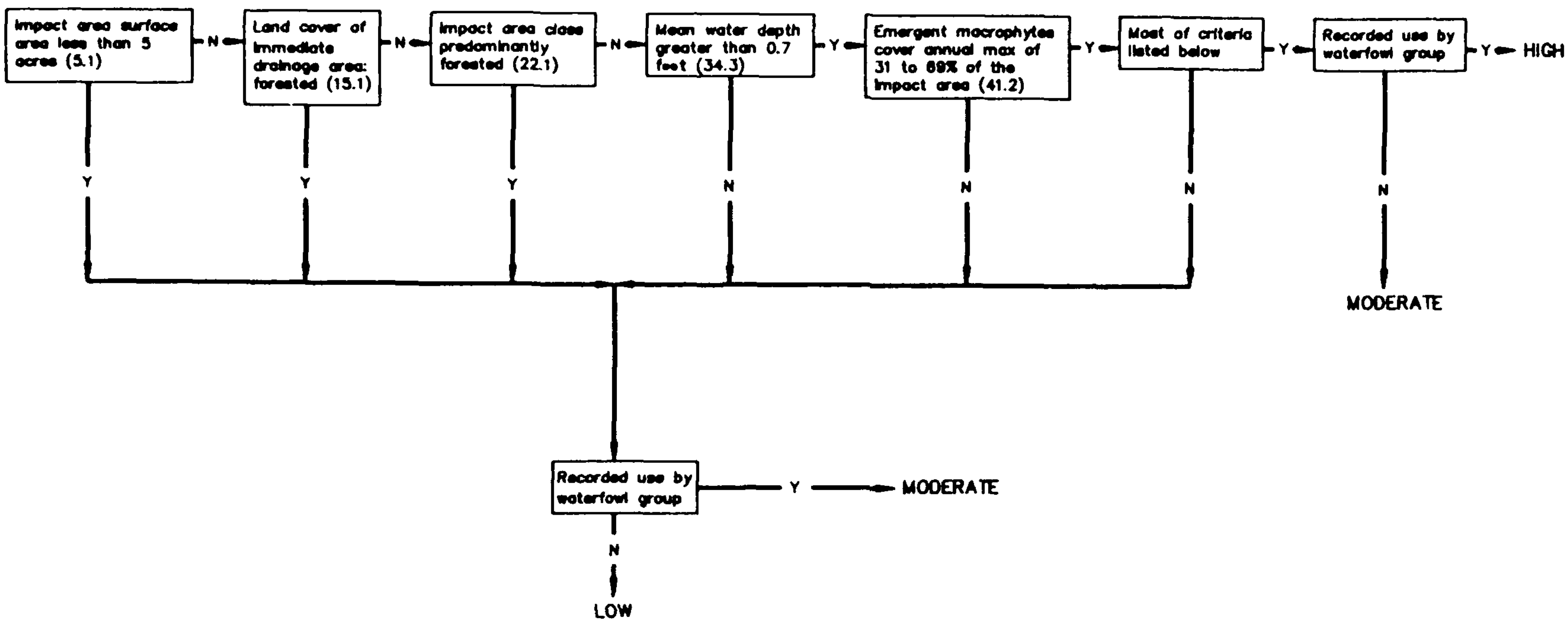
11) 29 Impact area characteristically "flashy" NO

12) 22.3 Impact area class predominantly aquatic bed YES
OR
22.4 Impact area class predominantly emergent YES

13) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES
OR
37.2 Wetland comprises all or part of an island YES

14) 5.2 Impact area surface area greater than 200 acres YES

WATERFOWL GROUPS 5 & 6 (MODIFIED) FIGURE C11



ADDITIONAL CRITERIA – WATERFOWL GROUPS 5 & 6

1) 1.1 Impact area has an inlet NO
AND
1.2 Impact area has an outlet NO

2) 6.2 Wetland surface area greater than 40 acres YES

3) 50 A plant comprising more than 10% of wetland is rated as high value for waterfowl group (Group 5 only) YES

4) 5.2 Impact area surface area greater than 200 acres YES

5) 10.1 (Skip unless riverine) Wetland is in stream of order 1 and 2 NO

6) 49.2 Impact area contains more than 5 vegetation forms YES

7) 44.1 Shape of wetland – open water edge is sinuous or irregular YES

8) 15.4 Land cover of immediate drainage area : cropped and/or grazed YES
OR
15.6 Land cover of immediate drainage area: ungrazed, unmanaged grassland YES

9) 39.6 Artificial channels are major contributors to the basin or tributaries NO

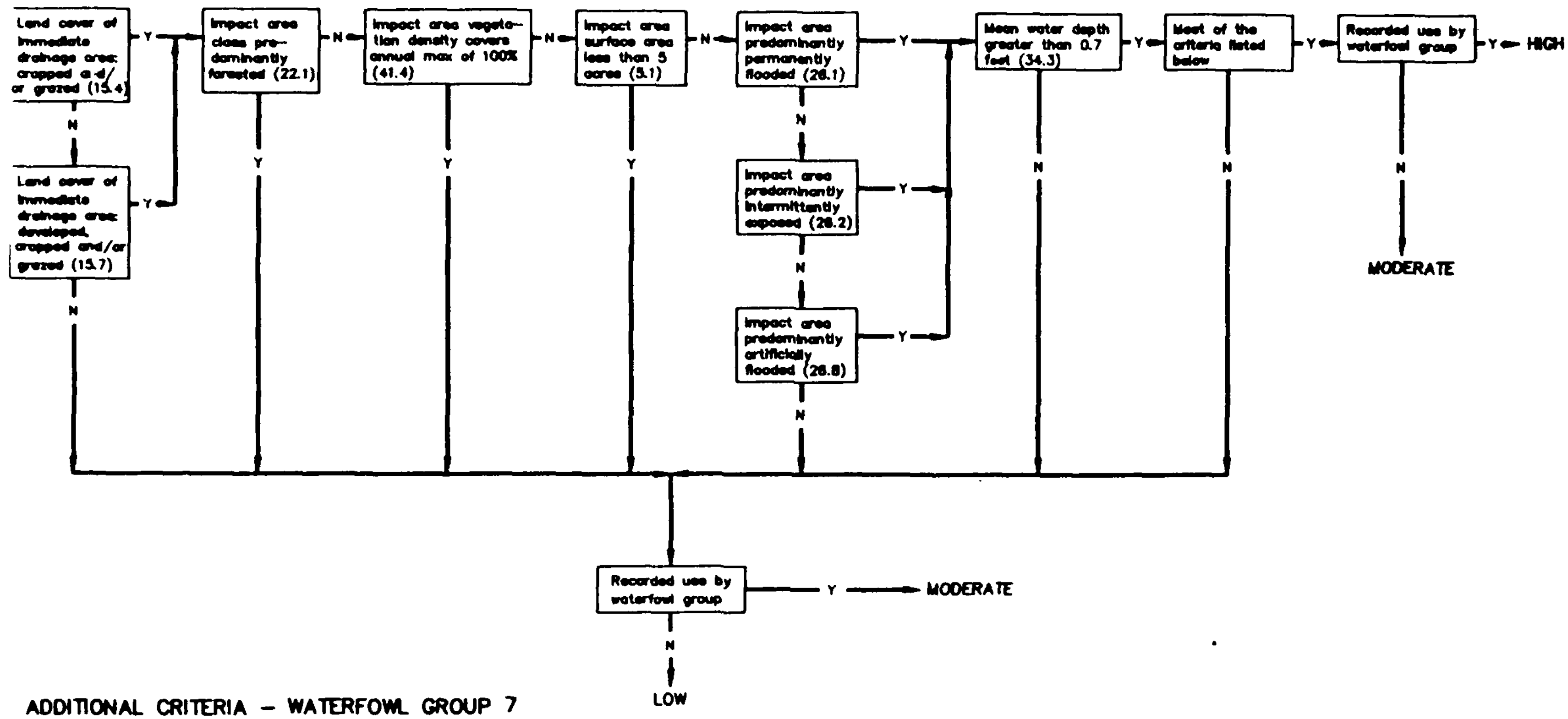
10) 26.3 Impact area predominantly semipermanently flooded YES
OR
26.4 Impact area predominantly seasonally flooded YES

11) 29 Impact area characteristically "flashy" NO

12) 22.3 Impact area class predominantly aquatic bed YES
OR
22.4 Impact area class predominantly emergent YES

13) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

WATERFOWL GROUP 7 (UNMODIFIED) FIGURE C12



ADDITIONAL CRITERIA – WATERFOWL GROUP 7

1) 1.1 Impact area has an inlet YES
AND
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES
OR
37.2 Wetland comprises all or part of an island YES

3) 3.1 Impact area is sinuous or irregularly shaped YES

4) 9.2) Impact area located in lower one-third of local watershed YES
OR
10.3 (Skip unless riverine) Wetland is in stream of order greater than 3 YES

5) 29 Impact area characteristically "flashy" NO

6) 10.1 (Skip unless riverine) Wetland is in stream of order 1 or 2 NO

7) 22.3 Impact area class predominantly aquatic bed YES
OR
22.4 Impact area class predominantly emergent YES

8) 40.1 Impact area contains less than 3 vegetation forms YES

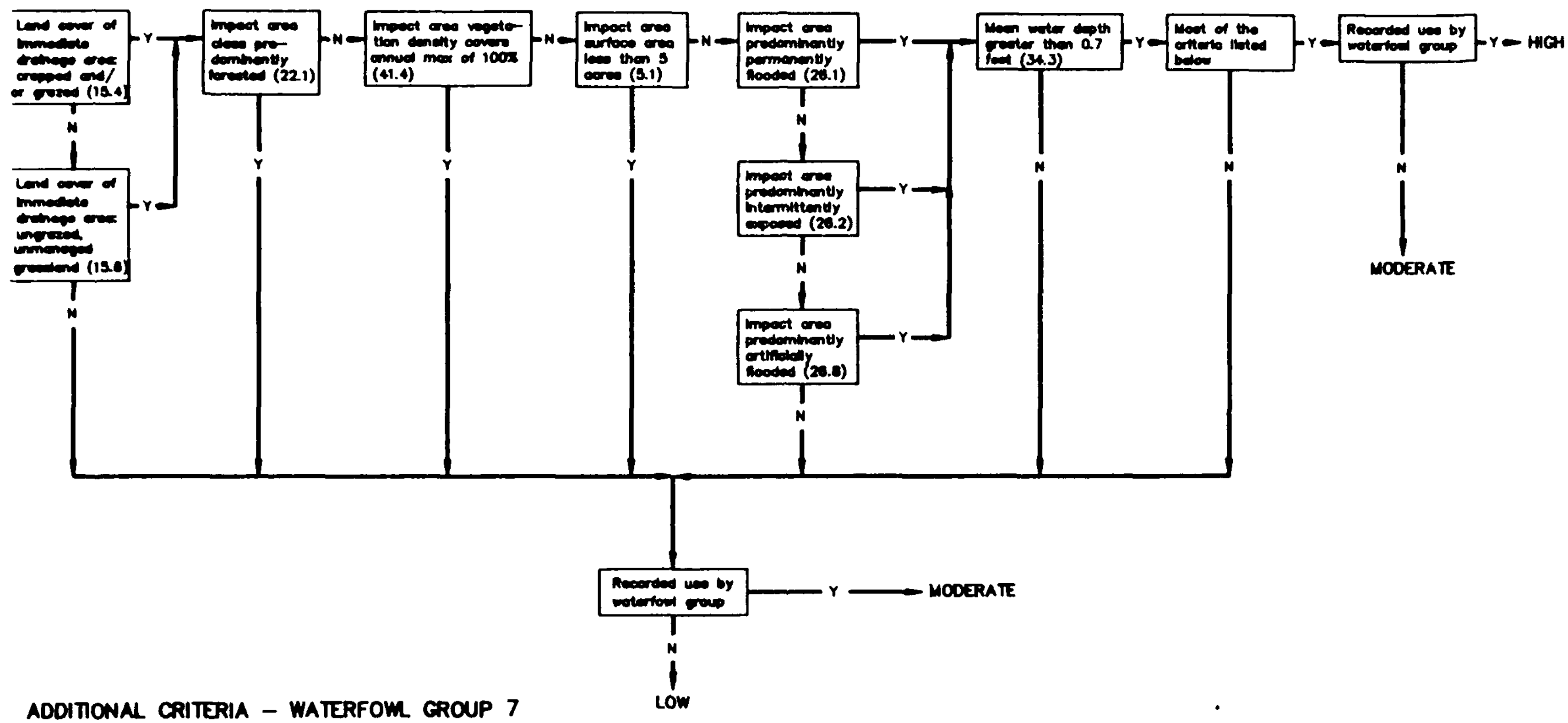
9) 40.2 Impact area contains more than 5 vegetation forms YES

10) 41.2 Emergent macrophytes cover annual max of 31 to 60% of the impact area YES

11) 44.1 Shape of wetland–open water edge is sinuous or irregular YES

12) 50 A plant comprising more than 10% of wetland is rated as high for given waterfowl group YES

WATERFOWL GROUP 7 (MODIFIED) FIGURE C13



ADDITIONAL CRITERIA – WATERFOWL GROUP 7

1) 1.1 Impact area has an inlet YES
AND
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 10.1 (Skip unless riverine) Wetland is in stream of order 1 or 2 NO

4) 22.3 Impact area class predominantly aquatic bed YES
OR
22.4 Impact area class predominantly emergent YES

5) 29 Impact area characteristically "flashy" NO

6) 41.2 Emergent macrophytes cover annual max of 31 to 60% of the impact area YES

7) 48.2 Impact area contains more than 5 vegetation forms YES

8) 44.1 Shape of wetland-open water edge is sinuous or irregular YES

9) 50 A plant comprising more than 10% of wetland is rated as high for given waterfowl group YES

VALUES NOT ADDRESSED

Other methods for assessing wildlife values (Adamus, 1983; COE, 1983) include non-game wildlife values and wintering/migration values. The reasons for not addressing these values in this method are briefly summarized below.

NON-GAME WILDLIFE VALUES

Although it is possible to include specific values related to non-game wildlife species (see Adamus, 1983; COE, 1983), they are not specifically addressed in this method for the following reasons:

a. The general diversity/productivity score coupled with scores for the various waterfowl groups should provide an adequate indication of values for other species.

b. Other methods for addressing non-game species are either based strictly on whether or not species use has been recorded (see COE, 1983) or are hampered by having to decide which additional species should be included in the analysis (see Adamus, 1983).

c. Social and agency concern about the value for a single non-game species is usually low. Hence, including a lot of non-game species in the method would not result in enough of an increase in the decision-making value of the method to justify the added complexity and volume.

Threatened and endangered species are not addressed in this section of the wetland evaluation methodology, but are addressed in the special features section.

WATERFOWL WINTERING/MIGRATION VALUES

Wintering and migration values for waterfowl are addressed in both the Adamus (1983) and Wisconsin (COE, 1983) methods, however, these values have been dropped from this method for the following reasons:

a. Only a minor portion of the species listed in any of the waterfowl groups have wintering ranges in the north central United States.

b. Wetlands that provide wintering values for waterfowl almost always have ice-free areas in the winter. Areas that are ice-free are rare in the north-central region and are therefore addressed in the special features section rather than in this section of the evaluation methodology.

c. Migration values of wetlands are hard to address. As Adamus states, "the degree to which individual wetlands are used may vary greatly depending on weather, harvest pressure, and unknown factors" (Adamus, 1983, Volume II, p. 82). The specific migration value for each wetland is therefore not addressed in the method (well-known staging and migration areas are given added value in the special features section).

COMPARISON OF VARIOUS WEIGHTING SYSTEMS

The intent of this section is to show that different weighting systems used with a Golet-style method have no real effect on the value scores of the wetlands. To accomplish this, the Golet method was applied to 59 wetlands and total scores were computed using 5 different weighting systems (see table C-2). The total scores show that the wetlands maintain basically the same order from highest value to lowest value under all weighting systems.

Table C-2 summarizes the results of this analysis. The wetlands are grouped according to the source of data used in the analysis. The first group in the table consists of the wetlands that were field tested by the Minnesota WEM task force, the second group was compiled from Minnesota Department of Transportation data, the third group was randomly selected from data compiled for the Crandon minerals project in Wisconsin, and the fourth group was selected from the same project by Bob Read (Wisconsin Department of Natural Resources).

The wetlands in table C-2 are listed in order of decreasing score received under the Golet (1978) weights. Examination of other weighting systems shows that the decreasing order is maintained regardless of weights used. This indicates wetlands maintain the same value order under any weighting system (i.e., the weights used have no effect on the conclusions reached).

There are some minor changes in order in table C-2 (e.g., POM D TE and ANOKA DI wetlands not in the same order under the Kittelson weights). To see if these changes in order are significant, the correlations between the values produced under the different weighting systems were calculated (table C-3, correlation matrix). Such high correlations indicate there is very little statistical difference between weighting systems.

TABLE C-2

WETLAND RATINGS USING GOLET WITH VARIOUS CRITERION WEIGHTS
(Sorted by Golet weights)

	CLASS RICH	DOM CLASS	SIZE	SUB CLASS RICH	SITE TYPE	SURR HAB TYPES	COVER TYPE	VEG INTER-SPERS	WTLND JUXT	pH	TOTAL (Without using pH criterion): GOLET WEIGHTS	GOLET 1976 WEIGHTS	EQUAL WEIGHTS	2 = IMPT 1 = LESS IMPT	KITTELSON WEIGHTS	TOTAL (Without using pH criterion) (Scaled from 0 to 10): GOLET WEIGHTS	GOLET 1976 WEIGHTS	EQUAL WEIGHTS	2 = IMPT 1 = LESS IMPT	KITTELSON WEIGHTS
WEIGHTS																				
GOLET	5	5	5	4	4	4	2	2	3	1										
GOLET 76	5	5	5	4	4	4	3	3	2	1										
EQUAL WT	1	1	1	1	1	1	1	1	1	1										
1 OR 2	2	2	2	2	2	2	1	1	1	1										
KITTELWT	5	5	5	4	2	3	4	4	2	1										
BLUE LK	3	3	2.5	2.5	3	2	2	3	3	2	91.5	93.5	24	40	90.5	9	9	9	9	9
LUNSTEN	2	3	2.5	2.5	3	3	2.5	2	3	2	89.5	91	23.5	39.5	86.5	9	9	9	9	8
BAKKE	2.5	3	2	2.5	1	3	2.5	1	3	3	79.5	80	20.5	34.5	78.5	8	8	8	8	8
HOLMAN	2	3	2.5	2.5	3	1	1.5	2	2	2	76.5	78	19.5	33.5	74.5	8	7	7	7	7
PON D TE	1	3	2	2	3	3	1.5	1	3	3	76	75.5	19.5	33.5	69	7	7	7	7	7
ANOKA DI	2	3	2.5	2	2	2	1.5	1	3	3	75.5	75	19	32.5	71.5	7	7	7	7	7
HLMN CON	2	3	1.5	2.5	1	3	3	1	2	3	72.5	74.5	19	32	73.5	7	7	7	7	7
TANGEN	1.5	3	1.5	2	1	3	2	1	2	3	66	67	17	29	65	6	6	6	6	6
HLMN IND	1	3	1	1.5	1	3	3	1	2	3	61	63	16.5	27	62	6	6	6	6	6
SWB PUR	1	3	2	1	1	3	1.5	1	2	3	61	61.5	15.5	26.5	59	6	6	6	6	6
SWB REF	1	3	1.5	1	1	3	1.5	1	2	3	58.5	59	15	25.5	56.5	6	6	6	6	6
2000UASO	1	3	1	1.5	1	1	2.5	1	2	2	52	53.5	14	22.5	54	5	5	5	5	5
ABDT WETLANDS																				
04-17	1	3	1.5	2	1	2	3	2	2	3	63.5	66.5	17.5	28	67.5	6	6	6	6	7
05-4	1	3	1	1.5	1	3	2.5	2	2	3	62	64.5	17	27.5	64	6	6	6	6	6
04-2	1	3	1	1.5	1	2	3	2	2	3	59	62	16.5	26	63	6	6	6	6	6
04-46	1	3	1	1.5	1	2	1.5	2	2	2	56	57.5	15	24.5	57	5	5	6	6	6
04-11	1	3	1	1	1	2	2	2	2	2	55	57	15	24	57	5	5	6	5	6
04-7	1	3	1	1	1	3	1	1	2	3	55	55	14	24	52	5	5	5	5	5
04-4	1	3	1	1.5	2	2	1	1	1	2	54	55	13.5	24	51	5	5	5	5	5
09-2	1	1.5	1	1.5	2	2	1	1	3	2	52.5	51.5	14	23	47.5	5	5	5	5	5
04-16	1	3	1	1.5	1	2	2	1	1	2	52	54	13.5	23	53	5	5	5	5	5
04-18	1	3	1	1	2	2	1	1	1	2	52	53	13	23	49	5	5	5	5	5
04-43	1	3	1	1	1	2	1	1	2	2	51	51	13	22	49	5	5	5	5	5
04-42	1	3	1	1	1	2	1	1	2	2	51	51	13	22	49	5	5	5	5	5
04-40	1	3	1	1	1	2	1	1	2	2	51	51	13	22	49	5	5	5	5	5
04-44	1	3	1	1	1	2	1	1	2	2	51	51	13	22	49	5	5	5	5	5
09-10	1	1.5	1	1.5	1	2	1	1	3	2	48.5	47.5	13	21	45.5	5	5	5	5	4
09-1	1	3	1	1.5	1	1	1.5	1	1	2	47	48.5	12	20.5	48	5	5	4	5	5
05-7	1	3	1	1	1	1	1.5	1	1	2	45	46.5	11.5	19.5	46	4	4	4	4	5
04-6	1	1.5	1	1	1	2	1	1	2	3	43.5	43.5	11.5	19	41.5	4	4	4	4	4
04-15	1	1.5	1	1.5	1	2	1.5	1	1	2	43.5	45	11.5	19.5	43.5	4	4	4	4	4
04-14	1	1.5	1	1	1	2	1.5	1	1	2	41.5	43	11	18.5	41.5	4	4	4	4	4
09-8	1	1.5	1	1	1	2	1	1	1	2	40.5	41.5	10.5	18	39.5	4	4	4	4	4
04-49	1	1.5	1	1	1	1	1	1	2	2	39.5	39.5	10.5	17	38.5	4	4	4	4	4
09-3	1	1.5	1	1	1	1	2	1	1	2	38.5	40.5	10.5	17	40.5	4	4	4	4	4
09-6	1	1.5	1	1	1	1	1	1	1	2	36.5	37.5	9.5	16	36.5	4	4	4	4	4
CRANDON WETLANDS (RANDOM)																				
B-4	1	2.5	1	1.5	3	2	1.5	3	3		66.5	68	16.5	29.5	64.5	7	6	7	7	6
F-12	1.5	3	1.5	1.5	2	2	2	2	2		66	68	17.5	29	66	6	6	6	6	6
P-1	1	2.5	1	1	3	2	1.5	2	3		62.5	63	17	27.5	58.5	6	6	6	6	6
F-30	1	2	1	1	3	2	1.5	1	3		58	57.3	15.5	25.5	52	6	5	6	6	5
I-1	1	2.5	1	1.5	1	2	3	2	1		53.5	57.5	15	24	58.5	5	5	6	5	6
F-70	1	2.5	1	1.5	1	2	1.5	3	1		52.5	56	14.5	23.5	56.5	5	5	5	5	6
E-1	1	2.5	1	1	1	2	3	2	1		51.5	55.5	14.5	23	56.5	5	5	5	5	6
F-50	1	2.5	1	1	1	2	1.5	1	1		46.5	48	12	20.5	46.5	5	5	4	5	5
CRANDON WETLANDS (B. SEAR)																				
F-66	1.5	2.5	1.5	1.5	3	2	1.5	3	3		71.5	73	19.5	31.5	69.5	7	7	7	7	7
F-23	1.5	3	1	1.5	2	3	1.5	2	3		69.5	70	18.5	30.5	66.5	7	7	7	7	7
F-28	1.5	2	2	1.5	2	2	2.5	3	3		69.5	72	19.5	30.5	71.5	7	7	7	7	7
F-29	2	2	1	1.5	3	2	1.5	3	3		68	70.5	19	30.5	67	7	7	7	7	7
F-9	1	2.5	1	1.5	3	2	1.5	3	3		66.5	68	18.5	29.5	64.5	7	6	7	7	6
F-62	1	2.5	1	1.5	3	2	1.5	2	3		64.5	65	17.5	28.5	60.5	6	6	6	6	6
F-60	1.5	2.5	1.5	1.5	2	2	1.5	3	2		64.5	67	17.5	28.5	65.5	6	6	6	6	6
F-65	1.5	2	1	1.5	2	2	3	2	3		63.5	65.5	18	28	64.5	6	6	7	6	6
F-63	1.5	2.5	1	1.5	2	2	1.5	2	3		63	63.5	17	27.5	61	6	6	6	6	6
F-16	1.5	2	1.5	1.5	2	2	1.5	2	2		60	61.5	16	26.5	59	6	6	6	6	6
H-1	1.5	2.5	1.5	1.5	1	2	1.5	3	1		57.5	61	15.5	25.5	61.5	6	6	6	6	6
F-27	1	2.5	1	1.5	2	2	1.5	2	2		57.5	58	15.5	25.5	56.5	6	6	6	6	6
T-2	1.5	2	1	1.5	1	3	1.5	3	1		56.5	60	15.5	25.5	59.5	6	6	6	6	6
F-64	1	2	1	1	2	2	1.5	2	3		56	56.5	15.5	24.5	54	5	5	6	5	5
T-1	1	2	1	1	1	3	1.5	2	1		50	59.5	13.5	22.5	51	5	5	5	5	5

TABLE C-3

Correlations* Between the Various Weighting Systems

	Golet	Golet 76	Equal weight	1 or 2	Kittel weight
Golet	1.000				
Golet 76	.9950	1.000			
Equal weight	.9856	.9899	1.000		
1 or 2	.9986	.9972	.9888	1.000	
Kittel weight	.9745	.9901	.9792	.9776	1.000

*The correlation value is the value of "r" which would be obtained from regressing one weighting system on another.

DESCRIPTION OF ECOREGIONS

SOUTHERN FOREST ECOREGION

The Southern Forest ecoregion is generally found in the southwestern portion of Wisconsin and the southeastern corner of Minnesota. These forests are composed of deciduous species and occur on a full range of moisture sites, from very wet places along rivers and lakes to very dry places on the thin soils of exposed hills and bluffs.

Common trees of upland deciduous forests are oak, beech, birch, hickory, walnut, maple, basswood, elm, and ash.

Lowland forest species include black willow, cottonwood, river birch, swamp white oak, silver maple, American elm, green ash, and basswood.

NORTHERN FOREST ECOREGION

This ecoregion lies between the boreal forest to the north and the Southern Forest and Prairie Grassland ecoregions to the south and west. It consists of either mixed stands of coniferous and deciduous species, or nearly pure deciduous forests on favorable habitats with good soil and pure coniferous forests on less favorable habitats that have poor soils.

Coniferous species occurring with the deciduous species include pine, spruce, hemlock, fir, white cedar, and tamarack.

These forests occur on a wide range of topographic sites from very wet to very dry and from thin rocky soils to deep loams and clays.

Forested wetlands contain either conifer swamps, dominated by black spruce, tamarack and white cedar, or hardwood swamps with black ash and yellow birch.

This ecoregion is generally found in the upper half of Wisconsin and the northeastern third of Minnesota.

PRAIRIE GRASSLAND ECOREGION

Prairies are generally located southwest of the tension zone and occupy the greatest area in the southwest and south central portions of both Minnesota and Wisconsin. Prairie areas tend to become smaller and more scattered near the tension zone.

The prairie is a plant community dominated by native grasses and a large variety of forbs. Most prairies in this ecoregion have been converted to agricultural uses due to their high arability.

Wet prairies are dominated by bluejoint grass, prairie cordgrass, big bluestem, and sedges.

The prairie potholes (poorly drained depressions within glacially influenced topography) in this ecoregion are important breeding areas for migrating waterfowl. Potholes are characteristically smaller in size than the marshes and swamps found in the Northern Forest and Southern Forest ecoregions.

Aquatic ecoregions of identifiable and measurable spatial patterns have been developed from mapped information by the Corvallis Environmental Research Laboratory of the U.S. Environmental Protection Agency (EPA). The seven ecoregions defined for Minnesota (table C-4) are based on land use, soils, land surface form and potential natural vegetation. The ecoregions provide a means by which various land and surface water characteristics can be grouped.
The Minnesota Pollution Control Agency (MPCA) has been working cooperatively with the EPA to use the aquatic ecoregions as a framework for predicting attainable nutrient levels and identifying patterns in trophic status for Minnesota lakes. A publication by Fandrei, et. al., with a more detailed description of these ecoregions is currently in press.

The descriptions of ecoregions used in this methodology are based on potential natural vegetation and greatly resemble the descriptions and map developed by MPCA and EPA. The EPA ecoregions compare to those used in this methodology in the following manner:

The Southern Forest ecoregion in this methodology is somewhat larger than the Driftless Area described by EPA. The Southern Forest boundary extends farther west to encompass some of the oak savannah found in Dodge and Mower Counties. Their descriptions of dominant vegetation species are nearly identical.

The Prairie Grassland ecoregion in this methodology includes nearly all of the Red River Valley and Western Cornbelt Plains ecoregions, all of the Northern Great Plains ecoregion, and part of the Central Hardwood Forests ecoregion described by EPA. Their vegetation descriptions are similar except for the wooded areas in central Minnesota. These are included in the Northern Forest ecoregion in this methodology.

The Northern Forest ecoregion includes the Northern Minnesota Wetlands and the Northern Lakes and Forests ecoregions described by EPA. As stated above, this methodology includes the hardwood forests of central Minnesota here.

If you are already familiar with the EPA ecoregion descriptions, the above comparisons should help you in determining which of the three ecoregions to use.

Table C4: Aquatic Ecoregions in Minnesota

ECOREGION	LAND USE	SOILS	LAND SURFACE FORM	POTENTIAL NATURAL VEGETATION
Red River Valley	Cropland (MU#1)	Lake deposits/aquolls/ humic gley solinchack	Flat plains (no lakes)	Prairie
Northern Minnesota Wetlands	Swamp & marshland (MU#13 & 14)	Dk. colored with restricted drainage/wet histosols	Flat plains	Conifer bog
Western Corn Belt Plains	Cropland (MU#1)	Moist mollisoils - udolls/brownizems - humic gley	Irregular plains	Bluestem prairie
Northern Great Plains	Cropland (MU#1)	Dry mollisoils/ chernozems	Flat to smooth plains	Grassland
Northern Lakes and Forests	Forest (MU#7)	Grey-brown podzolic, podzol & brown podzolic	Intermediate types (excluding flat plains and hills)	Needleleaf or broad-leaf needleleaf mix
Central Hardwood Forests	Cropland with pasture, woodland & forest (MU#3)	Grey-brown podzolic	Irregular plains	Maple basswood forest & northern hardwoods
Driftless Area	Cropland with pasture, woodland & forest (MU#3)	Grey-brown podzolic & humic gley	Hills	Oak savannah, bluestem praire, & maple-bass-wood forest

Wetland Classes and Subclasses

Open Water (OW). This class applies to water 3 to 6 feet deep, associated with any of the other wetland classes, but usually with deep or shallow marshes. Submergent and surface vegetation are dominant.

(OW-V) Vegetated open water. Surface vegetation is present. Submergents that reach to within 6 inches of the surface may be present.

(OW-NV) Nonvegetated open water. Surface vegetation and near surface submergents are absent.

Deep Marsh (DM). This class applies to wetlands with an average water depth between 6 inches and 3 feet during the growing season. Emergent marsh vegetation is usually dominant, with surface and submergent plants present in open areas.

(DM-DW) Dead woody deep marsh. Standing dead trees, dead shrubs or stumps are the most abundant form of cover.

(DM-P) Persistent emergent deep marsh. Herbaceous plants that stand above the surface of the water or soil and their plant remains persist into next year's growing season.

(DM-NP) Nonpersistent emergent deep marsh. Emergents that fall beneath the water and decompose over winter.

(DM-A) Aquatic deep marsh. Surface and/or submergent aquatic vegetation is the dominant form of cover.

Shallow Marsh (SM). This class applies to wetlands dominated usually by persistent emergents with an average water depth less than 6 inches during the growing season. Surface water may be absent during the late summer and abnormally dry periods.

(SM-P) Persistent emergent shallow marsh. See (DM-2) for definition of persistent emergent. Classified as shallow marsh since the average water depth is less than 6 inches.

(SM-NP) Nonpersistent emergent shallow marsh. See (DM-3) for definition of nonpersistent emergent. Classified as shallow marsh since average water depth is less than 6 inches.

Meadow (M). This class applies to wetlands dominated by meadow emergents with up to 6 inches of surface water during the late fall, winter, and early spring. During the growing season, the soil is saturated and the surface exposed except in shallow depressions and drainage ditches. Meadows occur most commonly on agricultural land where periodic grazing or mowing keeps shrubs from becoming established. The structural differences in meadow vegetation often result from grazing; therefore, meadows have been divided into grazed and ungrazed subclasses.

(M-UG) Ungrazed meadow. The effects of grazing are absent. By early summer, most ungrazed meadows support dense, unbroken stands of meadow emergents, and broad-leaved herbs are often present, but rarely dominant.

(M-G) Grazed meadow. Cover plants are greatly modified as a result of grazing, and most of the grasses and sedges are selectively removed.

Shrub Swamp (SS). This class applies to wetlands dominated by woody plants less than 20 feet tall. Tussock sedge (Carex stricta) is the characteristic ground cover beneath shrubs.

(SS-D) Deciduous shrub swamp. Woody plants less than 20 feet tall that drop their leaves in the fall. Includes both needle-leaved and broad-leaved deciduous shrubs.

(SS-DW) Dead shrub swamp. Dead shrubs are dominant.

(SS-E) Evergreen shrub swamp. Needle-leaved evergreen shrubs that keep their leaves over winter. Broad-leaved evergreen shrubs (heath family) are excluded because they typically grow on peat in bogs and will be addressed in the Bog class.

Wooded Swamp (WS). This class applies to wetlands dominated by woody plants greater than 20 feet tall. Several levels of vegetation are usually present, including trees, shrubs, and herbaceous plants.

(WS-D) Deciduous wooded swamp. Deciduous trees are dominant. Includes both needle-leaved and broad-leaved deciduous trees.

(WS-E) Evergreen wooded swamp. Evergreen trees with needle-like or scale-like leaves are dominant.

Bog. This class applies to wetlands where the accumulation of sphagnum moss, as peat, determines the nature of the plant community. Young bogs commonly have floating peat mats that creep outward from shore over the surface of open water. Black spruce and tamarack are characteristic tree species. A bog is differentiated from a sedge meadow by the presence of a nearly continuous carpet of sphagnum moss on the groundlayer. The two most important families are the Ericaceae (heath family) and Cyperaceae (cyperaceae) (sedge family). Orchids of many species such as the pitcher plant, sundews, and bladderworts are character istic of the bog class.

(BOG-EM) Emergent bog. Persistent emergents, usually sedges, are dominant.

(BOG-S) Shrub bog. Ericaceous (heath) shrubs are the dominant vegetation. Species include leatherleaf, bog Rosemary, bog laurel, and Labrador tea. This subclass also includes non-ericaceous shrubs such as bog birch and bog holly.

(BOG-F) Forested bog. Evergreen trees and needle-leaved deciduous trees are dominant, particularly black spruce and tamarack.

Freshwater Wetland Classes and Subclasses

Wetland Class	Wetland Subclasses	Wis. Wetland Inventory Subclass
Open Water (OW)	(OW-V) Vegetated	(A) Aquatic Bed (A1) (A2) (A3) (A4)
	(OW-NV) Nonvegetated	(W) Open Water (W) (W1) (W2) (W3) (W4)
Deep Marsh (DM)	(DM-DW) Dead Woody	(T7) (S7)
	(DM-P) Persistent emergent	(E1) (E2)
	(DM-NP) Nonpersistent emerg.	(E4) (E5) (E6)
	(DM-A) Aquatic	(A1) (A2) (A3) (A4)
Shallow Marsh (SM)	(SM-P) Persisitent emergent	(E1) (E2)
	(SM-NP) Nonpersistent emergent	(E4) (E5) (E6)
Meadow (M)	(M-UG) Ungrazed	(E1) (E2) (E3)
	(M-G) Grazed	(E1) (E2) (E3), special modifier "g"
Shrub Swamp (SS)	(SS-D) Deciduous	(S1) (S2) (S3)
	(SS-DW) Dead Woody	(S7)
	(SS-E) Evergreen	(S5) (S6)
Wooded Swamp (WS)	(WS-D) Deciduous	(T1) (T2) (T3)
	(WS-E) Evergreen	(T5) (T8)
	(WS-DW) Dead Woody	(T7)
Bog	(BOG-EM) Emergent	(E2), special modifier "m"
	(BOG-S) Shrub	(S2) (S4) (S5) (S6) (S8) (S9)
	(BOG-F) Forested	(T2) (T5) (T8)

APPENDIX D
PROCEDURES FOR EVALUATING VALUES TO MAJOR WATERFOWL GROUPS

APPENDIX D
PROCEDURES FOR EVALUATING VALUES TO MAJOR WATERFOWL GROUPS

This appendix describes the procedures for evaluating major waterfowl groups. This information is not included on the summary of ratings as part of the WEM computer program. It can be used as a basis for increasing the relative importance of the wildlife function as part of the synthesis of ratings if the user chooses to do so.

The value of a wetland to the following waterfowl groups is assessed using logic flow charts (figures D-1 through D-6). To use the flow chart, start in the upper left hand corner. If the criterion is met, follow the "Y" path (Y = yes), if it is not met, follow the "N" path (N = no). Continue working through the flow chart until a high, moderate, or low value is obtained. The numbers following the criteria in the flow chart correspond to the questions that follow the waterfowl group definitions. Note that "impact area" on the flow charts can be substituted by "wetland being studied."

Definition of Major Waterfowl Groups :

Group 1. Dabbling ducks that prefer grassland types . American widgeon, blue-winged teal, green-winged teal, gadwall, mallard, pintail, and shoveler.

Group 2. Forest-nesting dabbling ducks . Black duck, wood duck, and mallard (in some cases).

Group 3. Largely carnivorous ducks . Common merganser, red-breasted merganser, hooded merganser, and old squaw (Great Lakes).

Group 4. Forest-nesting diving ducks . Common goldeneye, bufflehead, and ring-necked duck.

Group 5. Prairie-nesting divers with mostly vegetable diet . Canvasback, redhead, and ruddy duck.

Group 6. Prairie-nesting divers with mostly invertebrate diet . Greater and lesser scaups.

Group 7. Inland swans and geese . Canada goose, snow goose, and whistling swan.

The following questions are required for assessing values to the major waterfowl groups Figures D-1 through D-6). Question numbers correspond to those used by Adamus (1983), since the evaluation of values to the major waterfowl groups is based on his work.

1. **CONTIGUITY.** Does surface water enter or leave the wetland or adjacent deep water areas through an:

1.1 inlet?
1.2 outlet?

5. **AREA OF WETLAND PLUS DEEP WATER**. Is the surface area of the wetland plus adjacent deep water:

5.1 less than 5 acres (2 hectares)?
5.2 greater than 200 acres (80 hectares)?

6. **WETLAND SURFACE AREA.** Is the wetland:

6.1 less than 5 acres in size (2 hectares)?
6.2 greater than 40 acres in size (16 hectares)?

10. **STREAM ORDER.** (Skip unless wetland is riverine.) Is the wetland included in a stream reach of stream order:

10.1 1 or 2?

15. **SURROUNDING LAND COVER.** Is 20 percent of land cover surrounding the wetland (particularly the part closest to the wetland):

15.1 forested?
15.2 scrub-shrub?
15.4 cropland and/or grazed grassland?
15.6 ungrazed, unmanaged grassland?

NOTE: More than one "yes" response is possible if there are several cover types surrounding the wetland.

22. **VEGETATION FORM**. Is the class of the wetland predominantly:

22.1 forested?
22.2 scrub-shrub?
22.3 aquatic bed?
22.4 emergent?

23. **SUBSTRATE TYPE**. Is the sediment type in the wetland plus adjacent deep water predominantly (select only one):

23.3 porous organic?
23.4 sand?

NOTE: In wetlands where there is a floating mat (e.g., bog), consider the bog mat as the substrate only if it occupies the largest percentage of the wetland's surface area.

26. **HYDROPERIOD**. Is the flooding regime of the wetland predominantly:

26.1 permanently flooded?
26.2 intermittently exposed?
26.3 semipermanently flooded?
26.4 seasonally flooded?
26.6 temporarily flooded?
26.8 artificially flooded?

29. **NATURAL WATER LEVEL FLUCTUATIONS.** In response to individual storms, is the wetland characteristically "flashy"* with regard to runoff or evaporation?

*Flashy wetlands are those having most of the following characteristics, and especially those with an (*):

____ * no inlet or outlet
____ sinuous or irregularly shaped wetland
____ if riverine, base flow occupies less than 60 percent of channel
____ small surface area, especially less than 5 acres
____ * small wetland size relative to size of Immediate Drainage Area
____ located high in watershed
____ small stream order (if riverine)
____ * Immediate Drainage Area is steeply sloped
____ tributaries steeply sloped
____ * adjacent land cover = developed (much pave ment) or cropland
____ system is riverine
____ regional evaporation exceeds precipitation
____ scarcity of rooted vascular (submerged) plants
____ hydroperiod = not permanently flooded
____ seasonal flooding is great
____ * tributaries are channelized, have no dams
____ * inflow from tile drains, stormwater outfalls, or artificial channels draining nearby wet soils
____ steep wetland and bank gradient (perpendicu lar to shore)
____ shoreline is unvegetated
____ potential for debris dams is great
____ * is mostly shallower than 3 feet
____ temperature anomalies or springs suggest groundwater discharge
____ water quality anomalies suggest discharge
____ * much land is watershed recently converted
____ * soils in Immediate Drainage Area mostly im pervious
____ underlying sediment not permeable

34. ***WATER DEPTH (MEAN).*** Is there a portion of the wetland that is greater than 5 acres* and has a mean water depth of:

34.1 less than 0.3 foot?
34.2 between 0.3 and 0.7 foot?
34.3 between 0.7 and 1.5 feet?
34.4 between 1.5 and 3.0 feet?
34.5 between 3.0 and 5.0 feet?
34.6 between 5.0 and 7.0 feet?
34.7 between 7.0 and 26.0 feet?
34.8 greater than 26.0 feet?

More than 2 categories can be selected if warranted.

*If the entire wetland is less than 5 acres, then use the mean water depth for the entire wetland.

37. **MORPHOLOGY OF THE WETLAND, RELATIVE TO ADJACENT DEEP WATER AREAS**

37.1 Does the wetland comprise all of a peninsula, protruding head delta, bar, island, or shoal?

39. **WETLAND ALTERATIONS**

39.6 Are tile drains, stormwater outfalls, or other artificial channels draining wet soils or pavement major contributors to the basin of nearby tributaries (if wetland has an inlet)?

41. ***WETLAND'S* VEGETATION DENSITY.*** Do emergency macrophytes (e.g., bulrushes, cattail, cordgrass, sedges) cover an annual maximum of:

41.1 0-30 percent of the wetland?
41.2 31-69 percent of the wetland?
41.3 70-99 percent of the wetland?
41.4 100 percent (no channels)?

*If the wetland is less than 5 acres, consider adjacent deep water areas in conjunction with the wetland's vegetative cover in answering this question.

44. ***WETLAND-WATER EDGE.*** (Skip if greater than 80 percent of the wetland's vegetated perimeter abuts uplands.) Is the shape of the wetland-open water edge* mostly:

44.1 sinuous, irregular, wetland is an island, or wetland vegetation is dissected by numerous interconnected channels?
44.2 relatively smooth, and wetland is dis sected by proportionately few channels?

*Excluding internal, nonconnected pools.

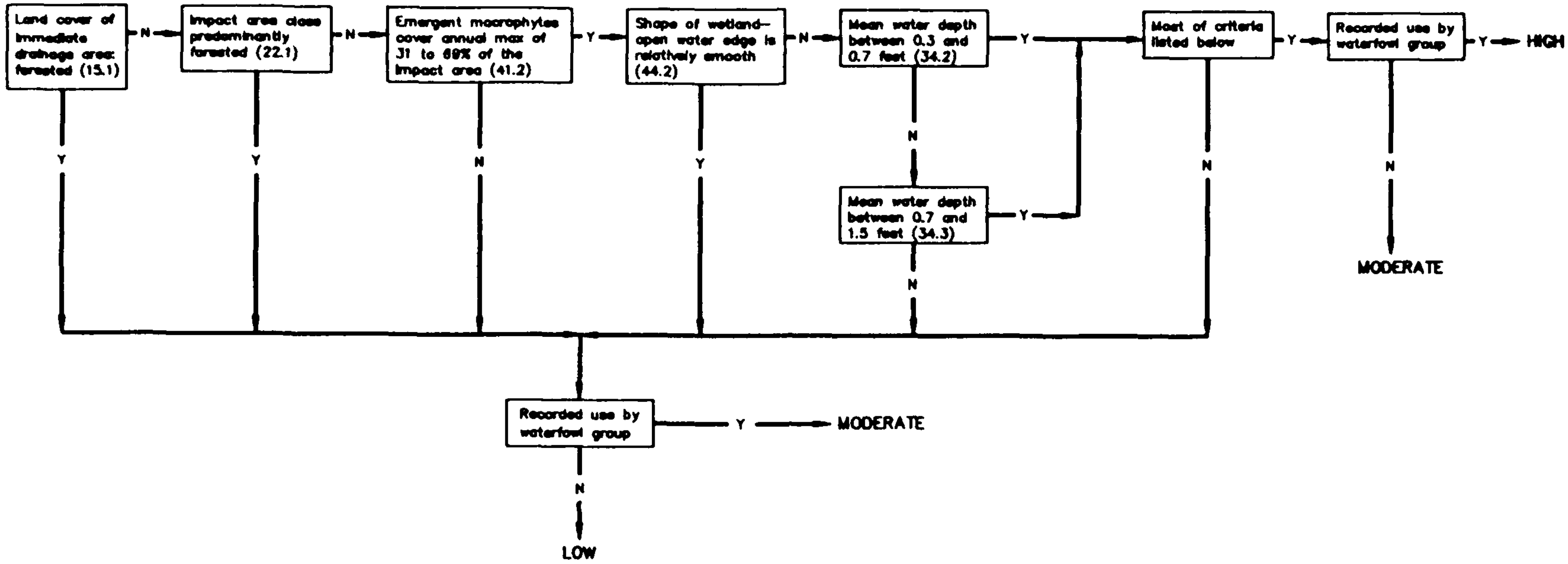
49. **PLANTS: FORM RICHNESS.** Does the wetland contain:

49.1 less than 3 vegetation forms (subclasses)?
49.2 more than 5 vegetation forms (sub

classes), with none of the 5 most dominant comprising less than 5 percent of the total area?

50. **PLANTS: WATERFOWL VALUE.** (Skip if wetland is entirely unvegetated.) For the waterfowl group(s) of primary interest, referenced to season, is any plant comprising more than 10 percent of the wetland rated as high use?

WATERFOWL GROUP 1 FIGURE D1



ADDITIONAL CRITERIA – WATERFOWL GROUP 1

1) 1.1 Impact area has an inlet NO
   AND
   1.2 Impact area has an outlet NO

2) 6.2 Wetland surface area greater than 40 acres YES

3) 50 A plant comprising more than 10% of wetland is rated as high value for waterfowl group YES

4) 10.1 (Skip unless riverine) Wetland is in stream of order 1 and 2 NO

5) 48.2 Impact area contains more than 5 vegetation forms YES

6) 44.1 Shape of wetland – open water edge is sinuous or irregular YES

7) 15.4 Land cover of immediate drainage area : cropped and/or grazed YES
   OR
   15.6 Land cover of immediate drainage area: ungrazed, unmanaged grassland YES

8) 30.6 Artificial channels are major contributors to the basin or tributaries NO

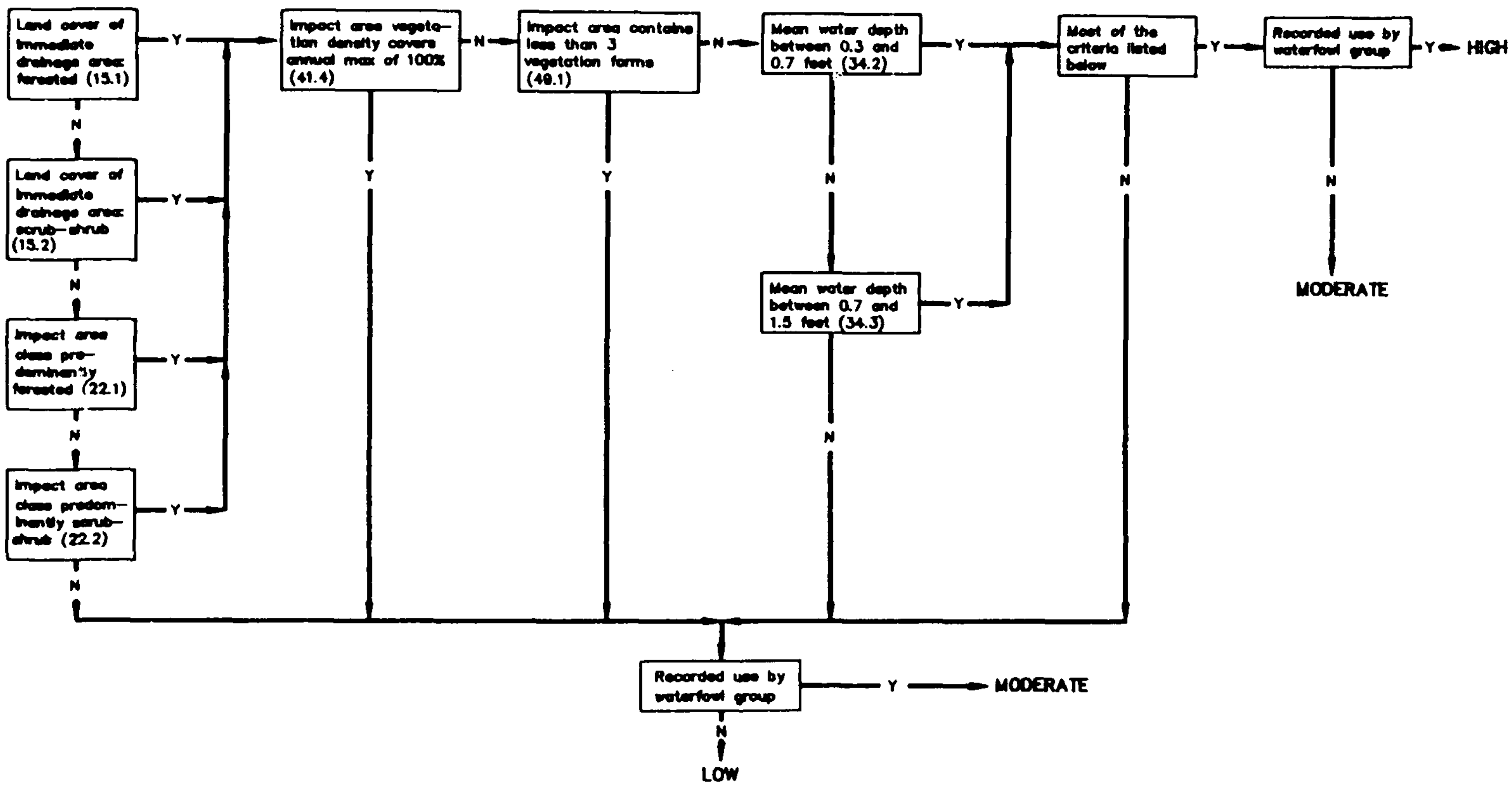
9) 28.3 Impact area predominantly semipermanently flooded YES
   OR
   28.4 Impact area predominantly seasonally flooded YES
   OR
   28.6 Impact area predominantly temporarily flooded YES

10) 29 Impact area characteristically "flashy" NO

11) 23.3 Substrate type: porous organic YES
   OR
   23.4 Substrate type: sand YES

12) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

WATERFOWL GROUP 2 (MODIFIED) FIGURE D2



ADDITIONAL CRITERIA – WATERFOWL GROUP 2

1) 1.1 Impact area has an inlet YES
AND
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 44.2 Shape of wetland–open water edge is relatively smooth NO

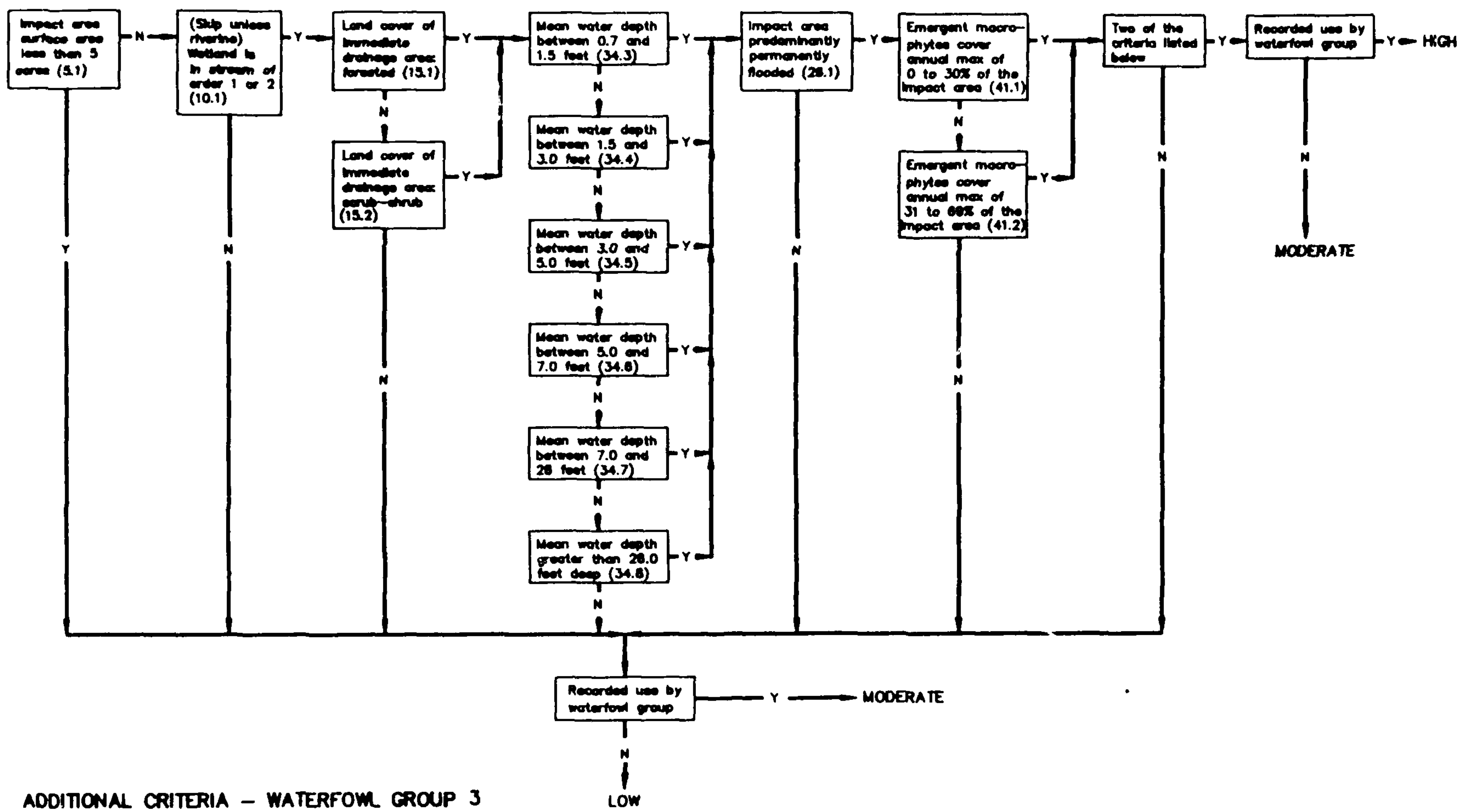
4) 26.1 Impact area predominantly permanently flooded YES
OR
26.2 Impact area predominantly intermittently exposed YES
OR
26.6 Impact area predominantly artificially flooded YES

5) 29 Impact area characteristically "flashy" (Black duck only) NO

6) 50 A plant comprising more than 10% of wetland is rated as high for given water fowl group YES

7) 41.1 Emergent macrophytes cover annual max of 0 to 30% of the impact area YES
OR
41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

WATERFOWL GROUP 3 FIGURE D3



ADDITIONAL CRITERIA – WATERFOWL GROUP 3

1) 1.1 Impact area has an inlet YES

OR

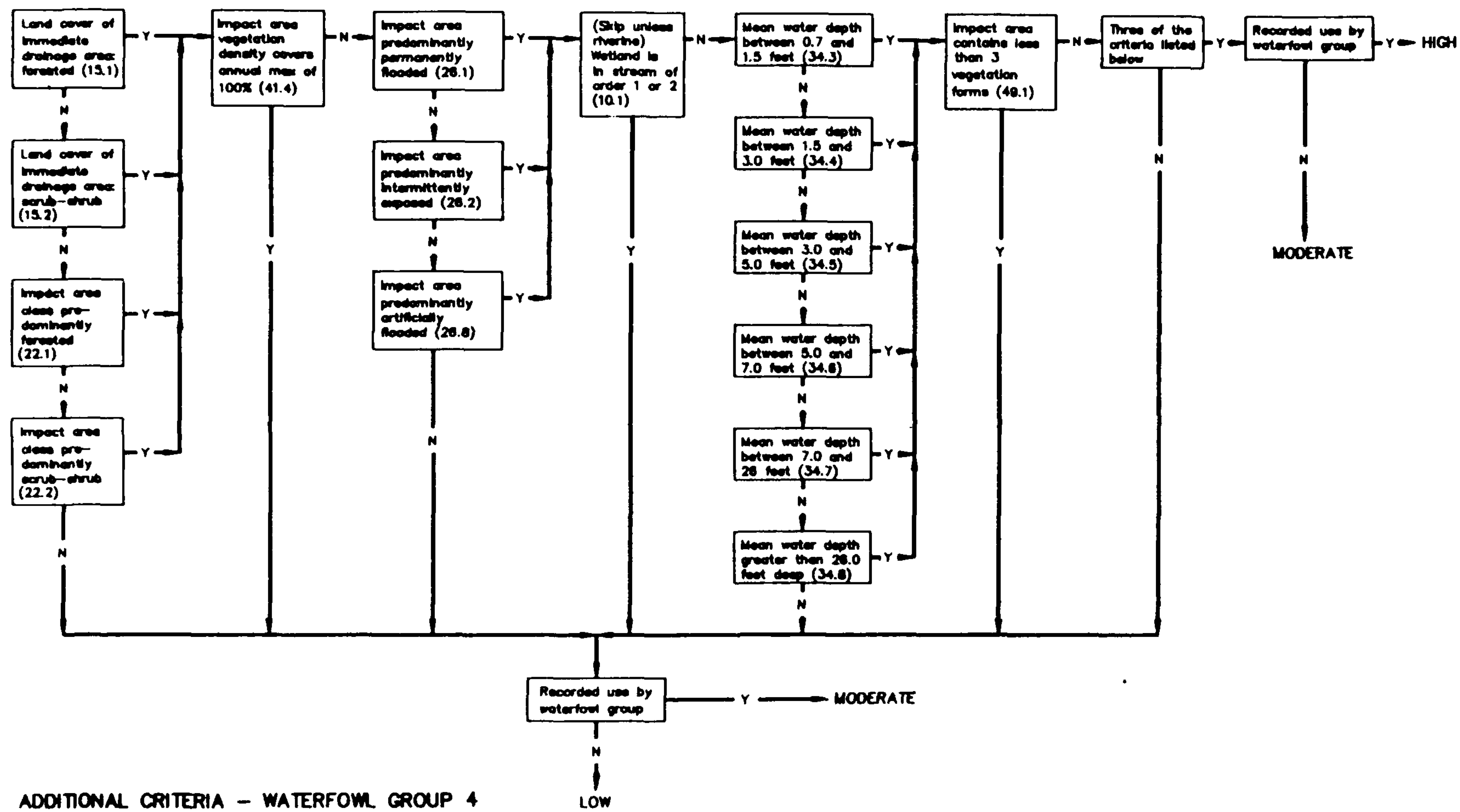
1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 5.2 Impact area surface area greater than 200 acres YES

4) 29 Impact area characteristically "flashy" (Except flooded) NO

WATERFOWL GROUP 4 FIGURE D4



ADDITIONAL CRITERIA – WATERFOWL GROUP 4

1) 1.1 Impact area has an inlet YES
   OR
   1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

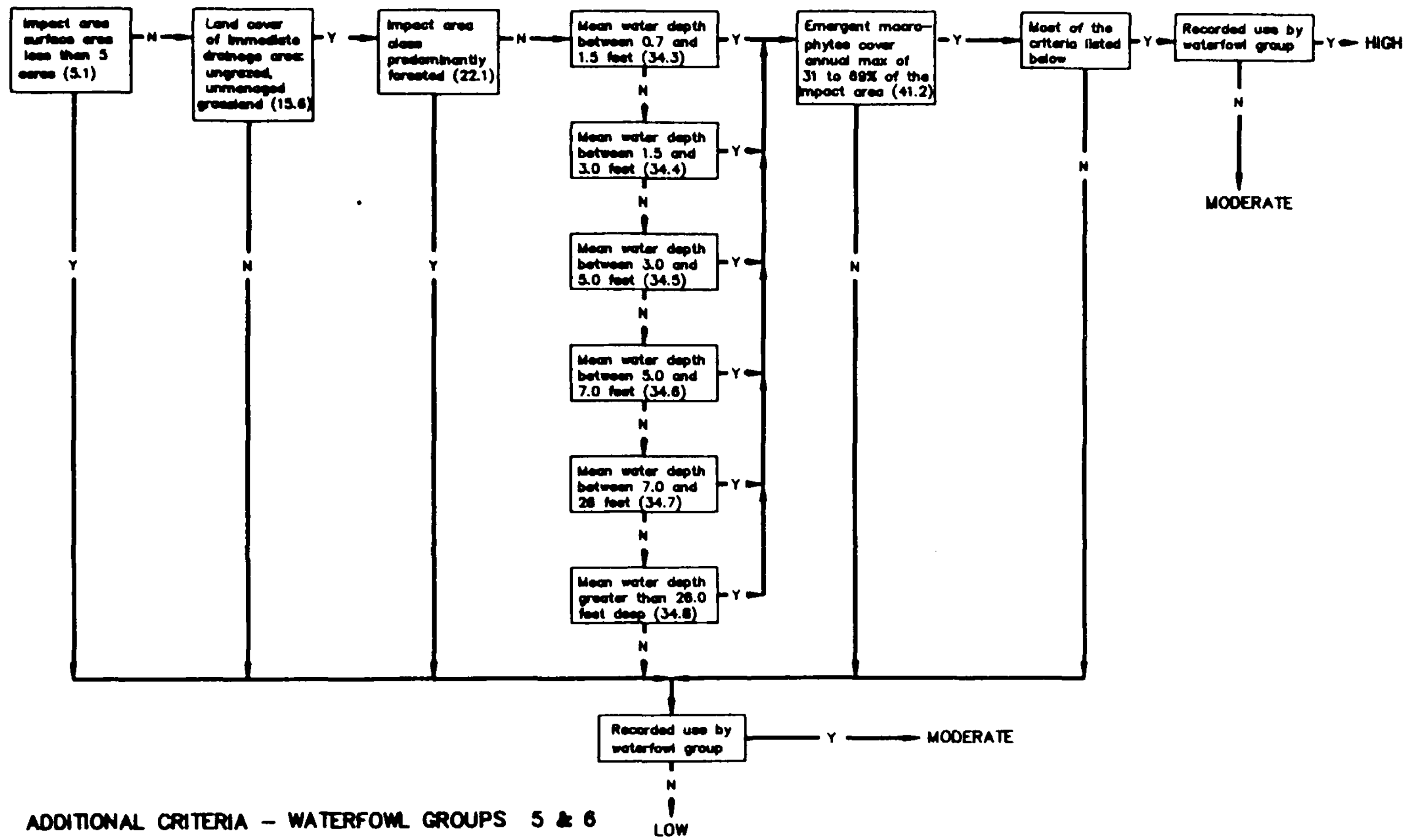
3) 49.2 Impact area contains more than 5 vegetation forms YES

4) 41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

5) 6.1 Wetland surface area less than 5 acres NO

6) 44.1 Shape of wetland-open water edge is sinuous or irregular YES

WATERFOWL GROUPS 5 & 6 FIGURE D5



ADDITIONAL CRITERIA – WATERFOWL GROUPS 5 & 6

1) 1.1 Impact area has an inlet NO
AND
1.2 Impact area has an outlet NO

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 29 Impact area characteristically "flashy" NO

4) 5.2 Impact area surface area greater than 200 acres YES

5) 6.2 Wetland surface area greater than 40 acres YES

6) 50 A plant comprising more than 10% of wetland is rated as high for given water fowl group (Group 5 only) YES

7) 15.4 Land cover of immediate drainage area: cropped and/or grazed YES
OR
15.6 Land cover of immediate drainage area: ungrazed, unmanaged grassland YES

8) 10.1 (Skip unless riverine) Wetland is in stream of order 1 or 2 NO

9) 28.3 Impact area predominantly semipermanently flooded YES
OR
28.4 Impact area predominantly seasonally flooded YES

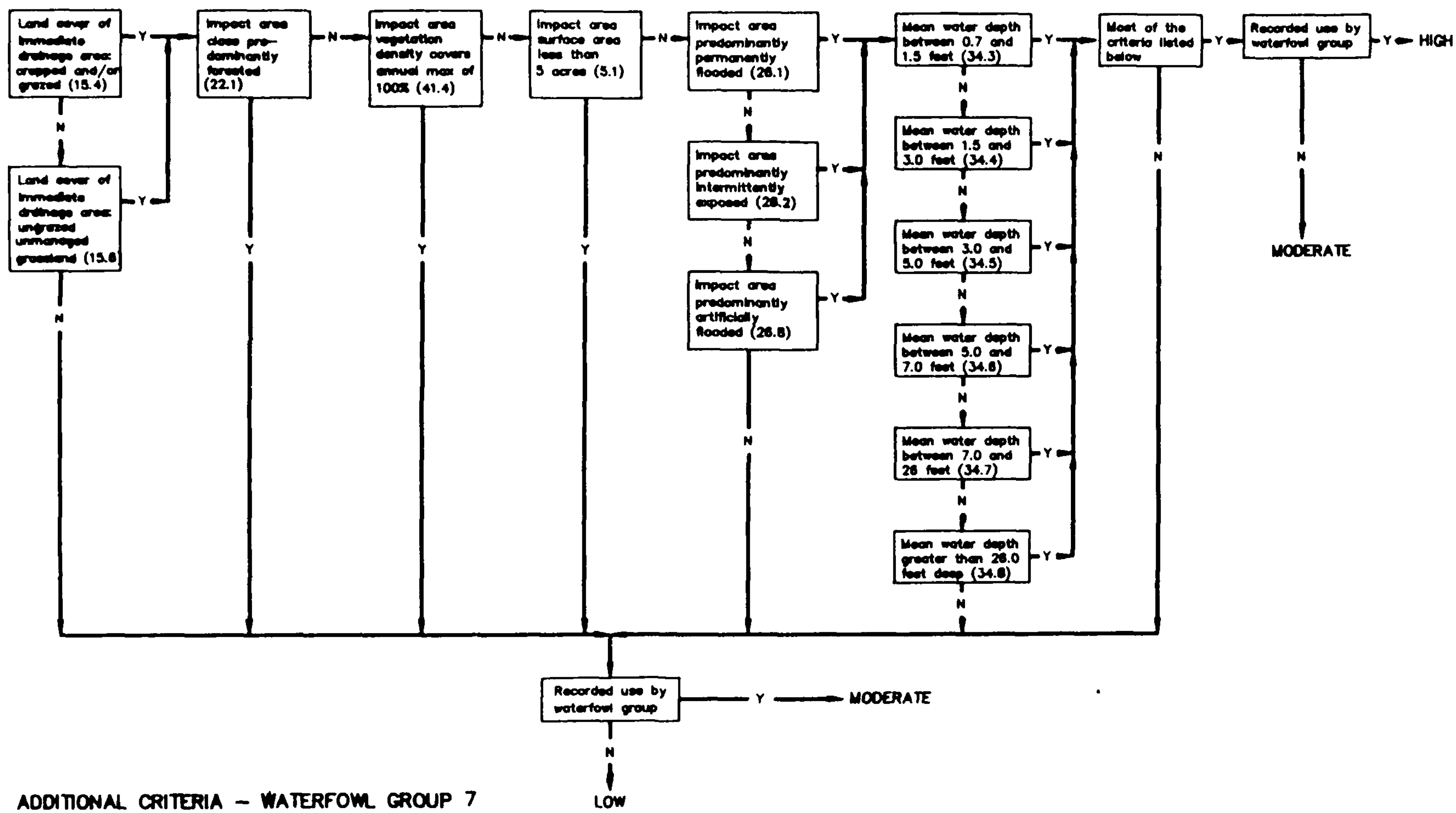
10) 22.3 Impact area class predominantly aquatic bed YES
OR
22.4 Impact area class predominantly emergent YES

11) 39.6 Artificial channels are major contributors to the basin or tributaries NO

12) 44.1 Shape of wetland— open water edge is sinuous or irregular YES

13) 49.2 Impact area contains more than 5 vegetation forms YES

WATERFOWL GROUP 7 FIGURE D6



ADDITIONAL CRITERIA – WATERFOWL GROUP 7

1) 1.1 Impact area has an inlet YES

AND

1.2 Impact area has an outlet YES

2) 37.1 Wetland comprises all of a peninsula, bar, delta, island, or shoal YES

3) 49.2 Impact area contains more than 5 vegetation forms YES

4) 41.2 Emergent macrophytes cover annual max of 31 to 69% of the impact area YES

5) 29 Impact area characteristically "flashy" NO

6) 44.1 Shape of wetland–open water edge is sinuous or irregular YES

7) 10.1 (Skip unless riverine) Wetland is in stream of order 1 or 2 NO

8) 22.3 Impact area class predominantly aquatic bed YES

OR

22.4 Impact area class predominantly emergent YES

9) 50 A plant comprising more than 10% of wetland is rated as high for given water fowl group

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